County of Los Angeles

Draft
Environmental Impact Report
SCH No. 2005051143
Volume XIX
Appendix 4.21 (continued)

MISSION VILLAGE

Prepared for:

Los Angeles County
Department of Regional Planning
320 West Temple Street
Los Angeles, California 90012

Prepared by:

IMPACT SCIENCES, INC.
803 Camarillo Springs Road, Suite A
Camarillo, California 93012
Phone: (805) 437-1900

NEWHALL RANCH
Newhall Ranch Company

OCTOBER 2010

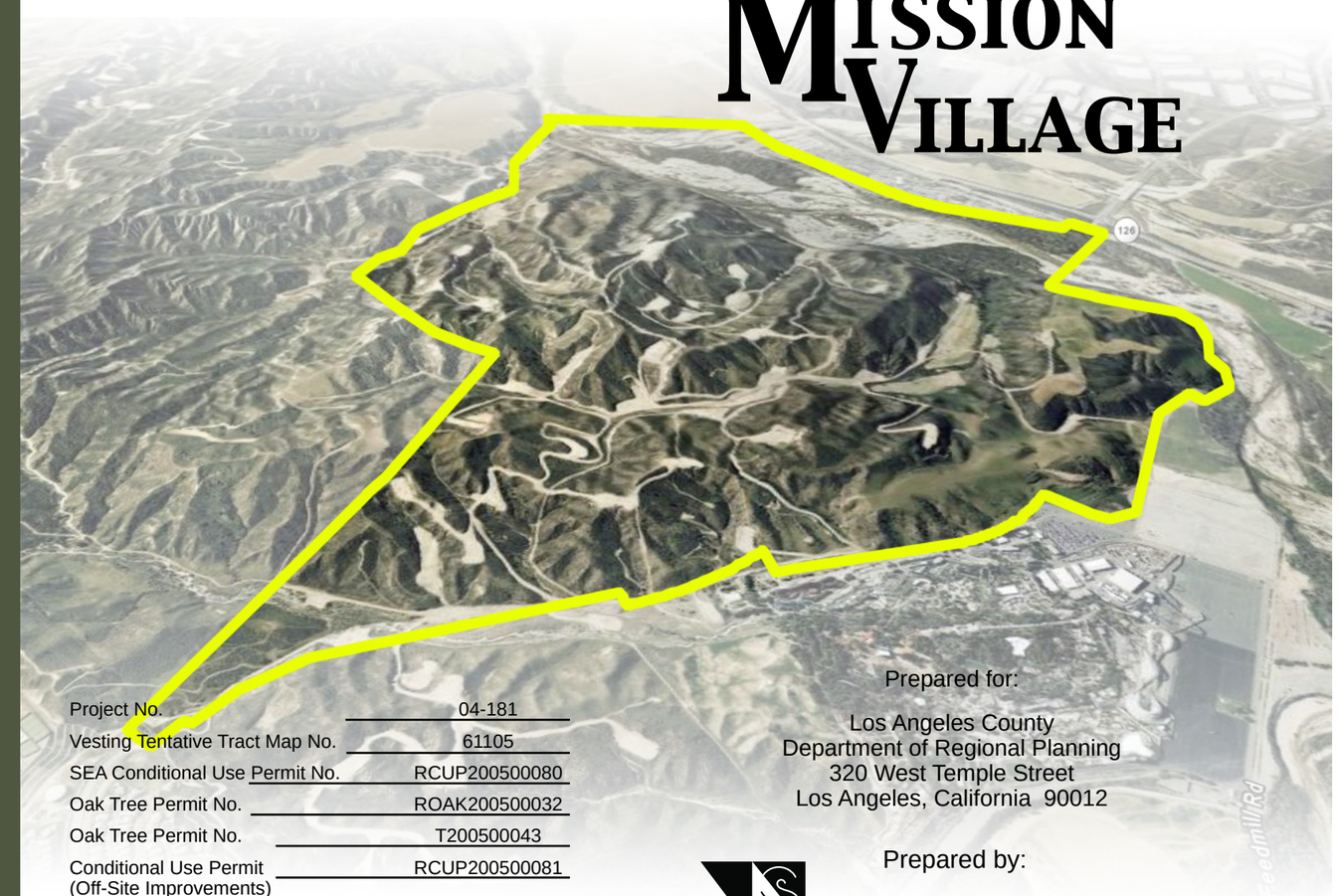
County of Los Angeles

Draft Environmental Impact Report

SCH No. 2005051143

Volume XIX
Appendix 4.21 (continued)

MISSION VILLAGE



Project No.	04-181
Vesting Tentative Tract Map No.	61105
SEA Conditional Use Permit No.	RCUP200500080
Oak Tree Permit No.	ROAK200500032
Oak Tree Permit No.	T200500043
Conditional Use Permit (Off-Site Improvements)	RCUP200500081

Substantial Conformance Determinations for Grading and Hillside Management Guidelines

NEWHALL RANCH
Newhall Ranch Company

Prepared for:

Los Angeles County
Department of Regional Planning
320 West Temple Street
Los Angeles, California 90012

Prepared by:

IMPACT SCIENCES, INC.
803 Camarillo Springs Road, Suite A
Camarillo, California 93012
Phone: (805) 437-1900

OCTOBER 2010

DRAFT
ENVIRONMENTAL IMPACT REPORT
for
MISSION VILLAGE

SCH No. 2005051143

County Project No. 04-181
Vesting Tentative Tract Map No. 61105
SEA Conditional Use Permit No. RCUP200500080
Oak Tree Permit No. ROAK200500032

Oak Tree Permit No. T200500043
Conditional Use Permit RCUP200500081
(Off-Site Improvements)

Volume XIX
Appendix 4.21 (continued)

Prepared for:

Los Angeles County
Department of Regional Planning
320 West Temple Street
Los Angeles, California 90012

Prepared by:

Impact Sciences, Inc.
803 Camarillo Springs Road, Suite A
Camarillo, California 93012
Phone: (805) 437-1900

October 2010

TABLE OF CONTENTS

Volume I

Section Page

Introduction I-1

Executive Summary ES-1

1.0 Project Description 1.0-1

2.0 Environmental and Regulatory Setting 2.0-1

3.0 Cumulative Impact Analysis Methodology 3.0-1

4.0 Environmental Impact Analysis 4.0-1
- 4.1 Geotechnical and Soil Resources 4.1-1
- 4.2 Hydrology 4.2-1
- 4.3 Biota 4.3-1
- 4.4 Visual Qualities 4.4-1

Volume II

- 4.5 Traffic/Access 4.5-1
- 4.6 Noise 4.6-1
- 4.7 Air Quality 4.7-1
- 4.8 Water Service 4.8-1
- 4.9 Wastewater Disposal 4.9-1
- 4.10 Solid Waste Services 4.10-1
- 4.11 Sheriff Services 4.11-1
- 4.12 Fire Protection Services 4.12-1
- 4.13 Education 4.13-1
- 4.14 Parks and Recreation 4.14-1
- 4.15 Library Services 4.15-1
- 4.16 Agricultural Resources 4.16-1
- 4.17 Utilities 4.17-1
- 4.18 Mineral Resources 4.18-1
- 4.19 Environmental Safety 4.19-1
- 4.20 Cultural/Paleontological Resources 4.20-1
- 4.21 Floodplain Modifications 4.21-1
- 4.22 Water Quality 4.22-1
- 4.23 Global Climate Change 4.23-1

5.0 Project Alternatives 5.0-1

6.0 Significant Irreversible Environmental Changes 6.0-1

7.0 Growth-Inducing Impacts 7.0-1

8.0 List of EIR Preparers, and Organizations/Persons Consulted 9.0-1

9.0 References 10.0-1

LIST OF APPENDICES

Volume III

Appendix I Initial Study/Notice of Preparation (NOP), and NOP Comment Letters
Initial Study/Notice of Preparation (NOP)
NOP Comment Letters

Appendix 1.0 Project Description Documentation
Vesting Tentative Tract Map No. 61105
Newhall Ranch Fiscal Impact Analysis, September 2006
Selected Exhibits and Tables from the Newhall Ranch Specific Plan

Appendix 2.0 Specific Plan Consistency Analysis, September 20, 2010

Appendix 3.0 Cumulative Impact Analysis Methodology
Development Monitoring System Database

Appendix 4.1 Geologic Reports
Geologic Report – Fault Investigation for Airport Mesa Area, Portion of Mesas East VTTM 61105, Newhall Ranch
Geologic and Geotechnical Report, Review of Vesting Tentative Tract Map 61105

Volume IV

Appendix 4.1 Geologic Reports (continued)
Geologic and Geotechnical Report, Review of Vesting Tentative Tract Map 61105 (continued)
Geologic and Geotechnical Report – Addendum No. 1, Response to Los Angeles County Geologic Review Sheet
Geologic and Geotechnical Report – Addendum No. 2, Response to Los Angeles County Geologic Review Sheet, January 26, 2005
Preliminary Geologic/Geotechnical Report, Review of Utility Corridor Plans (30% Submittal), Utility Corridor Along Highway 126, Newhall Ranch WRP Site to Travel Village, Castaic, May 25, 2007
Geologic and Geotechnical Report – Addendum No. 3, Response to Los Angeles County Geologic Review Sheet, September 17, 2007
Geologic and Geotechnical Report – Addendum No. 4, Response to Los Angeles County Geologic Review Sheet date January 16, 2008; March 13, 2008
Geologic and Geotechnical Report, Review Revised Vesting Tentative Tract Map 53108, December 21, 2009

Volume V

Appendix 4.1 Geologic Reports (continued)
Leighton and Associates, Inc., Geotechnical Report, Off-Site Grading for Proposed Southern California Edison Substation Alternatives, Responses to County of Los Angeles, Department of Public Works Geologic and Soils Engineering Review Sheets for TTM No. 61105 (Mission Village Project), November 26, 2007

LIST OF APPENDICES (continued)

Volume V (continued)

Appendix 4.1 Geologic Reports (continued)

Leighton and Associates, Inc., Responses to County of Los Angeles, Department of Public Works Geologic and Soils Engineering Review Sheets for Leighton's Geotechnical Report Off-Site Grading for Proposed Southern California Edison Substation Alternatives, March 11, 2008

Leighton and Associates, Inc., 100-Scale Grading Plan Review of Offsite Grading for Proposed Southern California Edison Substation Alternatives 1 and 2 March 2010, Vesting Tentative Tract Map 61105, County of Los Angeles March 16, 2010

R.T. Frankian & Associates, Evaluation of Building Setbacks, Airport Mesa (Area E1), Vesting Tentative Tract 61105, Newhall Ranch, Los Angeles County, California. October 14, 2009

R.T. Frankian & Associates, 100-Scale Plan Review, Revised Vesting Tentative Tract Map No. 61105, Mission Village, Newhall Ranch, December 21, 2009

R.T. Frankian & Associates, Response to County of Los Angeles Review Sheets and Geotechnical Plan Review, Revised Vesting Tentative Tract Map No. 61105, Mission Village, Newhall Ranch. March 30, 2010

Geologic/Geotechnical Report – EIR-Level Review of Preliminary Grading Study for Western Access Roads to Proposed Mission Village Development (VTTM 61105)

Geologic and Geotechnical Report – Review of Revised VTTM 61105 (Dated 12/21/05) for Screencheck Purposes

Geologic/Geotechnical Evaluation for Environmental Impact Report, Vesting Tentative Tracted Map No. 61105, March 31, 2010

R.T. Frankian & Associates, *Response to County of Los Angeles Review Sheets and Geotechnical Plan Review, Revised Tentative Tract Map No. 61105,* Mission Village, Newhall Ranch. April 29, 2010

Appendix 4.2 Hydrological Reports

Drainage Concept for Mesas VTTM 61105

Flood Technical Report – Santa Clara River, February 2007

Drainage Concept Report for Mission Village Santa Clara River Bank Protection, July 2007

Volume VI

Appendix 4.2 Hydrological Reports (continued)

California Regional Water Quality Control Board, Los Angeles Region, Review of Newhall Ranch Specific Plan Subregional Stormwater Mitigation Plan Letter, May 2008

Request for Conditional Letter of Map Revision, July 2007

Balance Hydrologics, Inc., "Assessment of Potential Impacts Resulting From Cumulative Hydromodification Effects, Selected Reaches of the Santa Clara River, Los Angeles County, California," (October 2005)

Newhall Ranch Santa Clara River Phase I River Fluvial Study, March 2006

LIST OF APPENDICES (continued)

Volume VI (continued)

Appendix 4.3 Biological Reports
California Native Plant Society, Inventory of Rare and Endangered Plants
California Natural Diversity Data Base
Compliance Biology, Inc., "Results of the Focused Western Spadefoot Toad Surveys on the Mission Village Project Site" (2006)
Entrix, Inc., "Focused Special-Status Aquatic Species Assessment – Santa Clara River, Mission Village Project, Newhall Ranch, California" (2006)
Impact Sciences, Inc., "Oak Tree Report: Mission Village VTTM 61105 Los Angeles County, California, March 2010 update" (2010)
Impact Sciences, Inc., "Mission Village VTTM 61105 Project Oak Tree Report, Los Angeles County, California" (2006)
Lemons, P., "Focused California Gnatcatcher Surveys for Mission Village, Los Angeles County, California" (January 26, 2008)
Dudek, "2007 Sensitive Plant Survey Results for the Newhall Ranch Specific Plan Area, Los Angeles County, California" (December 2007)

Appendix 4.5 Traffic Analysis
Mission Village Revised Traffic Impact Analysis, Austin-Foust Associates, Inc., October 2010
Westside Roadway Santa Clarita Valley Phasing Analysis, Austin-Foust Associates, Inc., November 2006
Westside Santa Clarita Valley Phasing Analysis for the City of Santa Clarita, Austin-Foust Associates, Inc., July 2006

Volume VII

Appendix 4.5 Traffic Analysis (continued)
Caltrans EIR/EIS Excerpts
City of Santa Clarita Department of Public Works and Los Angeles County Department of Public Works, Valencia B&T District Report Update, March 2008
City of Santa Clarita Transportation and Engineering Services, Via Princessa Bridge and Major Thoroughfare Construction Fee District Update Report, March 2002

Appendix 4.6 Noise Calculations
Noise Measurement Output Data and Analysis

Appendix 4.7 Air Quality Calculations
SCAQMD Santa Clarita Subregional Analysis, November 2004
Grading, Trenching, and Paving Emissions
Building Construction Emissions
Operational Emissions
CO Hotspots

LIST OF APPENDICES (continued)

Volume VII (continued)

Appendix 4.7 Air Quality Calculations (continued)
Localized Significance Thresholds Analysis
Health Risk Assessment

Appendix 4.8 Water Service Reports
SB 610 Water Supply Assessment
Water Supply Assessment Mission Village Vesting Tentative Tract Map No. 061105, April 2010
2005 Urban Water Management Plan
Los Angeles Superior Court Decision on Riverpark
Santa Barbara Superior Court Decision on West Creek
Newhall Ranch Revised Additional Analysis, Vol VIII

Volume VIII

Appendix 4.8 Water Service Reports (continued)
Nickel Water Contract Documentation
Nickel Environmental Documentation
The State Water Project Deliverability Reliability Report, Public Review Draft, November 16, 2005
The State Water Project Deliverability Reliability Report 2005, Final April 2006
Water Supply Contracts Between the State of California Department of Water Resources and CLWA including Amendment No. 18 (41,000 Acre-Feet Water Transfer)
Valencia Water Company Water Management Program Approved November 29, 2001, and Related CPUC Decisions
2002 Point of Delivery Agreement (Semitropic Groundwater Banking Program), February 13, 2004
California's Groundwater Bulletin 118, Update 2003, October 2003
CLWA Data Document Providing Economic Justification for Proposed Facility Capacity Fees, April 19, 2003
2004 Santa Clarita Valley Water Report, Dated May 2005
2005 Santa Clarita Valley Water Report, Dated April 2006
Results of Laboratory Testing of Valencia Water Company Wells
CH2MHill Memorandum, Effect of Urbanization on Aquifer Recharge in the Santa Clarita Valley, February 22, 2004
CH2MHill Final Report, Regional Groundwater Flow Model for the Santa Clarita Valley (Model Development and Calibration), April 2004
CH2MHill, Calibration Update of the Regional Groundwater Flow Model for the Santa Clarita Valley, Santa Clarita, California, August 2005
CH2MHill Final Report, Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, December 2004
CH2MHill Memorandum, Analysis of Near-Term Groundwater Capture Areas for Production Wells Located near the Whittaker-Bermite Property, December 21, 2004

LIST OF APPENDICES (continued)

Volume IX

Appendix 4.8 Water Service Reports (continued)
Analysis of Groundwater Basin Yield, Upper Santa Clara River Groundwater Basin, East Subbasin, Dated August 2005
Analysis of Groundwater Supplies and Groundwater Basin Yield Upper Santa Clara River Groundwater Basin, East Subbasin (2009 Basin Yield Update)
Draft EIR – Supplemental Water Project Transfer of 41,000 Acre-Feet of State Water Project Table A Amount, Dated June 2004
CLWA Draft Report, Recycled Water Master Plan, May 2002 and CLWA Resolution Regarding Availability of Recycled Water, Approved May 28, 2003
Impact and Response to Perchlorate Contamination, Valencia Water Company Well Q2, Dated April 2005
Groundwater Management Plan, Santa Clara River Valley Groundwater Basin, Dated December 2003
Memorandum of Understanding Between the Santa Clara River Valley Upper Basin Water Purveyors and United Water Conservation District, August 2001
Newhall Ranch Litigation, Statement of Decision, August 1, 2000

Volume X

Appendix 4.8 Water Service Reports (continued)
Slade, 2001 Update Report Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems, Dated July 2002
Interim Remedial Action plan, Dated December 2005
Valencia Water Company Letter to Impact Sciences, March 8, 2006
Luhdorf & Scalmanini Technical Memorandum: Evaluation of Groundwater Recharge Methods for the Saugus Formation in the Newhall Ranch Specific Plan Area, March 8, 2006
Luhdorf & Scalmanini Technical Memorandum: Potential Capture of Perchlorate Contamination, Valencia Water Company Wells E14-E17, April 26, 2006
Final Report, Reclaimed Water System Master Plan, CLWA, September 1993
CPUC Decision Dated November 29, 2001
CPUC Decision Dated October 16, 2003
CPUC Decision Dated August 24, 2006
2003 Point of Delivery Agreement (Semitropic Groundwater Banking Program), February 13, 2004
CLWA Resolution Regarding Availability of Recycled Water, Approved May 28, 2003
CLWA Memorandum to Board of Directors, June 1, 2007
Monterey Settlement Agreement
Friends of the Santa Clara River v. Castaic Lake Water Agency, 2003 WL 22839353 (*Friends II*)
DWR "News for Immediate Release," April 18, 2006
DWR Notice to SWP Contractors, May 23, 2007
DWR Bulletin 132-04, *Management of the California State Water Project*, September 2005
DWR Bulletin 132-03, *Management of the California State Water Project*, December 2004
DWR Bulletin 132-02, *Management of the California State Water Project*, January 2004

LIST OF APPENDICES (continued)

Volume X (continued)

Appendix 4.8 Water Service Reports (continued)

DWR Bulletin 132-01, *Management of the California State Water Project,* December 2002

DWR Bulletin 132-06, *Management of the California State Water Project*, December 2007

DWR's "Notices to State Water Project Contractors" 2000 to 2006

Sacramento County Trial Court's Order (re: Monterey Settlement Agreement)

Judgment Granting Peremptory Writ of Mandate, October 25, 2002

DWR Brief in the 41K litigation

California Water Impact Network, et al. v. Castaic Lake Water Agency, Appellate Court 2d Civil No. B177978 (Second District Court of Appeal's unpublished decision)

CalSim II: Simulation of Historical SWP-CVP Operations, Technical Memorandum, DWR Bay-Delta Office, November 2003

CalSimII Benchmark Studies

Musings On A Model: CalSim II In California's Water Community, San Francisco Estuary and Watershed Science, Vol. 3, Issue 1 (March 2005), Article 1, by Inês C. Ferreira, *et al*

DWR letter to Mindy McIntyre, Planning and Conservation League, April 20, 2006

Order Granting Plaintiff's Application for Temporary Restraining Order, February 3, 2006

Order Granting Plaintiff's Motion for Preliminary Injunction, February 15, 2006

Governor Schwarzenegger's release issued July 17, 2007

Volume XI

Appendix 4.8 Water Service Reports (continued)

2006 Santa Clarita Valley Water Report, May 2007

2008 Santa Clarita Valley Water Report, April 2009

Statement of Decision, *California Water Network v. Castaic Lake Water Agency*, Los Angeles County Superior Court No. BS098724, filed April 2, 2007 ("Chalfant Decision")

California Water Impact Network, Inc. v. Castaic Lake Water Agency, Second Appellate District, Division Five, Appellate Case No. B205622

Castaic Lake Water Agency Litigation Settlement Agreement

Order Granting Joint Motion for Court Approval, Good Faith Settlement Determination and Entry of Consent Order, July 13, 2007

Stipulation to Dismiss Plaintiffs' Claims and Defendants' Counterclaim, August 20, 2007

Carollo Engineers, Treatment of Perchlorate Contaminated Groundwater from the Saugus Aquifer, TM 3 Bench and Pilot Test Results, February 2004

DWR's 2009 Comprehensive Water Package, Special Session Policy Bills and Bond Summary, November 2009

DWR's Progress on Incorporating Climate Change into Management of California's Water Resources, July 2006

Emissions Pathways, Climate Change, Impacts on California, Katharine Hayhoe, et al., August 24, 2004

Pondering a Climate Conundrum in Antarctic, *Nature,* January 13, 2002

LIST OF APPENDICES (continued)

Volume XI (continued)

Appendix 4.8 Water Service Reports (continued)
Buried Soil Cement Evaluation after 2004/05 Winter Storm, PACE, May 8, 2007
In Hot Water: Water Management Strategies to Weather the Effects of Global Warming, NRDC, July 2007
Minute Order and Statement of Decision for the 2005 UWMP
Janavs Decision
Retired Irrigated Farmland, Tentative Tract Map No. TR61105, 2008
Valencia Water Company, Well E-15 Water Quality Compliance Monitoring Results – 2006 to 2009
Progress Letter Report from Hassan Amini, Ph.D., Project Coordinator for AMEC Geomatrix, to DTSC, September 15, 2009
Letter from Hassan Amini, Ph.D., Project Coordinator for AMEC Geomatrix, to DTSC, June 8, 2009
CLWA News Release, September 14, 2009
CLWA Memorandum from Brian J. Folsom to CLWA Board of Directors, October 1, 2009
U.S. EPA, Perchlorate, and Region 9 Perchlorate Update
Biological Opinion for Delta smelt, 2008

Volume XII

Appendix 4.8 Water Service Reports (continued)
Biological Opinion for Chinook salmon/sturgeon
Natural Resources Defense Council v. Kempthorne, 506 F.Supp.2d 322 (E.D. Cal. 2007) ("2007 Wanger decision")
Pacific Coast Federation of Fishermen's Associations, et al. v. Gutierrez, et al., No. 06-CV-00245-OWW-GSA (E.D. Cal. 2008) ("2008 Wanger decision")
NOAA/NMFS release summarizing the 2009 Biological Opinion, June 4, 2009
DWR release responding to the 2009 Biological Opinion, June 4, 2009
SWP Contractors release concerning litigation filed challenging the 2009 Biological Opinion, August 6, 2009
Coalition for a Sustainable Delta/Kern County Water Agency release concerning the litigation filed challenging the 2009 BO, August 28, 2009

Appendix 4.9 Wastewater Disposal
Wastewater Data

Appendix 4.10 Solid Waste Services
Calculations Details

Appendix 4.11 Sherriff Services
Written correspondence from Captain Patti A. Minutello, Los Angeles County Sheriff's Department, Santa Clarita Valley Station, November 3, 2004
Written communication from E. Conley, Captain, Commander, Newhall Area Station, California Highway Patrol, November 14, 2004

LIST OF APPENDICES (continued)

Volume XII (continued)

Appendix 4.12 Fire Protection Services
Written correspondence, David R. Leininger, Chief, Forestry Division, Prevention Bureau, County of Los Angeles Fire Department, December 22, 2004

Appendix 4.13 Education
School Facilities Funding Agreement entered into between the Newhall District and Newhall on October 17, 1995
School Facilities Funding Agreement Between the Saugus Union School District and Newhall Land and Farming Company, Effective February 18, 1997
School Facilities Funding Agreement Between the William S. Hart Union High School District and The Newhall Land and Farming Company, Effective October 1998
Facilities Mitigation and Funding Agreement By and Between Newhall Land Development, LLC, and the Newhall School District, December 1, 2009
Agreement for the Advancement of School Facilities Funds to the Saugus Union School District by the Newhall Land and Farming Company, Effective October 17, 2000
School Facilities Funding Agreement entered into between the Newhall District and Newhall Land and Farming Company (Newhall School Funding Agreement), Effective January 22, 2010
Student Generation Calculations

Appendix 4.15 Library Services
Written correspondence from Malou Rubio, Head, Staff Services, County of Los Angeles Public Library, Library Headquarters, August 11, 2004
Written correspondence from Malou Rubio, Head, Staff Services, County of Los Angeles Public Library, Library Headquarters, June 28, 2004
E-mail correspondence from Malaisha Hughes, County of Los Angeles Public Library, Library Headquarters, January 21, 2005
Library Calculations

Volume XIII

Appendix 4.19 Environmental Safety
Phase I Environmental Site Assessment of Proposed The Mesas East, Valencia, California
Phase I Environmental Site Assessment of Entrada Development Tract Map No. 53295, Henry Mayo Drive and The Old Road, Valencia, California, March 2007 (part 1)

Volume XIV

Appendix 4.19 Environmental Safety (continued)
Phase I Environmental Site Assessment of Entrada Development Tract Map No. 53295, Henry Mayo Drive and The Old Road, Valencia, California, March 2007 (part 2)
Phase I Environmental Site Assessment of Entrada Development Tract Map No. 53295, Henry Mayo Drive and The Old Road, Valencia, California, March 2007 (part 3)

LIST OF APPENDICES (continued)

Volume XV

Appendix 4.19 Environmental Safety (continued)
Phase I Environmental Site Assessment of Entrada Development Tract Map No. 53295, Henry Mayo Drive and The Old Road, Valencia, California, March 2007 (part 4)
Phase I Environmental Site Assessment of Parcel Map No. 060678, Highway 126, Valencia, California, September 2005 (part 1)

Volume XVI

Appendix 4.19 Environmental Safety (continued)
Phase I Environmental Site Assessment of Parcel Map No. 060678, Highway 126, Valencia, California, September 2005 (part 2)
Phase I Environmental Site Assessment of Parcel Map No. 060678, Highway 126, Valencia, California, September 2005 (part 3)

Volume XVII

Appendix 4.19 Environmental Safety (continued)
Phase I Environmental Site Assessment of Legacy Village Development Tract Map VTTM 061996, Valencia, California, March 2007

Volume XVIII

Appendix 4.19 Environmental Safety (continued)
Phase II Subsurface Investigation of Water Quality Basins, Entrada ME073-02 Basins, Valencia, California, September 2006
BA Environmental, *Phase I Environmental Site Assessment of River Village Tentative Tract Map No. 53108, Highway 126, Newhall Ranch, California*, September 27, 2004
BA Environmental, *Phase I Environmental Site Assessment Addendum Letter of Proposed Water Tank Locations and Utility Corridor Easements Associated with the proposed River Village Development, Tentative Tract Map No. 53108, Highway 126, Newhall Ranch, California*, September 28, 2004
BA Environmental, Phase I Environmental Site Assessment of Proposed SCE Substation Site and Soil Disposal Site, Valencia, California, May 2010

Appendix 4.20 Cultural Resources
Phase I Archaeological Survey of the West Ranch Area
Backhoe Testing Near the Asistencia de San Francisco

Appendix 4.21 Floodplain Modifications
PACE, Mission Village Flood Technical Report
ENTRIX, Focused Special-Status Aquatic Species Assessment

LIST OF APPENDICES (continued)

Volume XIX

Appendix 4.21 Floodplain Modifications (continued)
Geosyntec Consultants, "Newhall Ranch Specific Plan Sub-Regional Stormwater Mitigation Plan" (April 2008)
Pacific Advanced Civil Engineering, Inc., "Newhall Ranch River Fluvial Study Phase 1, Final Draft" (March 2006; 2006a)
Pacific Advanced Civil Engineering, Inc., "Newhall Ranch River Fluvial Study Phase 2" (January 2008)
Philip Williams and Associates, Ltd., "Newhall Ranch Tributary Channel Design Guidelines" (November 20, 2008)

Volume XX

Appendix 4.22 Water Quality
Mission Village Water Quality Technical Report, March 2010
Geosyntec, Newhall Ranch Specific Plan Sub-Regional Stormwater Mitigation Plan, April 2008

Appendix 4.23 Global Climate Change
ENVIRON, Climate Change Technical Report: Mission Village, August 2010
GSI Water Solutions, Inc., "Technical Memorandum Regarding Potential Effects of Climate Change on Groundwater Supplies for Newhall Ranch Specific Plan, Santa Clarita Valley, California," March 18, 2008
Mission Village Sustainability Overview, 2010
Global Climate Change and Its Effects on Sensitive Biological Resources, July 2010
Global Climate Change and Its Effects on California Water Supplies, July 2010

Appendix 5.0 Project Alternatives
Emissions Calculations

Geosyntec Consultants, "Newhall Ranch Specific Plan Sub-Regional Stormwater Mitigation Plan" (April 2008)

Prepared for

Los Angeles County
Department of
Public Works

NEWHALL LAND SPECIFIC PLAN SUB-REGIONAL STORMWATER MITIGATION PLAN

Prepared by

Geosyntec consultants

engineers | scientists | innovators

April 2008

Prepared for

Newhall Land
23823 Valencia Boulevard
Valencia, California 91355

NEWHALL LAND SPECIFIC PLAN

SUB-REGIONAL STORMWATER MITIGATION PLAN

Prepared by

Geosyntec consultants

engineers | scientists | innovators

2566 Overland Avenue, Suite 670
Los Angeles, California 90064

Project Number PW0114

April 2008

NEWHALL RANCH SPECIFIC PLAN

SUB-REGIONAL STORMWATER MITIGATION PLAN

Prepared for

Newhall Land
Valencia, California

Prepared by

Geosyntec Consultants
Los Angeles, California

April 2008

Table of Contents

1. INTRODUCTION 1

2. ENVIRONMENTAL SETTING 4

2.1. PROJECT DESCRIPTION 4
2.1.1. Circulation Plan 5
2.1.2. Trails Plan 5
2.1.3. Water Plan and Sewer Plan 6
2.1.4. Recreational and Open Areas 7
2.1.5. Conservation and Special Management Areas 7
2.1.6. Infrastructure Improvements 10
2.2. RECEIVING WATERS 14
2.2.1. Santa Clara River 14
2.2.2. Santa Clara River Reaches 18
2.2.3. Santa Clara River Tributaries 18
2.2.4. Receiving Water Beneficial Uses 24
2.3. EXISTING SURFACE RECEIVING WATER QUALITY 26
2.3.1. Wet Weather Water Quality Monitoring 27
2.3.2. Dry Weather Water Quality Monitoring 46
2.4. GROUNDWATER 54
2.4.1. Groundwater Beneficial Uses 54
2.4.2. Existing Groundwater Quality 54

3. REGULATORY SETTING 59

3.1. CLEAN WATER ACT 59
3.2. CWA SECTION 303(D) - TMDLS 59
3.3. CALIFORNIA TOXICS RULE 60
3.4. CALIFORNIA PORTER-COLOGNE ACT 63
3.5. BASIN PLAN 64
3.6. MS4 PERMIT 65
3.6.1. Stormwater Quality Management Program 65
3.6.2. Standard Urban Stormwater Mitigation Plan 67
3.6.3. Hydromodification and Peak Flow Control 69
3.7. CONSTRUCTION PERMITS 70
3.8. GENERAL WASTE DISCHARGE REQUIREMENTS FOR DISCHARGERS OF GROUNDWATER FROM CONSTRUCTION AND PROJECT DEWATERING 71
3.9. NPDES PERMIT FOR THE NEWHALL RANCH WRP 71
3.10. DISCHARGE OF FILL OR DREDGE MATERIALS 71
3.11. LAKE OR STREAMBED ALTERATION AGREEMENT (LSAA) 72

4. POLLUTANTS OF CONCERN AND SIGNIFICANCE CRITERIA 74

4.1. SURFACE WATER POLLUTANTS OF CONCERN 74
4.1.1. Pollutants of Concern 74
4.1.2. Other Constituents 78
4.2. GROUNDWATER POLLUTANTS OF CONCERN 80
4.2.1. Pollutants of Concern 81
4.2.2. Other Constituents 81
4.3. HYDROLOGIC CONDITIONS OF CONCERN (HYDROMODIFICATION) 83
4.4. SIGNIFICANCE CRITERIA AND THRESHOLDS FOR SIGNIFICANCE 83

4.4.1. Surface Water Quality Significance Thresholds *83*
4.4.2. Significance Thresholds for Hydrologic Conditions of Concern (Hydromodification Impacts) *86*
4.4.3. Cumulative Impacts *86*
4.4.4. Groundwater Quality Impacts *87*

5. POST DEVELOPMENT SURFACE WATER QUALITY AND HYDROMODIFICATION CONTROL PROJECT DESIGN FEATURES 88

5.1. SUSMP REQUIREMENTS AND PROJECT DESIGN FEATURES 88
5.2. LOW IMPACT/SITE DESIGN BMPS 95
5.2.1. Consideration of Spatial Scale *96*
5.2.2. Newhall Ranch Low Impact/Site Design BMPs *96*
5.3. TREATMENT BMPS 99
5.4. HYDROMODIFICATION CONTROL PDFS 103
5.4.1. Hydrologic Source Control *103*
5.4.2. Project-Based Flow Duration Control *104*
5.4.3. Geomorphically-Referenced Channel Design *104*
5.4.4. Hydromodification Control Performance Standard *106*
5.5. OPERATION AND MAINTENANCE 108
5.5.1. Monitoring *108*

6. WATER QUALITY ANALYSIS APPROACH 112

6.1. WATER QUALITY MODEL DESCRIPTION 112
6.2. POLLUTANTS MODELED 114
6.3. QUALITATIVE IMPACT ANALYSIS 115

7. IMPACT ASSESSMENT 117

7.1. POST DEVELOPMENT STORMWATER RUNOFF IMPACT ASSESSMENT FOR MODELED POLLUTANTS OF CONCERN 117
7.1.1. Stormwater Runoff Volume *118*
7.1.2. TSS *118*
7.1.3. Total Phosphorus *119*
7.1.4. Nitrogen Compounds *121*
7.1.5. Metals *123*
7.1.6. Chloride *126*
7.2. POST DEVELOPMENT STORMWATER IMPACT ASSESSMENT FOR POLLUTANTS AND BASIN PLAN CRITERIA ADDRESSED WITHOUT MODELING 127
7.2.1. Turbidity *127*
7.2.2. Pathogens *128*
7.2.3. Hydrocarbons *131*
7.2.4. Pesticides *132*
7.2.5. Trash and Debris *135*
7.2.6. Methylene Blue Activated Substances (MBAS) *136*
7.2.7. Cyanide *136*
7.3. MS4 PERMIT REQUIREMENTS FOR NEW DEVELOPMENT AS DEFINED IN THE SUSMP 138
7.4. CONSTRUCTION-RELATED IMPACTS 138
7.5. POLLUTANT BIOACCUMULATION 142
7.6. DRY WEATHER RUNOFF 143
7.7. SUMMARY OF SURFACE WATER QUALITY IMPACTS 144
7.7.1. Direct Impacts *144*
7.7.2. Cumulative Impacts *145*
7.8. GROUNDWATER IMPACTS 150

7.8.1. Direct Groundwater Quality Impacts *150*
7.8.2. Cumulative Groundwater Quality Impacts *151*
7.8.3. Groundwater Recharge Impacts *152*
7.9. HYDROMODIFICATION IMPACTS 153
7.9.1. Wet Weather Flows *154*
7.9.2. Dry Weather Runoff *164*

8. CONCLUSIONS 166

8.1. WATER QUALITY IMPACTS 166
8.2. GROUNDWATER IMPACTS 169
8.3. HYDROMODIFICATION IMPACTS 169

9. REFERENCES 172

APPENDIX A: POLLUTANTS OF CONCERN AND SIGNIFICANCE CRITERIA
APPENDIX B: WATER QUALITY MODELING METHODOLOGY
APPENDIX C: NEWHALL RANCH STORMWATER MONITORING DATA
APPENDIX D: REVIEW OF BACTERIA DATA FROM SOUTHERN CALIFORNIA WATERSHEDS
APPENDIX E: EFFECT OF URBANIZATION ON AQUIFER RECHARGE IN THE SANTA CLARITA VALLEY
APPENDIX F: ASSESSMENT OF POTENTIAL IMPACTS RESULTING FROM CUMULATIVE HYDROMODIFICATION EFFECTS, SELECTED REACHES OF THE SANTA CLARA RIVER, LOS ANGELES COUNTY, CALIFORNIA
APPENDIX G: NEWHALL RANCH HYDROMODIFICATION CONTROL

List of Tables

TABLE 2-1: NEWHALL RANCH SPECIFIC PLAN PROPOSED DEVELOPMENT 4
TABLE 2-2: LARWQCB SANTA CLARA RIVER REACHES 18
TABLE 2-3: BENEFICIAL USES OF SURFACE RECEIVING WATERS 25
TABLE 2-4: DEPTH AND DURATION OF STORMS MONITORED AT PROJECT SITE 27
TABLE 2-5: DEPTH AND DURATION OF STORMS MONITORED FOR NEWHALL RANCH WRP 28
TABLE 2-6: DEPTH AND DURATION OF STORMS MONITORED BY LACDPW AT S29 29
TABLE 2-7: AVERAGE CONCENTRATIONS OF SELECTED CONSTITUENTS FROM NEWHALL RANCH TRIBUTARY STORMWATER MONITORING, MARCH 2001 31
TABLE 2-8: NEWHALL RANCH WRP STARTUP WET WEATHER WATER QUALITY DATA FOR SELECTED GENERAL CONSTITUENTS IN THE SANTA CLARA RIVER, 2004 - 2006 31
TABLE 2-9: LACDPW STORMWATER MONITORING FOR SELECTED GENERAL CONSTITUENTS AT THE SCR MASS EMISSION STATION (S29), 2002 -2007 32
TABLE 2-10: USGS WATER QUALITY DATA FOR SELECTED GENERAL CONSTITUENTS IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951 – 1995 32
TABLE 2-11: AVERAGE CONCENTRATIONS OF NITRATE FROM NEWHALL RANCH TRIBUTARY STORMWATER MONITORING, MARCH 2001 35
TABLE 2-12: NEWHALL RANCH WRP PRE-STARTUP WET WEATHER WATER QUALITY DATA FOR SELECTED NUTRIENTS IN THE SANTA CLARA RIVER, 2004 - 2006 35
TABLE 2-13: LACDPW STORMWATER MONITORING OF SELECTED NUTRIENTS AT THE SCR MASS EMISSION STATION (S29), 2002-2007 36
TABLE 2-14: USGS WATER QUALITY DATA FOR SELECTED NUTRIENTS IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951 TO 1995 36

TABLE 2-15: AVERAGE CONCENTRATION OF HEAVY METALS FROM NEWHALL RANCH TRIBUTARY STORMWATER MONITORING, MARCH 2001 38
TABLE 2-16: NEWHALL RANCH WRP PRE-STARTUP WET WEATHER WATER QUALITY DATA FOR SELECTED METALS AND PESTICIDES IN THE SANTA CLARA RIVER, 2004 - 2006 38
TABLE 2-17: LACDPW STORMWATER MONITORING FOR METALS, PESTICIDES, AND CYANIDE AT THE SCR MASS EMISSION STATION (S29), 2002-2007....39
TABLE 2-18: USGS WATER QUALITY DATA FOR SELECTED METALS AND PESTICIDES IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951 TO 1995....40
TABLE 2-19: AVERAGE CONCENTRATIONS FOR FECAL INDICATOR BACTERIA FROM NEWHALL RANCH TRIBUTARY STORMWATER MONITORING, 2001 42
TABLE 2-20: NEWHALL RANCH WRP STARTUP WET WEATHER WATER QUALITY DATA FOR FECAL INDICATOR BACTERIA IN THE SANTA CLARA RIVER, 2004 - 2006....42
TABLE 2-21: LACDPW STORMWATER MONITORING FOR FECAL INDICATOR BACTERIA AT THE SCR MASS EMISSION STATION, 2002-2007 43
TABLE 2-22: USGS WATER QUALITY DATA FOR FECAL INDICATOR BACTERIA IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951 - 1995....43
TABLE 2-23: AVERAGE WET WEATHER MONITORING DATA (2-DAY ANTECEDENT RAINFALL OF 0.1 - 1.0 IN)....44
TABLE 2-24: AVERAGE WET WEATHER MONITORING DATA (2-DAY ANTECEDENT RAINFALL >1 INCH)....45
TABLE 2-25: LACDPW DRY WEATHER MONITORING FOR SELECTED GENERAL CONSTITUENTS AT THE SCR MASS EMISSION STATION (S29), 2002-2007....46
TABLE 2-26: NEWHALL RANCH WRP PRE-STARTUP DRY WEATHER MONITORING FOR SELECTED GENERAL CONSTITUENTS IN THE SCR, 2004-2006....47
TABLE 2-27: USGS DRY WEATHER WATER QUALITY MONITORING DATA FOR SELECTED GENERAL CONSTITUENTS IN THE SCR AT THE COUNTY LINE, 1951-1995....47
TABLE 2-28: LACDPW DRY WEATHER MONITORING OF SELECTED NUTRIENTS AT THE SCR MASS EMISSION STATION (S29), 2002-2007....48
TABLE 2-29: NEWHALL RANCH WRP PRE-STARTUP DRY WEATHER MONITORING FOR SELECTED NUTRIENTS IN THE SCR, 2004-2006....48
TABLE 2-30: USGS DRY WEATHER WATER QUALITY MONITORING DATA FOR SELECTED NUTRIENTS IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951 - 1995....49
TABLE 2-31: LACDPW DRY WEATHER MONITORING FOR METALS, PESTICIDES, AND CYANIDE AT THE SCR MASS EMISSION STATION (S29), 2002-2007....49
TABLE 2-32: NEWHALL RANCH WRP PRE-STARTUP DRY WEATHER MONITORING FOR METALS AND PESTICIDES IN THE SCR, 2004-2006....50
TABLE 2-33: USGS DRY WEATHER WATER QUALITY MONITORING DATA FOR METALS AND PESTICIDES IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951-1995 51
TABLE 2-34: LACDPW DRY WEATHER MONITORING AT THE SCR MASS EMISSION STATION (S29), 2002-2007 52
TABLE 2-35: NEWHALL RANCH WRP PRE-STARTUP DRY WEATHER MONITORING FOR INDICATOR BACTERIA IN THE SCR, 2004 - 2006 52
TABLE 2-36: USGS DRY WEATHER WATER QUALITY MONITORING DATA FOR INDICATOR BACTERIA IN THE SANTA CLARA RIVER AT THE COUNTY LINE, 1951-1995 52
TABLE 2-37: SUMMARY OF AVERAGE DRY WEATHER MONITORING DATA IN THE SANTA CLARA RIVER....53
TABLE 2-38: BENEFICIAL USES OF GROUNDWATERS 54
TABLE 2-39: GROUNDWATER MONITORING DATA....57
TABLE 3-1: 2006 CWA SECTION 303(D) LISTINGS FOR THE SANTA CLARA RIVER MAINSTEM....61
TABLE 3-2: 2006 CWA SECTION 303(D) LIST OF WATER QUALITY LIMITED SEGMENTS BEING ADDRESSED BY EPA APPROVED TMDLS 61
TABLE 3-3: TMDL WASTELOAD ALLOCATIONS FOR MS4 AND STORMWATER SOURCES TO SANTA CLARA RIVER REACH 5 62
TABLE 4-1: COMPARISON OF MINERAL BASIN PLAN OBJECTIVES WITH MEAN MEASURED VALUES IN LA COUNTY .79

TABLE 4-2: COMPARISON OF BASIN PLAN MINERAL GROUNDWATER OBJECTIVES WITH MEAN MEASURED VALUES IN LA COUNTY URBAN RUNOFF AND ANTICIPATED IRRIGATION WATER QUALITY 82
TABLE 5-1: SUSMP REQUIREMENTS AND CORRESPONDING NEWHALL RANCH PROJECT DESIGN FEATURES.....88
TABLE 5-2: NEWHALL LAND LOW IMPACT/SITE DESIGN BMPS 97
TABLE 5-3: TREATMENT CONTROL BMP SELECTION MATRIX.....101
TABLE 5-4: WATER QUALITY BMP OPERATION AND MAINTENANCE ACTIVITIES 109
TABLE 7-1: PREDICTED AVERAGE ANNUAL STORMWATER RUNOFF VOLUMES 118
TABLE 7-2: PREDICTED AVERAGE ANNUAL TSS CONCENTRATION AND LOADS.....119
TABLE 7-3: COMPARISON OF PREDICTED TSS CONCENTRATIONS WITH WATER QUALITY CRITERIA AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5 119
TABLE 7-4: PREDICTED AVERAGE ANNUAL TOTAL PHOSPHORUS CONCENTRATION AND ANNUAL LOAD.....120
TABLE 7-5: COMPARISON OF PREDICTED TOTAL PHOSPHORUS CONCENTRATION WITH WATER QUALITY CRITERIA AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5.....120
TABLE 7-6: PREDICTED AVERAGE ANNUAL NITRATE-N + NITRITE-N CONCENTRATION AND LOAD 121
TABLE 7-7: PREDICTED AVERAGE ANNUAL AMMONIA-N CONCENTRATION AND LOAD.....121
TABLE 7-8: PREDICTED AVERAGE ANNUAL TOTAL NITROGEN-N CONCENTRATION AND LOAD 121
TABLE 7-9: COMPARISON OF PREDICTED NITROGEN COMPOUND CONCENTRATIONS WITH WATER QUALITY OBJECTIVES, TMDLS, AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5.....122
TABLE 7-10: PREDICTED AVERAGE ANNUAL DISSOLVED COPPER CONCENTRATION AND LOAD.....123
TABLE 7-11: PREDICTED AVERAGE TOTAL LEAD CONCENTRATION AND ANNUAL LOAD.....124
TABLE 7-12: PREDICTED AVERAGE ANNUAL DISSOLVED ZINC CONCENTRATION AND LOAD 124
TABLE 7-13: PREDICTED AVERAGE ANNUAL TOTAL ALUMINUM CONCENTRATION AND LOAD 124
TABLE 7-14: COMPARISON OF PREDICTED TRACE METAL CONCENTRATIONS WITH WATER QUALITY CRITERIA AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5 125
TABLE 7-15: PREDICTED AVERAGE ANNUAL CHLORIDE CONCENTRATION AND LOAD.....126
TABLE 7-16: COMPARISON OF PREDICTED CHLORIDE CONCENTRATIONS WITH WATER QUALITY CRITERIA AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5 126
TABLE 7-17: PREDICTED AVERAGE ANNUAL COMBINED RUNOFF VOLUME AND POLLUTANT LOADS FOR THE NRSP, LEGACY VILLAGE, ENTRADA, AND VALENCIA COMMERCE CENTER PROJECTS.....147
7-18: PREDICTED AVERAGE ANNUAL COMBINED POLLUTANT CONCENTRATIONS FOR THE NRSP, LEGACY VILLAGE, ENTRADA, AND VALENCIA COMMERCE CENTER PROJECTS 147
TABLE 7-19: COMPARISON OF PREDICTED POLLUTANT CONCENTRATIONS FOR THE NRSP, ENTRADA, LEGACY VILLAGE, AND COMMERCE CENTER 26363 PROJECTS WITH WATER QUALITY CRITERIA AND OBSERVED CONCENTRATIONS IN SANTA CLARA RIVER REACH 5 148
TABLE 7-20: PREDICTED DRY WEATHER WATER BALANCE 165

List of Figures

(all figures follow text)

FIGURE 2-1 NEWHALL RANCH SPECIFIC PLAN LOCATION MAP
FIGURE 2-2 NRSP LAND USES
FIGURE 2-3 DRAINAGE IMPROVEMENTS
FIGURE 2-4 NEWHALL RANCH SPECIFIC PLAN SUBWATERSHED BOUNDARIES
FIGURE 2-5 SANTA CLARA RIVER REACH BOUNDARIES
FIGURE 5-1 CONCEPTUAL ILLUSTRATION OF A VEGETATED SWALE
FIGURE 5-2 EXAMPLES OF VEGETATED SWALES
FIGURE 5-3 CONCEPTUAL ILLUSTRATION OF A FILTER STRIP
FIGURE 5-4 CONCEPTUAL ILLUSTRATION OF A BIORETENTION FACILITY

FIGURE 5-5 EXAMPLES OF BIORETENTION FACILITIES
FIGURE 5-6 CONCEPTUAL ILLUSTRATION OF A DRY EXTENDED DETENTION BASIN
FIGURE 5-7 EXAMPLES OF EXTENDED DETENTION BASINS
FIGURE 5-8 CONCEPTUAL ILLUSTRATION OF A STORMFILTER™ MEDIA FILTER
FIGURE 5-9 EXAMPLES OF MODIFIED CHANNEL/ENGINEERED NATURAL CHANNEL

Acronyms

ASCE:	American Society of Civil Engineers
BAT:	Best Available Technology
BCT:	Best Conventional Technology
BMP:	Best Management Practice
BOD:	Biochemical Oxygen Demand
Cd:	Cadmium
CACO3:	Calcium Carbonate
CASQA:	California Stormwater Quality Association
CDFG:	California Department of Fish and Game
CEQA:	California Environmental Quality Act
CLWA:	Castaic Lake Water Agency
CNLM:	Center for Natural Lands Management
CTR:	California Toxics Rule
Cu:	Copper
CWA:	Clean Water Act
CWP:	Center For Watershed Protection
DCIA:	Directly Connected Impervious Area
DDT:	Dichlorodiphenyltrichloroethane
DLWC:	Department of Land and Water Conservation
EIR:	Environmental Impact Report
EMC:	Event Mean Concentration
Ep:	Erosion Potential
EPA:	Environmental Protection Agency
ETo:	Reference Evapotranspiration Rate
FIB:	Fecal Indicator Bacteria
HOA:	Home Owners Association
IPM:	Integrated Pest Management
IRWD:	Irvine Ranch Water District
JPA:	Joint Powers Authority
LACDPW:	Los Angeles County Department of Public Works
LARWQCB:	Los Angeles Regional Water Control Board
LID:	Low Impact Development
LMD:	Local Maintenance District
LSAA:	Lake and Streambed Alteration Agreement
MBAS:	Methylene Blue Activated Substances
MEP:	Maximum Extent Practicable
MGD:	Million Gallons per Day
mg/L:	Milligrams per Liter
MPN:	Most Probable Number
MS4:	Municipal Separate Storm Sewer System
NCDC:	National Climatic Data Center
NPDES:	National Pollutant Discharge Elimination System

NRSP :	Newhall Ranch Specific Plan
NSWQ:	National Storm Water Quality Database
O&M:	Operations and Maintenance
PAH:	Polycyclic Aromatic Hydrocarbons
Pb:	Lead
PCB:	Polychlorinated Biphenyl
PDF:	Project Design Feature
PIPP:	Public Information and Participation Program
RMDP:	Resource Management and Development Plan
RWQCB:	Regional Water Quality Control Board
SAR:	Sodium Adsorption Ratio
SCR:	Santa Clara River
SEA:	Significant Ecological Area
SMA:	Special Management Area
SWMP:	Stormwater Mitigation Plan
SQMP:	Stormwater Quality Management Plan
SUSMP:	Standard Urban Stormwater Mitigation Plan
SWPPP:	Storm Water Pollution Prevention Plan
SWRCB:	State Water Resources Control Board
TDS:	Total Dissolved Solids
TKN:	Total Kjeldahl Nitrogen
TMDL:	Total Maximum Daily Load
TN:	Total Nitrogen
TP:	Total Phosphorus
TPH:	Total Petroleum Hydrocarbons
TRM:	Turf Reinforcement Mat
TSS:	Total Suspended Solids
USEPA:	United States Environmental Protection Agency
USGS:	United States Geological Survey
WEF:	Water Environment Federation
WDR:	Waste Discharge Requirements
WHO:	World Health Organization
WMA:	Watershed Management Area
WMC:	Watershed Management Committee
WRP:	Water Reclamation Plant
WQTR:	Water Quality Technical Report
Zn:	Zinc

1. INTRODUCTION

This sub-regional Stormwater Mitigation Plan (SWMP) was developed by Newhall Land, consistent with the Los Angeles County Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit and the Standard Urban Stormwater Mitigation Plan (SUSMP), to set forth the urban runoff management program that will be implemented for the Newhall Ranch Specific Plan (NRSP) subregion. Stormwater management, including planning for water quality and hydromodification control, is central to assuring the long-term viability of beneficial uses, including important habitat systems and species dependent upon those systems. This sub-regional SWMP assesses potential water quality and hydromodification impacts associated with the proposed specific plan development and proposes control measures to address those potential impacts.

The Los Angeles Regional Water Quality Control Board (LARWQCB) has established a program for implementing federal stormwater/water quality management requirements, including the implementation of the SUSMP. In 2001, the LARWQCB (LARWQCB, 2001) issued an NPDES Permit and Waste Discharge Requirements (Order No. 01-182) under the CWA and the Porter-Cologne Act for discharges of urban runoff in municipal separate storm drain systems (MS4) in Los Angeles County (herein referred to as the "MS4 Permit"). The MS4 Permit requires implementation of a development-planning program for managing the effects of new development and redevelopment projects, as outlined in the Permit and the County of Los Angeles' "Manual for the Standard Urban Stormwater Mitigation Plan." The Manual is a model guidance document for use by Permittees and individual project owners to select post-construction best management practices (BMPs) and otherwise comply with the SUSMP requirements. It addresses water quality and drainage issues by specifying design standards for structural or treatment control BMPs that infiltrate or treat stormwater runoff and control peak flow discharge. BMPs are defined in the Manual and SUSMP requirements as any program, technology, process, sizing criteria, operational methods or measures, or engineered systems, which, when implemented, prevent, control, remove, or reduce pollution. The MS4 Permit and SUSMP Manual provided the overall context for the preparation of this document.

MS4 Permit §4.D(9) allows for the development of a regional or sub-regional stormwater mitigation program to substitute in part or wholly for SUSMP requirements. This NRSP sub-regional mitigation program must be approved by the Regional Board, and shall:

1. Result in equivalent or improved stormwater quality;
2. Protect stream habitat;
3. Promote cooperative problem solving by diverse interests;
4. Be fiscally sustainable and have secure funding; and

5. Construction of regional treatment facilities shall be completed prior to the use of the facility by any project within the subregion for post-development runoff treatment.

At 11,999 acres, the Newhall Ranch Specific Plan subregion is among the largest of the land holdings in the region having a single owner or small number of owners. The size and single ownership of the site provide a unique opportunity to develop a comprehensive, master-planned stormwater mitigation approach.

This NRSP Sub-Regional SWMP is the first of three levels of stormwater plan preparation. These levels include the Sub-Regional SWMP, which applies to the entire Newhall Ranch Specific Plan area; the Project Water Quality Technical Report, which will provide the project-level impact analysis for each of the villages within the Specific Plan area; and the final Project SUSMP, which will be prepared prior to the recordation of any final subdivision map (except those maps for financing or conveyance purposes only) or the issuance of any grading or building permit (whichever comes first). The NRSP Sub-Regional SWMP sets the framework for the future levels of stormwater plan preparation.

This NRSP Sub-Regional SWMP has been developed using a watershed-based approach that addresses pollutants of concern and hydrologic conditions of concern that can affect aquatic and riparian habitat and natural resources, including species associated with these habitats and natural communities. The Sub-Regional SWMP includes concept-level site design, source control, treatment control, and hydromodification control BMPs, consistent with the Los Angeles County SUSMP, that will be incorporated into each development area within the Newhall Ranch Specific Plan subregion.

This SWMP and the water quality and hydromodification control measures specified in it complement the avoidance, minimization, mitigation, restoration, and enhancement measures required by and evaluated in the Newhall Ranch Resource Management and Development Plan (RMDP). Implementation of this SWMP will assure that potential water quality and hydromodification impacts will not adversely affect Newhall Ranch Specific Plan area receiving waters or implementation of the RMDP.

Prior to the approval of a stormwater plan for each project within the NRSP, a Project Water Quality Technical Report (WQTR) will be prepared consistent with the terms and content of this Sub-Regional SWMP. The Project WQTR will provide more specific information and detail concerning how the provisions of the NRSP Sub-Regional SWMP will be implemented within the area covered by the individual Project WQTR. At a minimum, each Project WQTR will provide supplemental and refined information concerning: (1) how site design, source control, treatment control, and hydromodification control BMPs will be implemented at the project level for the area in question; (2) potential facility sizing and location within the subject project area; and (3) monitoring and operation and maintenance of stormwater BMPs within the relevant project area.

A final Project SUSMP will be prepared, consistent with the terms and content of both the Sub-Regional SWMP and Project WQTR, that specifically identifies the BMPs to be used on site. The Project SUSMP will be submitted to the Los Angeles County Department of Public Works (LACDPW) for review prior to the recordation of any final subdivision map (except those maps for financing or conveyance purposes only) or the issuance of any grading or building permit (whichever comes first). The Project SUSMP will identify: (1) site design BMPs (as appropriate); (2) source control BMPs; (3) treatment control BMPs; (4) hydromodification control BMPs; (5) whether long-term operation and maintenance of structural BMPs will be public or private; and (6) structural BMP sizing.

This report also addresses the potential impacts of the proposed Newhall Ranch Specific Plan project on water quality and hydromodification in local surface water bodies, including the Santa Clara River and its tributaries within the subregion. Potential changes in water quality and hydrology are addressed for pollutants of concern and hydrologic conditions of concern based on runoff water quality and quantity modeling, literature information, and best professional judgment. The level of significance of impacts is evaluated using a weight of evidence approach considering significance criteria that include predicted runoff quality for proposed versus existing conditions; MS4 Permit, Construction General Permit, and General Dewatering Permit water quality requirements; and reference to receiving water quality benchmarks, including Total Maximum Daily Load (TMDL) waste load allocations and water quality standards from the Basin Plan and California Toxics Rule.

2. ENVIRONMENTAL SETTING

2.1. Project Description

After conducting additional analysis, the County of Los Angeles Board of Supervisors approved the NRSP in May 2003 to guide development of Newhall Ranch projects. The NRSP covers a total of approximately 11,999 gross acres, the majority of which (8,334 acres) consists of high country, river corridor, open area, open space, and slopes that will remain undeveloped (Table 2-1). The Specific Plan contains the land use plan, development regulations, design guidelines, and implementation program for the long-term development of NRSP projects. Subsequent development plans and tentative tract maps are required to be consistent with the NRSP (as amended), the County of Los Angeles General Plan, and the Santa Clarita Valley Area Plan.

The NRSP subregion is located in the unincorporated area of Los Angeles County west of Interstate 5 and east of the Los Angeles/Ventura County line (Figure 2-1). The subregion is adjacent to and bisected by the Santa Clara River. The NRSP subregion currently consists of primarily agricultural land uses (farming and grazing), oil and gas operations, and undeveloped property.

The Specific Plan allows for a broad range of residential, mixed-use, and non-residential land uses within five villages (Table 2-1, Figure 2-2). The build-out of the Specific Plan is projected to occur over approximately 25 to 30 years, depending upon economic and market conditions.

Table 2-1: Newhall Ranch Specific Plan Proposed Development

Land Use Designation	Area (Acres)
Business Park	135.2
Commercial	228.9
Commercial Park	63.0
Estate	352.6
Elementary School	38.5
Fire Station	2.2
Golf Course	172.5
High Density Residential	151.2
High Country	4234.3
High School	41.1
Junior High School	20.9
Low Density Residential	419.3
Library	1.0
Lake	24.2
Low-Medium Density Residential	978.4
Medium Density Residential	610.9
Neighborhood Park	52.3
Open Area	763.3

Land Use Designation	Area (Acres)
Open Space	1,354.8
River Corridor	761.9
Road	340.0
Sub-Station	2.2
Slope	1,219.8
Visitor Serving	15.8
Water Reclamation	14.9
Total	11,999.2

2.1.1. Circulation Plan

The roadway network for Newhall Ranch is set forth in the Master Circulation Plan (NRSP, Section 2.4). Primary access to the Specific Plan site is currently provided via State Route 126 (SR-126), which is presently a four-lane highway between the Los Angeles County/Ventura County line and its connection to Interstate 5 (I-5), located approximately one mile east of the Specific Plan site.

In addition, Chiquito Canyon Road/Del Valle Road is an existing two-lane road designated as a Limited Secondary Highway in the Santa Clarita Valley Area Plan. San Martinez Grande Road is an existing local road, which provides access to portions of the Specific Plan site north of SR-126. The Specific Plan calls for improvements to several existing roadways in the Specific Plan area, including SR-126, Magic Mountain Parkway, Potrero Valley Road, Commerce Center Drive, Chiquito Canyon Road/Del Valle Road, San Martinez Grande Road, Valencia Boulevard, and Pico Canyon Road. These roadway improvements, as well as the other NRSP internal roadways, have been included in the project impact analysis presented in this report.

2.1.2. Trails Plan

The Master Trails Plan (NRSP Section 2.4) provides a comprehensive bicycle, pedestrian, and equestrian trails system throughout the Specific Plan area, and includes potential connections to regional trail systems within the Santa Clarita Valley. Portions of the proposed trail system would cross drainage channels or be located in areas under the jurisdiction of the Corps and CDFG. Construction details for the approved trails system are depicted on Exhibits 2.4-6, 2.4-7, and 2.4-8 of the approved Specific Plan.

The trails system would extend the existing planned regional trails into the Specific Plan site and provide additional recreational opportunities for both local and regional residents. The trails would provide access to Open Areas and the River Corridor and High Country SMAs, and connections between living areas, shopping, employment, entertainment, schools, and civic and

recreational facilities. The trails system provides a hierarchy of trails, including the Regional River Trail, community trails, local trails, pathways, and unimproved trails.

2.1.3. Water Plan and Sewer Plan

The Conceptual Backbone Water Plan, (NRSP Section 2.5), identifies conceptual onsite water storage and distribution systems to provide adequate fire and domestic water service to the Specific Plan site. The Specific Plan site is within the service area of the Castaic Lake Water Agency (CLWA), a wholesale water agency in the Santa Clarita Valley. Valencia Water Company, which currently serves Valencia and parts of the Newhall and Castaic communities, would provide retail water service to the Specific Plan. The domestic water demands for the Specific Plan are based on the projections for the specific land uses and their intensities, balanced with historical use factors.

The two sources of non-potable supplies needed to meet the Specific Plan's non-potable demand are recycled water from the Specific Plan's WRP and from existing upstream WRPs. The Specific Plan WRP's treatment capacity is planned to be 6.8 mgd of wastewater generated by the Specific Plan, all of which would be treated at the WRP, and upon tertiary treatment, reclaimed for landscape irrigation purposes (except for wet winters when irrigation demands would be lower, requiring the discharge of unused reclaimed water to the Santa Clara River during periods of high river flow). Recycled water from the WRP would be used to partially meet the non-potable water demands (e.g., irrigation) of the Specific Plan. The WRP, to be located along the Santa Clara River in the western edge of the Specific Plan site, is planned to be constructed in stages as the Specific Plan is developed over time. Construction of the WRP will require outfall facilities in and near the Santa Clara River.

CLWA also would serve the Specific Plan site with recycled water from existing upstream WRPs, consistent with CLWA's draft "Reclaimed Water System Master Plan." CLWA's master plan is being implemented in stages. CLWA's recycled water source would meet the remaining non-potable water demand of the Specific Plan.

Since approval of the Specific Plan by Los Angeles County, the Los Angeles County Local Area Formation Commission completed formation of the Newhall Ranch County Sanitation District. The new County sanitation district was formed effective July 27, 2006.

The Conceptual Backbone Sewer Plan (NRSP Section 2.5) sets forth a conceptual system for sewage collection that includes the Newhall Ranch WRP, a collection system with pump stations, and both gravity and force mains/siphons. All facilities of the sanitary sewer system would be designed and constructed for maintenance by the County of Los Angeles and/or the Sanitation Districts in accordance with their criteria, procedures, and requirements.

The Newhall Ranch Revised Draft EIR (March 8, 1999) contains a project-level analysis of the potential significant environmental impacts associated with construction and operation of the

approved Newhall Ranch WRP. This report addresses the potential impacts of reclaimed water use for irrigation on groundwater quality and considers the potential cumulative impacts of WRP discharges on water quality and hydromodification in the Santa Clara River.

2.1.4. Recreational and Open Areas

The land resources devoted to passive and active recreational uses, as well as environmental preservation, make up over one-half, (6,170 acres) of the NRSP area (see the Open Areas, Habitat Management Areas, and Parks Plan, NRSP Section 2.6). NRSP components comprising parks, recreational uses, open areas, and habitat management areas are summarized below.

Neighborhood and Community Parks. The Specific Plan Land Use Plan features 10 neighborhood parks dispersed throughout the Specific Plan and sited to meet the anticipated needs of Newhall Ranch residents. In addition, there are three approved community parks. The community parks include the 141-acre Oak Valley community park, the 16-acre Landmark Village community park, and the approximately 20-acre Mission Village community park.

Community Lake/Golf Course. A man-made community lake and golf course are approved as part of the Potrero Valley Village. The 15-acre lake and 180-acre golf course are to be situated in the central portion of the Potrero Valley Village to provide recreational amenities for the entire community. Scenic views of the lake would be provided from both commercial and residential areas. A pedestrian pathway along the lake would provide residents and Potrero Valley Village visitors with active and passive recreation opportunities.

Open Area. The approved Specific Plan's Open Area land use designation provides opportunities for active and passive recreation within the Specific Plan site. The Open Area designation encompasses approximately 1,010 acres of land through the central portion of the Specific Plan's development areas. The Open Area includes community parks, significant landforms and ridges, creeks and drainages, oak woodland and savannahs, utility and trail system easements, and often functions as a transition between Specific Plan development areas to the River Corridor and High Country SMAs.

2.1.5. Conservation and Special Management Areas

The Specific Plan Land Use Plan (Figure 2.0-7) designates a total of approximately 5,172 acres for the River Corridor and High Country Special Management Areas (SMAs). The River Corridor SMA is generally 1,500 to 2,000 feet wide and is located along the north and south sides of the Santa Clara River. The High Country SMA is located in the southern portion of the Specific Plan site. The SMAs are designed primarily to protect the existing natural resources within Los Angeles County's Significant Ecological Areas (SEA), SEA 20 and SEA 23. Limited public access through the SMAs would be provided by the trail system to be developed, consistent with the Specific Plan Master Trails Plan. Additional information regarding the two SMA/SEA areas is included in the Newhall Ranch Revised Draft EIR (March 8, 1999), Section

4.6, Biota, and the Newhall Ranch Revised Additional Analysis, Volume VIII (May 2003), Section 2.4, SEA General Plan Consistency. The two SMAs/SEAs, and other important preserve/conservation areas on and adjacent to the Specific Plan site, are summarized below.

River Corridor SMA. The 975-acre River Corridor SMA/SEA 23 includes the Santa Clara River within the Specific Plan site and associated habitats. The value of the River Corridor SMA/SEA 23 is derived from the inherent value of its wetland and riparian habitats and associated species, and from its function as a regional east-west wildlife corridor. Four federally-listed endangered species and numerous other sensitive species have been observed or detected in riparian habitats of the River. These wildlife species include the state and federally-listed endangered unarmored three-spine stickleback (Gasterosteus aculeatus williamsoni), Southwestern willow flycatcher (Empidonax traillii extimus), and least Bell's vireo (Vireo bellii pusillus); and the federally-listed endangered arroyo toad (Bufo californicus). The Santa Clara River is also an important migration and genetic dispersion corridor for many wildlife species, including aquatic taxa, riparian-obligate species (resident and migratory), and larger more mobile terrestrial animals.

The Specific Plan's previously adopted Resource Management Plan requires a permanent, non-revocable conservation and public access easement to be offered to the County of Los Angeles over the portion of the River Corridor SMA/SEA 23 within each Newhall Ranch subdivision. The easement is to be offered upon completion of development of all land uses, utilities, roads, flood control improvements, bridges, trails, and other improvements necessary for implementation of the Specific Plan within that subdivision allowing construction within or adjacent to the River Corridor SMA/SEA 23. The Resource Management Plan also contains a mitigation and habitat management program for the River Corridor SMA/SEA 23. Mitigation for the Specific Plan's impacts on riparian resources includes habitat restoration and enhancement activities. Habitat restoration refers to the revegetation of native plant communities on sites that have had the habitat removed due to past activities. Enhancement refers to the rehabilitation of areas of native habitat that have been moderately disturbed by past activities. A new Regional River Trail providing limited public access would be established on the north side of the River.

Prior to recording the River Corridor SMA/SEA 23 conservation and public access easement to Los Angeles County, the applicant is to provide a plan for the permanent ownership and management of the River Corridor SMA/SEA 23, including any necessary funding. This plan is to include the transfer of ownership of the River Corridor SMA/SEA 23 to the Center for Natural Lands Management. Long-term management strategies for the River Corridor SMA/SEA 23 include limitations on grazing, prohibition of agriculture, and limiting recreational activities to the use of the established trail system. The conservation and public access easement must be consistent with any other conservation easements to state or federal resource agencies, which may have been granted as part of the mitigation actions required by state and federal permits.

High Country SMA. The largest land use designation of the Newhall Ranch Specific Plan Land Use Plan is the 4,185-acre High Country SMA/SEA 20. The High Country SMA/SEA 20 is located in the southern portion of the site and includes oak savannahs, high ridgelines, and various canyon drainages, including the Salt Creek watershed in Los Angeles County. Salt Creek is a regionally significant wildlife corridor that provides an important habitat link to the Santa Clara River. As previously discussed, the Santa Clara River is an important east-west riparian corridor within the Specific Plan site. This corridor also serves as an important connection between the upland habitats to the north and south of the River. Specifically, large expanses of undeveloped land (i.e., Salt Creek in Los Angeles County) allow for the movement of wildlife to the River and back. Salt Creek also provides wildlife movement connectivity between the River Corridor SMA/SEA 23 and the High Country SMA/SEA 20.

The Specific Plan's previously adopted Resource Management Plan requires the High Country SMA/SEA 20 to be dedicated in fee to a Joint Powers Authority (JPA) consisting of representatives from the Los Angeles County (four members), the City of Santa Clarita (two members), and the Santa Monica Mountains Conservancy (two members). The JPA would have overall responsibility for recreation within and conservation of the High Country SMA/SEA 20. The Center for Natural Lands Management would be responsible for resource conservation and management in the High Country SMA/SEA 20. An assessment district would be formed under the authority of the Los Angeles County Board of Supervisors to generate revenue to be distributed to the JPA for recreation, maintenance, construction, conservation, and related activities within the High Country SMA/SEA 20.

Prior to dedication in fee of the High Country SMA/SEA 20, the Specific Plan requires that a conservation and public access easement be offered to the County of Los Angeles and that a conservation and management easement be offered to the Center for Natural Lands Management. The Specific Plan also requires that the County's conservation and public access easement be consistent with any other conservation easements to state or federal resource agencies, which may have been granted as part of the mitigation actions required by state and federal permits. In addition, the conservation and public access easement is to prohibit grazing within the High County SMA/SEA 20, except for those grazing activities associated with long-term resource management plans; and restrict recreation to the established trail system.

Pursuant to the Specific Plan, the High Country SMA/SEA 20's dedication in fee is to occur in three approximately equal phases of about 1,400 acres each, proceeding from north to south within the Specific Plan site, as follows: (a) the first offer of dedication would take place with issuance of the 2,000th residential building permit of the Specific Plan; (b) the second offer of dedication would take place with issuance of the 6,000th residential building permit; and (c) the remaining offer of dedication would be completed by the 11,000th residential building permit.

Salt Creek Dedication and Management Area. As part of its approval of the Specific Plan in 2003, the Los Angeles County Board of Supervisors imposed an off-site condition requiring the

applicant to dedicate to the public the remaining 1,517-acre portion of the Salt Creek watershed in Ventura County, adjacent to the western boundary of the Specific Plan site. The applicant is required to satisfy this condition by dedicating the Salt Creek area in fee and/or by conservation easement to the JPA, which is responsible for overall recreation and conservation of the High Country SMA/SEA 20. The Salt Creek area will be transferred upon approval of the first tract map adjacent to Ventura County in the Oak Valley (Potrero) Village portion of the Newhall Ranch Specific Plan. The Salt Creek area is to be managed in conjunction with and in the same manner as the High Country SMA/SEA 20. Protection of the Salt Creek area in both Los Angeles County and Ventura County enhances the Specific Plan's compatibility with animal movement in the region.

San Fernando Valley Spineflower CDFG Conservation Easements. Two conservation easements have been granted to CDFG for the purpose of conserving populations of spineflower found on the Specific Plan site. The easements are located on the south side of the River, and include a 20-acre preserve at Airport Mesa (east of Middle Canyon), and a 44-acre preserve at Grapevine Mesa (east of Humble Canyon). The conservation easements granted to CDFG are found in the approved Specific Plan (Appendix Volume II, Section 7.8).

2.1.6. Infrastructure Improvements

2.1.6.1. Conceptual Backbone Drainage Plan

The Conceptual Backbone Drainage Plan for the Specific Plan site is found on Exhibit 2.5-1 of the approved Specific Plan. From a sub-watershed standpoint, post-construction drainage basins will largely conform to the existing drainage areas onsite; project-related grading will not significantly alter the sub-watershed boundaries on Newhall Ranch. Storm flows through the site will largely follow existing drainage patterns, and will be conveyed through the site in open, soft bottom stream channels and closed drainage systems. A full description of the drainage facilities can be found in the Newhall Ranch Specific Plan (SCH # 95011015, May 2003).

Biological impacts associated with physical alterations to drainages in the Santa Clara River in connection with the construction of drainage and flood control facilities were evaluated in the Newhall Ranch Revised Draft EIR (March 8, 1999), Section 4.6, Biota. Biological impacts were further assessed in the Newhall Ranch Revised Additional Analysis (May 2003), Section 2.3, Floodplain Modifications, Volume VIII. Biological impacts associated with physical alterations to drainages and the Santa Clara River in connection with the construction of drainage facilities described in the RMDP are addressed in the Newhall Ranch Resource Management and Development Plan and Spineflower Conservation Plan Draft Joint Environmental Statement and Environmental Impact Report (SCH #2000011025), Section 4.5, Biological Resources, and Section 4.6, Jurisdictional Waters and Streams, and related biotechnical reports.

2.1.6.2. RMDP Infrastructure Improvements

The proposed RMDP infrastructure improvements to implement the approved Specific Plan are described in further detail in Section 2.6 of the Newhall Ranch Resource Management and Development Plan and Spineflower Conservation Plan Draft Joint Environmental Statement and Environmental Impact Report (SCH #2000011025) . The proposed RMDP infrastructure improvements are briefly summarized as follows:

Bridges and Road Crossing Culverts. Three bridges and sixteen new road crossing culverts would be installed to serve the Specific Plan and to accommodate future traffic associated with development of the Specific Plan and the region. There are two proposed bridges, Potrero Canyon Bridge and Long Canyon Road Bridge, and one previously approved bridge, Commerce Center Drive Bridge. [1] The three bridges would be located over the main stem of the Santa Clara River. The bridges are proposed to be constructed of conventional concrete girders placed over concrete filled piers. Fifteen of the 16 new road crossing culverts would cross five tributaries to the Santa Clara River. A sixteenth road crossing culvert would cross Ayers Canyon, near Potrero Mesa. The road crossings would be constructed of earthen fill and pre-fabricated arched culverts.

Bank Stabilization. Bank stabilization/protection would be installed along portions of the Santa Clara River and its tributary drainages within the RMDP site. Bank protection would include buried soil cement, grouted and ungrouted rock riprap, turf reinforcement mats, and limited gunite slope lining in and around bridge abutments. Building pad elevation of the ground surface also would occur in areas along the Santa Clara River and major tributary drainages in order to protect land uses from flooding.

Drainage Facilities. Drainage facilities would be installed and include open and closed drainage systems, inlets, outlets, bank stabilization, and water quality basins. The proposed drainage structures focus on minimizing the amount of debris that would enter the drainage system and maintaining the quality of water within the system.

Water Quality Control Facilities. Pursuant to regulatory requirements (see Section 3.6), urban runoff treatment control BMPs would be implemented. Proposed treatment control BMPs are described in Section 5.3 of this report.

Tributary Drainages. In order to accommodate the Specific Plan development, some of the existing major tributary drainages within the Specific Plan site (Chiquito Canyon and San Martinez Grande Canyon) would require stabilizing treatments to protect the channel and surrounding development from excessive vertical scour and lateral channel migration. The

---

[1] The Commerce Center Drive Bridge was previously analyzed in the Final EIS/EIR prepared and approved by the Corps and CDFG in connection with the previously adopted NRMP (SCH No. 1997061090, August 1998).

existing drainages would remain intact, but would sustain permanent and temporary impacts from construction of stabilization elements, including buried bank stabilization and grade stabilization structures.

Due to the existing conditions within portions of some drainages in the Specific Plan site (portions of Long, Lion, and Potrero canyons), stabilization of the existing drainages is not feasible; and, therefore, in order to meet the County's flood protection objectives, these drainages would be graded, and a new drainage would be constructed in the same or similar location. The new drainages would be designed to incorporate buried bank stabilization and grade stabilization, and would have sufficient hydrologic capacity to pass the Los Angeles County Capital Flood without the need for clearing vegetation from the channels. The new channel banks would be planted with riparian vegetation following construction.

Among the minor tributary drainages within the RMDP site, some are located in areas where no impacts are proposed, and are distant enough from surrounding development that bank stabilization is not required. These drainages would remain in their existing condition; the RMDP does not propose to impact or enhance these drainages. In most situations, unmodified drainages would be located within future open space areas and maintain their current hydrologic functions, as well as providing linkages for wildlife movement to and from the Santa Clara River.

Some of the drainages within the Specific Plan site, including many of the smallest, ephemeral streams, would be graded as part of the grading operations required to facilitate build-out of the Specific Plan. Flows in these drainages meet the Los Angeles County flood criteria (less than 2,000 cfs) to be conveyed by storm drain. Because of the small, ephemeral nature of these drainages, the RMDP does not proposed to create new drainage channels to replace these impacted drainages. Rather, the wet-weather flows that currently occupy the drainages would be routed into the development's storm drain system, and would be discharged to the Santa Clara River via the proposed storm drain outlets.

Grade Stabilization Structures. Grade stabilization structures would be installed on five existing tributaries (Chiquito Canyon, Long Canyon, Potrero Canyon, San Martinez Grande Canyon, and Lion Canyon) to the main stem of the Santa Clara River. The grade stabilization structures are designed to contain the hydraulic "jump" that occurs when there is a significant drop in streambed elevation, so that higher velocities are dissipated within the area; the structures would help control erosion and changes to the configuration of the bed of the stream channel. Such structures would be constructed of soil cement, sheet piles, or reinforced concrete.

Utility Crossings. Various electrical, sewer, water, gas, and communications lines would be installed across the Santa Clara River, Chiquito Canyon, San Martinez Canyon, Potrero Canyon, and Long Canyon to serve the Specific Plan. Typically, the utility lines would be installed in

rights-of-way adjacent to bridges where access for installation and maintenance can be easily accommodated.

Temporary Haul Routes for Grading Equipment. Temporary haul routes across the Santa Clara River would be used during construction to move equipment and excavated soil to locations in the RMDP site where fill is needed.

WRP Outfall Construction Activities. An effluent outfall pipeline would be constructed from the Newhall Ranch WRP through the bank stabilization to the bed of the Santa Clara River. An earthen channel and adjacent walkway also would be constructed to reach the actual flow path of the river.

Maintenance Activities. DPW or other management entity would conduct regular and ongoing maintenance of flood, drainage, and water quality protection facilities on the RMDP site. Such activities would include periodic inspection of structures and monitoring of vegetation growth and sediment buildup to ensure that the integrity of the structures is maintained and that planned conveyance capacity is present, routine repairs and maintenance of bridges and bank protection, and emergency maintenance activities.

Recreation Facilities. In addition to the comprehensive system of bicycle, pedestrian, and equestrian trails that would be implemented by the adopted Specific Plan Master Trails Plan, the RMDP proposes to construct up to eight nature viewing platforms that would be located in jurisdictional areas along the Santa Clara River.

Habitat Enhancement and Restoration Activities. The RMDP incorporates a variety of design features that minimize impacts to riparian and upland resources along and within the Santa Clara River and its tributary drainages, including avoidance, minimization, restoration, and enhancement activities. In addition, the RMDP includes enhancement design features, such as removal of grazing to enhance riparian habitat, and rehabilitating native habitat areas that have been disturbed by past activities or invaded by non-native plant species.

Consistent with the resource management objectives, a multi-disciplinary approach was used to design the RMDP. This approach includes factors such as biology, land use, geology, topography, hydrology, soils, and infrastructure. By incorporating design considerations and resource preservation methods, implementation of the RMDP would result in a conservation strategy to allow for development of the Specific Plan in a way that avoids or minimizes the Specific Plan's significant impacts on waters, jurisdictional streams and drainages, and sensitive biological resources. RMDP implementation also would build upon the preserve assembly process that originated with the Specific Plan's Resource Management Plan. This preserve assembly process involves the dedication of the High Country SMA/SEA 20, River Corridor SMA/SEA 23, Salt Creek, and Open Areas.

The RMDP also proposes mitigation and management activities to address the significant impacts on jurisdictional waters/drainages and sensitive biological resources resulting from the Specific Plan. The impacts and mitigation and management measures identified in the RMDP are discussed in both Section 7.0 of the RMDP and Section 4.5, Biological Resources, of the Newhall Ranch Resource Management and Development Plan and Spineflower Conservation Plan Draft Joint Environmental Statement and Environmental Impact Report (SCH # 2000011025).

The RMDP includes plans for monitoring and management. In addition, the RMDP provides an adaptive management program and remedial measures for the River Corridor SMA/SEA 23, High Country SMA/SEA 20, Salt Creek, and Open Areas. The RMDP includes reporting requirements associated with the River Corridor SMA/SEA 23, High Country SMA/SEA 20, Salt Creek, Open Area, and oak resources, and it describes the funding mechanisms that would be utilized to implement the plan.

2.2. Receiving Waters

2.2.1. Santa Clara River

2.2.1.1. Watershed Description

The 11,999-acre NRSP subregion is located within the Santa Clara River Hydrologic Basin and associated watershed, which is 1,634 square miles in area. The portion of the Santa Clara River watershed that is located generally upstream or east of the Ventura County/Los Angeles County jurisdictional line is approximately 640 square miles in size, and drains portions of the Los Padres National Forest from the north, the Angeles National Forest from the north and northeast, and the Santa Susana Mountains from the south and southeast. The NRSP subregion intersects 18 tributary drainage areas, all of which drain into the Santa Clara River (Figure 2-4). The Santa Clara River extends approximately 5.5 miles east to west across the NRSP subregion. The NRSP subarea comprises 2.9 percent of the Santa Clara River watershed upstream of the Los Angeles/Ventura County Line, 1.1 percent of the total Santa Clara River watershed, and approximately 58 percent of the 20,724-acre tributary drainage area.

The Santa Clara River (SCR) watershed drains an area in the Transverse mountain range of southern California. The SCR flows generally west from its headwaters near Acton to the Pacific Ocean near the City of Ventura, approximately 40 miles downstream of the NRSP subregion. The river exhibits some perennial flow in its eastern-most stretches within the Angeles National Forest then flows intermittently westward within Los Angeles County. The principal tributaries of the upper river watershed in Los Angeles County are Castaic Creek, Bouquet Canyon Creek, San Francisquito Creek, and the South Fork of the Santa Clara River. Placerita Creek is a large tributary draining the western-most end of the San Gabriel Mountains; it joins the South Fork, which flows directly into the Santa Clara River. Castaic Creek is a south-

trending creek that confluences with the Santa Clara River downstream of the City of Santa Clarita. Castaic Lake is a DWR-owned reservoir located on Castaic Creek. San Francisquito Canyon Creek is an intermittent stream in the watershed adjacent to Bouquet Canyon to the southeast. Elevations within the watershed range from sea level at the river mouth to 8,800 feet at the summit of Mount Pinos in the northwest corner of the watershed.

The principal sources of water contributing to the base flow of the Santa Clara River are: (a) groundwater from the Alluvial aquifer basin in Los Angeles County, which seeps into the riverbed near, and downstream of, Round Mountain (located just below the mouth of San Francisquito Creek); (b) tertiary-treated water discharged to the Santa Clara River from two existing Los Angeles County Sanitation District WRPs -- the Saugus WRP, located near Bouquet Canyon Road bridge and the Valencia WRP, located immediately downstream of I-5 (for locations, see Figure 2-1); and (c) in some years, DWR-released flood flows from Castaic Lake into Castaic Creek during winter and spring months (CH2M Hill, 2005). The Saugus Water Reclamation Plant, located near Bouquet Canyon Road bridge, has a permitted dry weather average design capacity of 6.5 million gallons per day (mgd) creating surface flows from the outfall to near Interstate 5. The Valencia Water Reclamation Plant outfall is located immediately downstream of the Interstate 5 bridge and has a permitted dry weather average design capacity of 21.6 mgd, creating surface flows extending through the Project area and into the far eastern portion of Ventura County. The combined average treated discharge from both WRPs between January 2004 and June 2007 was approximately 20 mgd.

The reach of the SCR within and adjacent to the NRSP subregion has multiple channels (braided). This kind of system is characterized by high sediment loads, high bank erodibility, and intense and intermittent runoff conditions. Combined with the relatively flat gradient of the SCR at this point (less than one percent), the SCR has a high potential to aggrade (deposit sediment) at low flow velocities (PACE, 2006).

The following description of the physiography, climate, flows, and vegetation of the Santa Clara River are summarized primarily from Assessment of Potential Impacts Resulting from Cumulative Hydromodification Effects, Selected Reaches of the Santa Clara River, Los Angeles County, California (Balance Hydrologics, provided in Appendix F).

2.2.1.2. Physiography

The Santa Clara River flows through a complex, tectonically-active trough. Some of the most rapid rates of geologically-current uplift in the world are reported from the Ventura anticline and San Gabriel Mountains, just to the northwest and southeast, respectively, of the river. Slopes are very steep, with local relief of 3,000 to 4,000 feet being common. These faults bring harder, more resistant sedimentary rocks over softer and younger sedimentary formations, but all formations are fundamentally soft and erodible. On either side of the faults, sandstone and mudstones prevail. The northeastern and southeastern corners of the watershed are underlain by

deeply-weathered granitic and schistose rocks, which produce sands that are coarser than those of other rock units when they weather and erode. The San Gabriel fault crosses the valley, bringing slightly more resistant rock to the surface and creating a local base level reflected as a slight rise or 'bump' on the river's longitudinal profile.

Most geologic materials in the watershed decompose mainly to silts, clays, and sand, with some coarser materials. Most sediment moved by the Santa Clara River and its main tributaries is fine, with less than 5 percent bedload-sized material (>0.25 mm, or about 0.01 inches in diameter). Some gravels and cobbles do occur within the beds of the stream and in their alluvium. Nonetheless, both the bed and the sediment transported by the river tend to be finer than in most Southern California watersheds.

2.2.1.3. Flows

Downstream of the Valencia WRP, the SCR is perennial past the Los Angeles/Ventura County line to approximately Rancho Camulos. Flows in the SCR can also be affected by groundwater dewatering operations or by diversions for agriculture or groundwater recharge. Throughout the Santa Clara River channel, there are complex surface water/groundwater interactions where both gaining and losing river segments are found. Downstream of the County line, however, the Santa Clara River flows through the Piru groundwater basin, which represents a "Dry Gap" where dry-season surface flows are interrupted and streamflow is lost to groundwater.

The SCR is underlain by several distinct alluvial groundwater basins in Ventura County—the Piru, Fillmore, and Santa Paula Basins. These basins are divided longitudinally by sills or ridges of bedrock that support areas of locally-high (shallow) groundwater, including the area upstream from the County line (above the Piru Basin), and upstream from the mouth of Sespe Creek (the transition between the Piru and Fillmore Basins). This locally-high groundwater sustains summer baseflow and riparian vegetation within the SCR corridor even through relatively dry climatic cycles.

Flows in the SCR, as in most southern California streams, are highly episodic. For the gaged period between 1953 and 1996, annual flow at the Los Angeles/Ventura County line gage ranged between 253,000 acre-feet (1969) and 561 acre-feet (1961). Annual peak flows at the County line between 1953 and 1996 ranged from 68,800 cfs (1969) to 109 cfs (1960). Of note is that the second highest annual peak (32,000 cfs in 1966) was less than half of the highest peak (68,800 in 1969). These large episodic events have a significant impact on the geomorphic characteristics of the Santa Clara River mainstem.

After studying the response of the river to several different anthropogenic and natural disturbances, Balance Hydrologics (2005) concluded that the Santa Clara River, as with many streams in semi-arid southern California, is highly episodic. Concepts of "normal" or "average" sediment-supply and flow conditions have limited value in this "flashy" environment, where

episodic storm and wildfire events have enormous influence on sediment and storm flow conditions. In these streams, a large portion of the sediment movement events can occur in a matter of hours or days. Other perturbations which can potentially affect channel geometry appear to have transitory or minor manifestations. For example, effects on SCR channel width due to the 1980s levee construction was barely discernible by the first few years of the 21st century, probably mostly due to morphologic compensation associated with the storm events in the mid- to late-1990s. As a result, channel morphology, stability, and character of the Santa Clara River is almost entirely determined by the "reset" events that occur within the watershed.

2.2.1.4. Vegetation and Habitat Types

Much of the watershed upstream of the Newhall Ranch Specific Plan area receives rainfall averaging about 18 to 25 inches per year. As throughout Southern California, rainfall in the Santa Clara watershed alternates between wet and dry periods, a variation that is central to understanding the geomorphic history of the watershed. Wet cycles tend to persist for several years, sometimes for periods of 6 or 8 years, during which rainfall, although variable, may average about 140 to 150 percent of the long-term average. For the woody riparian vegetation along the banks and on islands in the braided channels, these are crucial periods for establishment and growth. During dry cycles, the roots of the riparian vegetation must grow downward to the water table or perched zones, and where it cannot do so, this band of vegetation will die back.

The existing SCR channel contains a variety of vegetation types (Impact Sciences, 2003). The active SCR channel is mostly barren due to scouring by seasonal storm flows. However, vegetation types on the adjacent terraces vary based on elevation relative to the active channel bottom and the frequency of flooding. The following series of vegetation types occur along a vertical gradient from the channel bottom to the highest SCR terrace on the floodplain: emergent herbaceous, woody shrubs, and trees.

The Santa Clara River corridor at the NRSP site supports three general categories of habitat (Impact Sciences, 2003): (1) aquatic habitats, consisting of flowing or ponded water; (2) wetland habitats, consisting of emergent herbs rooted in ponded water or saturated soils along the margins of the active channel; and (3) riparian habitat, consisting of woody vegetation along the margins of the active channel and on the floodplain. Both year-round and seasonal aquatic habitats are provided and are subject to periodic disturbances from winter flood flows. These flows inundate areas that are dry most of the year. They also carry and deposit sediment, seeds, and organic debris; form new sandbars and destroy old ones; and erode stands of vegetation. New stands of vegetation are created where vegetation becomes established by seeds or buried stems. Thus, the aquatic habitats of the river are in a constant state of creation, development, disturbance, and destruction.

2.2.2. Santa Clara River Reaches

The SCR is divided into reaches for purposes of establishing beneficial uses and water quality objectives (Figure 2-5). However, there are two reach classifications, one established by the Los Angeles Regional Water Quality Control Board (LARWQCB), and one established by the United States Environmental Protection Agency (USEPA). Both of these reach classifications are used by the LARWQCB and the USEPA in various documents, which at times is a source of confusion. This report will use the LARWQCB reach numbers.

Table 2-2 lists the LARWQCB and USEPA reaches, respectively. Figure 2-5 illustrates both reach designations. The reach boundaries are mostly identical in the two classifications, except that the third and fourth LARWQCB Reaches are each subdivided into two reaches in the USEPA reach designation. The NRSP subregion is located along LARWQCB Reach 5 (USEPA Reach 7).

Table 2-2: LARWQCB Santa Clara River Reaches

LARWQCB Reach	Corresponding USEPA Reach	Boundary Description
1	1	Santa Clara Estuary to Highway 101
2	2	Highway 101 to Freeman diversion dam
3	3 & 4	Freeman diversion dam to Fillmore “A” Street
4	5 & 6	Fillmore “A” St to Blue Cut gaging station
5	7	Blue Cut gaging station to West Pier Highway 99 (NRSP Subregion Location)
6	8	West Pier Highway 99 to Bouquet Canyon Road
7	9	Bouquet Canyon Road to Lang gaging station
8	10	Above Lang gaging station

2.2.3. Santa Clara River Tributaries

The existing drainages within the subregion consist of Castaic Creek and the drainage courses of: Chiquito Canyon; San Martinez Grande Canyon; Homestead Canyon; Off-Haul Canyon; Mid-Martinez Canyon; Middle Canyon; Magic Mountain Canyon; Dead End Canyon; Exxon Canyon; Lion Canyon; Humble Canyon; Long Canyon; Ayers Canyon; Potrero Canyon; Salt Creek Canyon; and other unnamed drainage courses tributary to the Santa Clara River (Figure 2-4). Combined, the tributary drainage watersheds comprise 20,724 acres, 11,963 acres of which are within the NRSP subregion boundary. The drainage watersheds are located within an area that is generally delineated by SR-126 and lower portions of San Martinez Grande and Chiquito Canyons on the north, the Magic Mountain Theme Park on the east, the crest of the Santa Susana Mountains on the south, and the Los Angeles/Ventura County line on the west.

With the exception of drainage crossings under SR-126, all of the tributaries within the NRSP subregion boundary are unimproved. Each of the tributaries have been mapped as blue-line streams by the U.S. Geologic Survey (USGS). While it is the intent of the USGS to indicate that blueline streams are flowing perennial streams, in arid states such as California, and particularly in Southern California, this is not always the case. For example, the blueline stream in upper Potrero Canyon contains water only during the rainy periods; during non-rainy periods this stream contains no water and is an ephemeral drainage. Aside from the lower portions of Salt and Potrero Canyons, each of the tributaries within the NRSP subregion is classified as an intermittent or ephemeral drainage[2] (URS, 2006).

Post-developed stormwater runoff will flow to four of the tributary drainages within the NRSP subregion boundary: Chiquito Canyon, San Martinez Grande Canyon, Long Canyon, and Potrero Canyon. Middle Canyon, Magic Mountain Canyon, Homestead Canyon and other small ephemeral drainages located within the Newhall Ranch area will be incorporated into the storm drain system in the post-development condition (Figure 2-3). The tributary drainages are described below.

The majority of the tributaries' watersheds are characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem drainage. Approximately 90 percent or more of the watersheds' area consists of rugged foothill topography with the remainder being the narrow valley floor. Generally, the soils in the watersheds are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the watersheds can be predominately classified as being in hydrologic soil group C (higher runoff potential) with exception of areas adjacent to the main stem drainages that are Type A (lower runoff potential) and Type B in the lower reaches.

The 4.85 square mile (3,106 acre) Chiquito Canyon watershed is a tributary to the northern bank of the Santa Clara River. Approximately 490 acres of Chiquito Canyon, or only 16% of the watershed area, is located within the NRSP boundary, with the majority being upstream of the NRSP boundary in the developed Val Verde community (PACE, 2006). The upper portion of the drainage is aligned in a general west to east direction while the lower portion of the drainage flows in a north to south direction. The linear distance from the upper headwaters to the canyon mouth is approximately 28,318 feet, with an average overall slope of 0.031. The major natural main stem drainage course within the watershed has an average slope through the NRSP area of approximately 0.025. The topography for the watershed varies from a maximum elevation of 1,800 feet in the headwaters to a low elevation of 925 feet near the mouth of the canyon at the Santa Clara River valley. The area surrounding the upper channel in Chiquito Canyon within the

[2] Intermittent drainages carry flows due to seasonal high groundwater in addition to storm flows, while ephemeral drainages flow only in response to storm events.

Newhall Ranch project area is primarily comprised of agricultural land (URS, 2003). In contrast to the vegetation found in the upper portion of Chiquito Canyon within the project area, the vegetation found in the downstream portion of the drainage within the project area is quite diverse, supporting scalebroom scrub, coast live oak woodlands, and Great Basin scrub.

The 0.16 square mile (105 acre) Mid-Martinez Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 67 acres of the watershed or 64% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general north to south direction, similar in alignment to Grande Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 6,803 feet with an average overall slope of 0.07. The majority of the Mid-Martinez Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Zamora Loam. Also, the soils within the Mid-Martinez Canyon watershed can be predominately classified as being in hydrologic soil group B (lower runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub and agriculture.

The four square mile (2,569 acre) San Martinez Grande Canyon watershed is also tributary to the northern bank of the Santa Clara River. Approximately 473 acres of San Martinez Grande Canyon, or only 18% of the watershed area, is located within the NRSP boundary, with the majority being upstream of the NRSP boundary. The drainage in the headwaters is aligned in a general west to east direction, while the lower portion of the drainage flows in a north to south direction, similar in alignment to Chiquito Canyon. The linear distance from the upper headwaters to the canyon mouth is approximately 20,000 feet, with an average overall slope of 0.059 (PACE, 2006). The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed of approximately 0.022. The topography for the watershed varies from a maximum elevation of 2,062 feet in the headwaters to a low elevation of 890 feet near the mouth of the canyon at the Santa Clara River. The San Martinez Grande watershed contains a diverse variety of habitats including Great Basin scrub, mule fat scrub, coastal sage scrub, and some grassland (URS, 2003). Two small patches of elderberry scrub exist near the northern boundary of the project footprint. The area just upstream of the Santa Clara River confluence is dominated by arrow weed scrub. San Fernando Valley spineflower was also found to be present within this watershed. The northern, upstream reaches of the drainage are dominated by coastal sage scrub on the west bank, and by grassland on the east. The channel then flows through areas of alluvial scrub and coastal sage scrub, and through agricultural fields to the Santa Clara River.

The 0.92 square mile (587 acre) Off-Haul Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 470 acres of the watershed or 80% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general north to south direction, similar in alignment to Grande Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon

mouth is approximately 9,094 feet with an average overall slope of 0.12. The majority of the Off-Haul Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic-Balcom silty clay loams. Also, the soils within the Off-Haul Canyon watershed can be predominately classified as being in hydrologic soil group C (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California annual grassland and agriculture.

The 0.12 square mile (75 acre) Homestead Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 75 acres of the watershed or 100% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general north to south direction, similar in alignment to San Martinez Grande Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 3,606 feet with an average overall slope of 0.65. The majority of the Homestead Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic-Balcom silty clay loams. Also, the soils within the Homestead Canyon watershed can be predominately classified as being in hydrologic soil group C (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California annual grassland and agriculture.

The 1.32 square mile (847 acre) Magic Mountain Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 178 acres of the watershed or 27% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general south to north direction and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 13,700 feet with an average overall slope of 0.02. The majority of the Magic Mountain Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic and Saugus soils and Castaic-Balcom silty clay loams. Also, the soils within the Magic Mountain Canyon watershed can be predominately classified as being in hydrologic soil group C (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub and disturbed land.

The 0.53 square mile (340 acre) Middle Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 272 acres of the watershed or 80% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 9,952 feet with an average overall slope of 0.05. The majority of the Middle Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic-Balcome silty clay loams. Also, the soils within the Middle Canyon watershed can be predominately classified as being in

hydrologic soil group C (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub and disturbed land.

The 0.19 square mile (124 acre) Dead-End Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 124 acres of the watershed or 100% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 3,173 feet with an average overall slope of 0.13. The majority of the Dead-End Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic-Balcom silty clay loams. Also, the soils within the Dead-End Canyon watershed can be predominately classified as being in hydrologic soil group C (high runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub and disturbed land.

The 0.03 square mile (16 acre) Exxon Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 16 acres of the watershed or 100% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 1,876 feet with an average overall slope of 0.22. The majority of the Exxon Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Saugus loam. Also, the soils within the Exxon Canyon watershed can be predominately classified as being in hydrologic soil group B (lower runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub and disturbed land.

The 1.8 square mile (1,124 acre) Lion Canyon watershed is tributary to the southern bank of the Santa Clara River. Approximately 859 acres of Lion Canyon, or 76% of the watershed area, is located within the NRSP boundary, with the remainder being upstream in the Legacy Village subregion (see Figure 2-1). The drainage in the headwaters is aligned in a general southwest to northeast direction. The distance from the upper headwaters to the canyon mouth is approximately 7,900 lineal feet with an average overall slope of 0.057 (PACE, 2006). The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed of approximately 0.049. The topography for the watershed varies from a maximum elevation of 1,400 feet in the headwaters to a low elevation of 946 feet near the mouth of the canyon at the Santa Clara River valley. The upper reaches of the Lion Canyon watershed, which contains several branches, contains mostly mixed chaparral and coastal sage scrub habitat (URS, 2003). Along the channel, alluvial scrub, live oak woodland, grassland, scalebroom scrub, and chamise chaparral are present. The two easternmost branches of this drainage also contain great basin scrub, which is absent from the watershed of the western branch.

The 0.41 square mile (261 acre) Humble Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 253 acres of the watershed or 97% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 5,919 feet with an average overall slope of 0.10. The majority of the Humble Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic and Saugus soils. Also, the soils within the Humble Canyon watershed can be predominately classified as being in hydrologic soil group C (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of agriculture and chaparral.

The two square mile (1,295 acre) Long Canyon watershed is also tributary to the southern bank of the Santa Clara River. Approximately 845 acres of Long Canyon, or 65% of the watershed area, is located within the NRSP boundary, with the remainder being upstream in the Legacy Village subregion (see Figure 2-1). The drainage in the headwaters is aligned in a general west to east direction. The distance from the upper headwaters to the canyon mouth is approximately 18,350 lineal feet, with an average overall slope of 0.052 (PACE, 2006). The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed of approximately 0.11. The topography for the watershed varies from a maximum elevation of 2,600 feet in the headwaters to a low elevation of 930 feet near the mouth of the canyon at the Santa Clara River valley. Both sides of this watershed contain habitat types comprised primarily of coastal sage scrub, with small pockets of chamise chaparral, and grassland present (URS, 2003). Within the stream channel, there is a mixture of grassland, elderberry scrub, live oak woodland, alluvial scrub, great basin scrub, mixed chaparral, and alluvial scrub.

The 0.2 square mile (147 acre) Ayres Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 147 acres of the watershed or 100% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Potrero Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 6,972 feet with an average overall slope of 0.01. The majority of the Ayres Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Castaic and Saugus soils. Also, the soils within the Ayres Canyon watershed can be predominately classified as being in hydrologic soil group B/C (moderate runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of California sagebrush scrub (black sage) and agriculture.

The 4.7 square mile (3,034 acre) Potrero Canyon watershed is also tributary to the southern bank of the Santa Clara River. Approximately 2,643 acres of Long Canyon, or 87% of the watershed

area, is located within the NRSP boundary, with the remainder being upstream in the Legacy Village subregion. The lower Potrero Canyon drainage extends approximately 18,270 feet upstream from the canyon mouth at the Santa Clara River valley to the NRSP boundary. The geomorphology of the active drainage reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features (PACE, 2006). There is also a steady variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel, with the active portion of the drainage being more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active drainage banks and there is little overbank flow. The changes in drainage geometry and form may indicate influences from the upper watershed that affect the sediment delivery. The changes in channel geometry are also reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.024. The average slopes ranges from 0.055 in the contraction to 0.011. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. Habitat types in the Potrero Canyon drainage are comprised primarily of grassland and coastal sage scrub, although a wide variety of habitat is represented (URS, 2003). Live oak woodland, mule fat scrub, great basin scrub, mesic meadow, elderberry scrub, and valley oak woodland are all present within the Potrero watershed, along with agricultural land.

The 9.2 square mile (5,859 acre) Salt Creek Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 3808 acres of the watershed or 65% of the watershed area is located within the Newhall Ranch property boundary. The creek flows in a general east to west direction, similar in alignment to Potrero Canyon and joining the Santa Clara River floodplain valley. The distance from the upper headwaters to the canyon mouth is approximately 205,701 feet with an average overall slope of 0.10. The majority of the Salt Creek Canyon watershed is characterized by both rugged and steeply developed foothills. Generally, the soils in the watershed are characterized as Gaviota rocky sandy loam. Also, the soils within the Salt Creek Canyon watershed can be predominately classified as being in hydrologic soil group C/D (higher runoff potential). The associated vegetative cover within the watershed varies, but primarily consists of burned California sagebrush scrub and burned chaparral.

2.2.4. Receiving Water Beneficial Uses

The Water Quality Control Plan for the Los Angeles Region (Basin Plan) (LARWQCB, 1994, as amended) lists beneficial uses of major water bodies within this region (Table 2-3). The Santa Clara River Reach 5 is listed and has specific beneficial uses assigned to it. As identified in Table 2-3, the existing beneficial uses of Santa Clara River Reach 5 include the following:

- MUN*: Conditional potential municipal and domestic water supply

- IND: Industrial activities that do not depend primarily on water quality
- PROC: Industrial activities that depend primarily on water quality
- AGR: Agricultural supply waters used for farming, horticulture, or ranching
- GWR: Groundwater recharge for natural or artificial recharge of groundwater
- FRSH: Natural or artificial maintenance of surface water quantity or quality
- REC1: Water contact recreation involving body contact with water and ingestion is reasonably possible
- REC2: Non-contact water recreation for activities in proximity to water, but not involving body contact
- WARM: Warm freshwater habitat to support warm water ecosystems
- WILD: Wildlife habitat waters that support wildlife habitats
- RARE: Waters that support rare, threatened, or endangered species and associated habitats
- WET: Wetland ecosystems

Table 2-3: Beneficial Uses of Surface Receiving Waters

Water Body	MUN	IND	PROC	AGR	GWR	FRSH	REC1	REC2	WARM	WILD	RARE	WET[1]
Santa Clara River (Hydrologic Unit 403.51)	P*	E	E	E	E	E	E	E	E	E	E	E

[1]Waterbodies designated as WET may have wetlands habitat associated with only a portion of the waterbody. Any regulatory action would require a detailed analysis of the area.
E – Existing beneficial use; P * – Asterixed MUN designations are conditional potential MUN designations[3].
Source: Water Quality Control Plan for the Los Angeles Region (Basin Plan) (LARWQCB, 1994, as amended)

[3] On December 5, 2001, the U.S. Federal District Court issued an order that effectively invalidated EPA's requirement that the asterisked MUN designated uses (MUN* uses) in the Los Angeles Basin Plan be immediately enforced. See Order granting plaintiffs' motion for summary judgment and remanding action to EPA, No. CV 00-08919 R(RZx), City of Los Angeles et al. v. United States Environmental Protection Agency…, dated December 18, 2001. See also letter dated February 15, 2002, from Alexis Strauss, USEPA Region IX, to Celeste Cantu, Executive Director, California SWRCB: "…waters identified with an ("*") in Table 2-1 do not have an MUN as a designated use until such time as the State undertakes additional study and modifies its Basin Plan." EPA also stated that this conditional use designation has no legal effect.

2.3. Existing Surface Receiving Water Quality

Due to the size of the study area and the highly variable nature of wet weather surface water quality in the Santa Clara River throughout the study area, it was not appropriate to summarize water quality data for a single timeframe or location in order to establish baseline water quality conditions. As discussed above, flows in the Santa Clara River are highly episodic in nature and this characteristic can affect surface water quality considerably. The data summarized below, however, is recent and provides an accurate and reasonable characterization of existing water quality conditions that exist in the Project area. Data collected by the USGS at the Ventura/Los Angeles County line also summarized below provides historical perspective of water quality within the Santa Clara River at the downstream Project boundary.

Wet and dry weather surface water quality in the Project area was characterized from available water quality monitoring data obtained from the following four sources:

1. Newhall Ranch Tributary Stormwater Monitoring. Two storm events in March 2000 were monitored by the Newhall Ranch in five tributaries to the Santa Clara River within the NRSP area: Potrero Canyon, Long Canyon, San Martinez Grande Canyon, Middle Canyon, and Chiquito Canyon. Although limited, this data is relevant in terms of characterizing the existing stormwater runoff within the Santa Clara River tributaries within the NRSP area as the conditions within these watersheds have not been altered since 2000. Four of the five tributaries (all but Middle Canyon) will receive post-developed flows from the NRSP area.

2. Newhall Ranch WRP. The Newhall Ranch is required by the LARWQCB to conduct pre-startup water quality monitoring at upstream and downstream locations from the outfall of the approved Newhall Ranch WRP for the Newhall Ranch WRP individual NPDES Permit and Waste Discharge Requirements (WDRs) application. Summarized wet weather monitoring data were collected from two stations in the Santa Clara River from the spring of 2004 until the spring of 2006: one station is near the downstream boundary of the NRSP area near to the proposed WRP outfall location, and the second is about 2.5 miles further downstream.

3. LA County Monitoring. The County of Los Angeles conducts in-stream water quality monitoring on the mainstem of the Santa Clara River at a mass emission station located at The Old Road, at the upstream boundary of the Project area. Wet weather monitoring data are available from November 2002 through February 2007. The Los Angeles County monitoring data are the most current and are the only source of wet weather monitoring in the Santa Clara River immediately upstream of the NRSP area.

4. USGS Monitoring. The USGS collected a large number of water quality data in the Santa Clara River near the Ventura/Los Angeles County line from 1951 through 1995.

These data provide a historical perspective of wet weather water quality in the Santa Clara River immediately downstream of the NRSP area.

2.3.1. Wet Weather Water Quality Monitoring

2.3.1.1. Wet Weather Monitoring Locations and Rainfall Conditions

NRSP Area Stormwater Monitoring. Newhall Land conducted stormwater monitoring of tributary streams in the NRSP area to characterize the existing surface water quality during wet weather conditions (the monitoring data is provided in Appendix C). Stormwater samples were collected during two storm events in March 2001 at five monitoring locations (Stations A-E) shown on Figure 2-1. Three of the five monitoring stations were located at the mouths of SCR tributaries in Potrero Canyon (Sta. A), San Martinez Grande Canyon (Sta. B), and Middle Canyon (Sta. D). The other two monitoring stations were located on tributaries upstream from the mainstem of the SCR; one was just downstream of the community of Val Verde in Chiquito Canyon (Sta. E) and one was on an unnamed tributary in Long Canyon, ¼ mile upstream of the 'Onion Field' (Sta. C). Aside from Station E, which is downgradient of existing residential development, the land uses in the areas tributary to the Stations A, B, C, and D are predominately open space with some agriculture and oil and gas operations.

Table 2-4 lists the rainfall depth and duration of the two monitored storm events. The first storm was a small event (0.2 inches) that was likely just large enough to result in stormwater runoff. The depth of the second event was larger and slightly larger than the median storm depth (0.6 inches) at the nearby National Climatic Data Center (NCDC) Newhall rain gauge (see location on Figure 2-1). The median depth of 0.6 inches is based on a storm event analysis which identified 543 storms exceeding 0.1 inches that occurred from October 1968 to December 2006. The average storm duration in the 38-year Newhall gage rainfall record is 11.3 hours.

Table 2-4: Depth and Duration of Storms Monitored at Project Site

Date	Depth (in)[1]	Duration (hours)[1]
03/06/01	0.2	3
03/08/01	0.7	10

[1] Based on rainfall measured at the Newhall rain gauge.

Newhall Ranch WRP Pre-Startup Monitoring. Newhall Land has conducted pre-startup receiving water quality monitoring for the approved Newhall Ranch WRP (Newhall, 2006) at two locations in the SCR (see Figure 2-1):

- NR1 is located in the SCR 300 feet upstream of the WRP outfall location, and

- NR3 is located in the SCR approximately 7,500 feet downstream of the WRP outfall.

Five storms with rainfall depths ranging from 0.1 to 0.6 inch were sampled at NR1 and NR3 and one very large storm with a depth of 4.45 inches was sampled at NR3 (Table 2-5). Grab sampling methods were used.

Table 2-5: Depth and Duration of Storms Monitored for Newhall Ranch WRP

Date	Storm Depth (in)	Duration (hours)
12/07/04[(1)]	0.12	6
2/17/05[(2)]	0.60	12
2/18/05 [(2)]	4.45	12
11/9/05[(1)]	0.12	6
11/10/05[(2)]	0.20	1
2/17/06[(1)]	0.32	7

[1]Depth and duration measured at the Newhall rain gauge, [2] Estimated due to lack of gage data

LA County Department of Public Works Monitoring Data. The Los Angeles County Department of Public Works (LACDPW) has conducted dry and wet weather monitoring in the Santa Clara River for five wet seasons - from 2002 through 2007 (LACDPW, 2003 - 2007). The monitoring station (S29) is located in the Santa Clara River at The Old Road (Figure 2-1). It is approximately two miles upstream from the eastern boundary of the NRSP area. The monitoring station is downstream of the Saugus Water Reclamation Plant and the City of Santa Clarita and upstream of the Valencia Water Reclamation Plant. The monitoring station is intended to provide long-term information about water quality trends in areas with heterogeneous land uses and has a tributary area of 411 square miles.

Monitoring at the mass emission station included nineteen storm events. Composite samples were collected for most parameters, except grab sampling was used for bacteria, oil and grease, and cyanide analyses. The Santa Clara River Station is not automated so composite samples were obtained by sampling discretely every twenty minutes for the first three hours of the storm, and then mixing the discrete samples in the laboratory in proportion to the measured flow rates. Table 2-6 lists the rainfall depths and durations of the nineteen monitored storm events based on hourly rainfall measurements at the Newhall rain gage. The depth of eight of the ten storms was greater than the median storm depth for the Newhall rain gage (0.60 inches). In particular, storm events beginning on 2/11/03 and 1/7/05 were very large events, with total storm depths of 8.0 and 9.99 inches, respectively.

Table 2-6: Depth and Duration of Storms Monitored by LACDPW at S29

Date	Depth (inches)[1]	Duration (hours)[1]
11/8/02	1.6	21
12/16/02	1.9	5
2/11/03	8.0	32
3/15/03	2.0	16
10/31/03	0.30	4
12/25/03	1.80	14
1/2/04	0.4	9
10/17/04	0.64	7
10/26/04	2.22	13
1/7/05	9.99	92
10/17/05	1.61	14
12/31/05	0.6	4
1/14/06	0.08	2
2/17/06	0.32	7
12/9/06	0.47	2
12/16/06	0.12	2
1/30/07	0.44	16
2/19/07	0.24	5
2/22/07	0.32	3

[1] Based on rainfall measured at the Newhall rain gage

USGS Water Quality Monitoring Data. The US Geological Survey (USGS) has collected stream flow and water quality data at a number of locations in the SCR watershed (http://waterdata.usgs.gov/nwis). Among the largest data sets are flow and water quality data collected at USGS station 11108500 located on the Santa Clara River just downstream of the Los Angeles / Ventura County Line. This station is located approximately one mile downstream of the NRSP area (Figure 2-1), and downstream of both existing Water Reclamation Plants. The USGS collected water quality data between April 1951 and October 1995, probably using depth integrated sampling. These data thus provide a historical perspective of water quality in the SCR within the NRSP area.

Data presentation. To facilitate interpretation, the wet weather water quality data were grouped into two categories depending on the depth of 2-day antecedent rainfall measured at the Newhall rain gauge:

1. ***0.1 – 1 inches***. Rainfall depths that would likely produce runoff volumes characteristic of more frequent, smaller storm events.

2. ***> 1 inch***. Rainfall depths that would likely produce runoff volumes characteristic of larger, less frequent storm events.

2.3.1.2. Selected General Constituents

The selected general constituents examined were total suspended solids (TSS), total dissolved solids (TDS), hardness, and chloride (see Section 4 for a discussion of pollutant selection). TSS is a measure of the particulate matter suspended in water. Total dissolved solids (TDS) are a measure of the dissolved cations and anions, primarily inorganic salts (calcium, magnesium, potassium, sodium, chlorides and sulfates). TDS is an impairing pollutant in Reach 3 of the SCR as listed in the State's 2006 303(d) list of impaired water bodies. High TDS levels can impair agricultural, municipal supply, and groundwater recharge beneficial uses.

Hardness and chloride are important components of TDS. Hardness is a measure of the polyvalent cations, primarily calcium and magnesium. It is expressed as an equivalent concentration of calcium carbonate ($CaCO_3$). Hardness measurements are important because the toxicity of metals (and the associated water quality objectives) decreases as hardness increases. Chloride comprises a large proportion of the TDS. High levels of chloride in Santa Clara River Reaches 3, 5, and 6 are causing impairment of listed beneficial uses for agricultural irrigation. Irrigation of salt sensitive crops, such as avocados and strawberries, with water containing elevated levels of chloride can result in reduced crop yields

Results for concentrations of TSS, TDS, chloride, and hardness for the four datasets are listed in Tables 2-7 through 2-10. Rather than measuring TDS, the USGS station has recorded specific conductance (that is, the extent to which the sample conducts an electric current), which is related to TDS concentration. TDS concentration can be estimated as 0.55 to 0.9 times the specific conductance (Sawyer et al, 1994).

Table 2-7: Average Concentrations of Selected Constituents from Newhall Ranch Tributary Stormwater Monitoring, March 2001

Constituent	Site A Mouth of Potrero	Site B Mouth of San Martinez Grande	Site C Long Canyon Upstream of Onion Field	Site D Mouth of Middle Canyon	Site E Middle of Chiquito
TSS (mg/L)	835	41,100	36,000	5,650	6,645
TDS (mg/L)	7,380	2,825	190	160	205
Hardness (mg/L as $CaCO_3$)	2,225	1,205	147	59	107
Chloride (mg/L)	870	125	3	3	11

Table 2-8: Newhall Ranch WRP Startup Wet Weather Water Quality Data for Selected General Constituents in the Santa Clara River, 2004 - 2006

Constituent	2-day Antecedent Rainfall (inches)	Sample Site	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
TSS	0.1 – < 1.0	NR1	5	5	32	107	58
		NR3	5	5	32	235	112
	≥ 1.0	NR3	1	1	-	-	43,360
TDS	0.1 – < 1.0	NR1	5	5	622	1,136	855
		NR3	5	5	698	2,020	1,076
	≥ 1.0	NR3	1	1	-	-	2,100
Hardness (mg/L as $CaCO_3$)	0.1 – < 1.0	NR1	5	5	304	464	387
		NR3	5	5	352	670	475
	≥ 1.0	NR3	1	1	-	-	832
Chloride	0.1 – < 1.0	NR1	2	2	84	117	100
		NR3	2	2	89	121	105
	≥ 1.0	NR3	1	1	46	46	46

- = no or insufficient data

Table 2-9: LACDPW Stormwater Monitoring for Selected General Constituents at the SCR Mass Emission Station (S29), 2002 -2007

Constituent	2-day Antecedent Rainfall (in)	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
TSS	0.1 – < 1.0	11	11	135	2,202	845
	≥ 1.0	8	8	53	6,591	1,635
TDS	0.1 – < 1.0	11	11	174	732	458
	≥ 1.0	8	8	28	364	216
Hardness	0.1 – < 1.0	11	11	90	428	249
	≥ 1.0	8	8	15	170	108
Chloride	0.1 – < 1.0	11	11	17	118	68
	≥ 1.0	8	8	3	52	24

Table 2-10: USGS Water Quality Data for Selected General Constituents in the Santa Clara River at the County Line, 1951 – 1995

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum	Maximum	Average
TSS (mg/L)	0.1 – < 1.0	10	10	248	4,730	2,291
	≥ 1.0	41	41	107	51,200	10,711
Specific Conductance (uS/cm)	0.1 – < 1.0	33	33	831	4,220	2,246
	≥ 1.0	42	42	637	3,240	1,309
Hardness (mg/L)	0.1 – < 1.0	27	27	270	1,500	773
	≥ 1.0	37	37	250	1,200	546
Chloride (mg/L)	0.1 – < 1.0	34	34	21	290	122
	≥ 1.0	39	39	14	192	61

TSS. It is generally expected that TSS concentrations in alluvial streams can be greatly elevated during storm runoff because of the combination of high sediment supply and a high capacity for instream transport and erosion. TSS concentrations in Table 2-7 to 2-10 are sometimes very high, due to the highly erodible, easily transportable, sandy alluvial soils and sediments. High TSS concentrations were measured at some of the tributary canyons (Table 2-7), and were also observed in the SCR (Table 2-9 and Table 2-10). These later results show the capacity of high flows in the Santa Clara River for sediment transport and are consistent with other data showing that large rainfall events result in a “reset” of the main channel. As concluded by Balance Hydrologics (2005), concepts of “normal” or “average” sediment-supply and flow conditions have limited value in this “flashy” environment, where episodic storm and wildfire events have

enormous influence on sediment and storm flow conditions. In the Santa Clara River, a large portion of sediment movement events can occur in a matter of hours or days.

Average and maximum concentrations are much higher for the larger storms than the smaller storms. The average TSS concentrations for the larger storms were greater at the lower SCR sites (NR-1, NR-3, USGS) than at the upstream LACDPW Mass Emission Station. This may reflect the difference in sampling techniques (grab sample versus composite sample), and/or occasionally large inputs of TSS from tributaries, such as some of those draining through the NRSP area (Table 2-7). It may also reflect a lower river bed gradient (and hence better settling characteristics) of the SCR near the LACDPW station.

TDS. Stormwater monitoring data collected in the NRSP tributaries (Table 2-7) show greatly differing TDS levels among the five monitoring stations. Measured TDS concentrations were very high at Sites A and B, while TDS concentrations at the other three sites were low. Elevated TDS levels in runoff at Site A and B are likely a result of the natural soil properties of the marine layers of the Pico formation, and the high groundwater table conditions in these two canyons, suggesting that groundwater discharges to the channels contributed to the elevated TDS levels. These greatly differing dissolved solid (TDS) concentrations are also reflected in some of the components that make up the TDS (chloride and hardness) as described below.

Average concentration of TDS in the Santa Clara River were moderate to high, ranging from 216 mg/L to 2,100 mg/L. The Basin Plan objective for TDS in Santa Clara River Reach 5 is 1,000 mg/L. Using an estimate of 0.64 times the specific conductance for the USGS data, the TDS concentrations at this station averaged around 1,400 mg/L for storm flows. Much higher average concentrations were observed at the three downstream SCR stations (NR-1, NR-3, USGS) compared with the upstream LACDPW station, and this could be due to their location downstream of Potrero Canyon and San Martinez Grande Canyon (Sites A and B), with their much higher TDS content.

Hardness. Hardness is a measure of the multivalent metallic cations in water, principally calcium, magnesium, strontium, iron, and manganese (Sawyer et al, 1994). These cations are capable of reacting with soap to form precipitates and with certain anions to form scale. The hardness in water is derived largely from contact with soil and rock formations, and affects the CTR values for certain metals as discussed above. Waters with a hardness concentration from 150 mg/L to 300 mg/L as CaCO3 are considered hard; waters with a hardness concentration above 300 mg/L as CaCO3 are considered very hard.

The stormwater monitoring data for hardness were analogous to the data for TDS. Hardness concentrations were very high at the tributary Sites A and B, and low to moderate at the other three tributary sites. High hardness at Sites A and B are likely due to natural high levels of calcium and magnesium in the local soils (such as lime and gypsum deposits), and the high

groundwater table conditions in these two canyons, suggesting again that groundwater discharges contributed to the elevated hardness levels.

In the SCR, average hardness values were greater downstream (NR3, NR1, USGS sites – Table 2-8 and 2-10) than at the LACDPW station (Tables 2-9). This is most likely due to the influence of tributary inflows of high hardness waters (such as measured at Sites A and B – Table 2-6), other groundwater inputs, and agricultural return flows that enter the Santa Clara River between these stations. However, the magnitude of hardness concentrations was somewhat inconsistent, with the USGS station (Table 2-10) showing higher average hardness concentrations than those measured at NR-1 and NR-3 (Table 2-8) in the smaller storms, but the opposite in the larger storms.

Except for at NR1 and NR3, the average hardness concentration decreased with larger antecedent rainfall depth, as was found for TDS concentrations.

Chloride. Similar to TDS and hardness, monitoring data collected in the NRSP tributaries (Table 2-7) found very high chloride concentrations at Site A, high levels at Site B, and low concentrations at the remaining three sites.

As with the other dissolved ionic parameters (TDS and hardness), the average chloride concentrations at the LACDPW station (Table 2-9) were lower than those measured at downstream sites (NR1, NR3, USGS – Table 2-8 and 2-10). As described previously, this is likely due to differences in salt content of local soils.

Overall, the average chloride concentrations during recent stormwater monitoring were highly variable and ranged between 3 mg/L and 125 mg/L, with the exception of the very high chloride concentrations detected at the mouth of Potrero Canyon (Site A). Average chloride concentration at the USGS station was about 61 mg/L for storm flows. The average chloride concentration observed in the larger storms at all of the SCR stations were lower than the Basin Plan objective for chloride of 100 mg/L, while the average chloride concentrations in the smaller storms were above the Basin Plan objective at the downstream monitoring stations.

2.3.1.3. Nutrients

The major nutrients nitrogen and phosphorus are described here. Phosphorus was measured as total phosphorus (TP) and sometimes as dissolved phosphorus. Dissolved phosphorus is the more bioavailable form of phosphorus compared to TP, which is often made up of a high proportion of particulate phosphorus. Nitrogen is measured variously as nitrate, nitrite, ammonia, and total Kjeldahl nitrogen (TKN). TKN is the measure of ammonia plus the organic forms of nitrogen. Nitrate, nitrite, and ammonia are the more bioavailable forms of nitrogen, and of these, nitrate (or nitrate + nitrite) has the higher concentration in natural waters and is more important than ammonia as a nutrient. Tables 2-11 through 2-14 summarize available data

for these nutrients. Only nitrate was measured in the Newhall Ranch Tributary Stormwater Monitoring.

Table 2-11: Average Concentrations of Nitrate from Newhall Ranch Tributary Stormwater Monitoring, March 2001

Constituent	Site A Mouth of Potrero	Site B Mouth of San Martinez Grande	Site C Long Canyon Upstream of Onion Field	Site D Mouth of Middle Canyon	Site E Middle of Chiquito
Nitrate + Nitrite-N (mg/L)	17.5	3.0	1.6	15.3	2.8

Table 2-12: Newhall Ranch WRP Pre-Startup Wet Weather Water Quality Data for Selected Nutrients in the Santa Clara River, 2004 - 2006

Constituent	2-day Antecedent Rainfall (inches)	Sample Site	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Total Phosphorus	0.1 – < 1.0	NR1	5	5	0.4	0.5	0.4
		NR3	5	5	0.3	0.7	0.4
	≥ 1.0	NR3	1	1	13.4	13.4	13.4
Nitrate as N	0.1 – < 1.0	NR1	5	5	1.9	4.8	3.2
		NR3	5	5	2.3	3.7	3.0
	≥ 1.0	NR3	1	1	1.4	1.4	1.4
Nitrite as N	0.1 – < 1.0	NR1	5	0	<0.005	<0.005	-
		NR3	5	0	<0.005	<0.005	-
	≥ 1.0	NR3	1	0	<0.005	<0.005	-
Ammonia as N	0.1 – < 1.0	NR1	5	4	<0.005	0.3	0.2
		NR3	5	5	0.02	0.1	0.1
	≥ 1.0	NR3	1	1	0.5	0.5	0.5
TKN as N	0.1 – < 1.0	NR1	5	4	<0.04	0.7	0.3
		NR3	5	4	<0.04	0.6	0.4
	≥ 1.0	NR3	1	1	46.0	46.0	46.0

- = no or insufficient data

Table 2-13: LACDPW Stormwater Monitoring of Selected Nutrients at the SCR Mass Emission Station (S29), 2002-2007

Constituent	2-day Antecedent Rainfall (in)	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved Phosphorus	0.1 – < 1.0	11	11	0.17	0.43	0.24
	≥ 1.0	8	8	0.10	0.45	0.26
Total Phosphorus	0.1 – < 1.0	11	11	0.37	1.17	0.60
	≥ 1.0	8	8	0.18	0.84	0.42
Nitrate-N	0.1 – < 1.0	11	9	0.50	1.85	1.15
	≥ 1.0	8	6	0.50	1.36	0.80
Nitrite-N	0.1 – < 1.0	11	4	<0.03	1.00	0.17
	≥ 1.0	8	3	<0.03	0.87	0.18
Ammonia-N	0.1 – < 1.0	11	5	<0.08	0.26	0.14
	≥ 1.0	8	6	<0.08	1.09	0.29
TKN as N	0.1 – < 1.0	11	11	0.80	8.70	2.54
	≥ 1.0	8	8	0.66	31.70	5.58

Table 2-14: USGS Water Quality Data for Selected Nutrients in the Santa Clara River at the County Line, 1951 to 1995

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved Phosphorus	0.1 – < 1.0	3	3	0.35	0.66	0.46
	≥ 1.0	1	1	0.01	0.01	0.01
Total Phosphorus	0.1 – < 1.0	5	5	0.81	1.8	1.28
	≥ 1.0	2	2	0.63	1.4	1.02
Ammonia as N	0.1 – < 1.0	3	3	0.03	0.39	0.16
	≥ 1.0	0	0	-	-	-
Nitrate + Nitrite as N	0.1 – < 1.0	7	7	0.87	4	2.1
	≥ 1.0	4	4	1.2	2	1.7
TKN as N	0.1 – < 1.0	1	1	0.64	0.64	0.64
	≥ 1.0	1	1	0.69	0.69	0.69
Total Nitrogen	0.1 – < 1.0	2	2	0.6	2.2	1.4
	≥ 1.0	2	2	3.5	4.4	4.0

- = no or insufficient data

Phosphorus. Recent wet weather monitoring (LACDPW Mass Emission Station and Newhall Ranch WRP Startup Monitoring) showed somewhat consistent total phosphorus levels, of a magnitude of about 0.4 to 0.6 mg/L. An exception was the large storm sample (>1.0 inch) collected at station NR-3, which measured 13.4 mg/L. This was likely due to the high concentration of total suspended solids measured during the same storm event, because total phosphorus is predominately found in the particulate-phase in stormwater runoff. Historical average total phosphorus concentrations at the USGS station were somewhat higher than recent results at 1.0 to 1.3 mg/L and appeared to be somewhat independent of storm event size.

Nitrogen. Nitrate-nitrogen was the only nutrient measured in the NRSP tributary stormwater monitoring. Measured nitrate-nitrogen concentrations in the tributary stormwater monitoring were generally low (less than 3 mg/L as N) at three of the sites, and were elevated at Sites A and D (17.5 mg/L and 15.3 mg/L, respectively). The numeric target for nitrate plus nitrite-nitrogen in the Santa Clara River Nitrogen Compounds TMDL is 4.5 mg/L (30-day average) based on achieving the Basin Plan water quality objective of 5 mg/L (note that nitrate-nitrogen is typically an order of magnitude greater than nitrite-nitrogen in natural waters, as nitrite is converted to nitrate in aerobic conditions). The Santa Clara River average nitrate-nitrogen concentrations were below this objective (0.8 mg/L to 3.2 mg/L). The average historical nitrate-N + nitrite-N concentrations at the USGS station were roughly similar, varying from 2.1 mg/L for lower storm flows to 1.7 mg/L for higher storm flows.

Average ammonia concentrations were low and ranged from 0.1 to 0.5 mg/L. The ammonia water quality objectives in the Santa Clara River Nitrogen Compounds TMDL range from 3.4 mg/L to 5.5 mg/L (one hour average) and 1.2 mg/L to 2.0 mg/L (30-day average).

Average total Kjeldahl nitrogen (TKN) concentrations, which is the measure of ammonia plus the organic forms of nitrogen, generally ranged from 0.3 mg/L to 5.6 mg/L. One exception was the concentration found in the large storm at NR-3, which measured 46 mg/L. As with total phosphorus, the organic forms of nitrogen in stormwater runoff are generally in the particulate-phase, and this result correlated with the high levels of total phosphorus and suspended solids measured during this same event.

2.3.1.4. Selected Metals, Pesticides, and Cyanide

The heavy metals cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) can be toxic at high concentrations. Trace metals occur naturally in soils and sediments, and are present in urban runoff. Aluminum is one of the more abundant elements in the earth's crust. The organophosphorus pesticides chlorpyrifos and diazinon are two pesticides of concern due to their potential toxicity in receiving waters and, in the past, have been frequently detected downstream from urban and agricultural land uses. These pesticides are currently banned for residential use. Cyanide is a highly toxic substance and has a number of man-made and natural sources.

Tables 2-15 through 2-18 summarize the data for these metals and pesticides in the tributaries and the Santa Clara River. Cyanide was only measured at the LACDPW Mass Emission station. Available data for metals at the USGS station were very limited. For copper and lead, there were a considerable number of non-detects with very high detection limits. Therefore, comparison of the USGS data for copper, lead, and zinc with the recent monitoring information is considered inappropriate. Metals data were not collected in the one large storm event sampled for the Newhall Ranch WRP pre-startup monitoring; thus summarized data for this station represent storms less than one inch in depth.

Table 2-15: Average Concentration of Heavy Metals from Newhall Ranch Tributary Stormwater Monitoring, March 2001

Constituent	Site A Mouth of Potrero	Site B Mouth of San Martinez Grande	Site C Long Canyon Upstream of Onion Field	Site D Mouth of Middle Canyon	Site E Middle of Chiquito
Total Copper (µg/L)	15	175	170	10	70
Total Lead (µg/L)	6.1	53.5	95.2	7.6	36.8
Total Zinc (µg/L)	40	330	330	30	225
Total Cadmium (µg/L)	0.3	11.2	2	0.4	1.9

Table 2-16: Newhall Ranch WRP Pre-Startup Wet Weather Water Quality Data for Selected Metals and Pesticides in the Santa Clara River, 2004 - 2006

Constituent	2-day Antecedent Rainfall (inches)	Sample Site	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved Aluminum	0.1 – < 1.0	NR1	1	1	27	27	27
		NR3	1	1	19	19	19
Total Aluminum	0.1 – < 1.0	NR1	1	1	740	740	740
		NR3	1	1	770	770	770
Dissolved Copper	0.1 – < 1.0	NR1	1	1	4.6	4.6	4.6
		NR3	1	1	3.6	3.6	3.6
Total Copper	0.1 – < 1.0	NR1	2	2	4.6	5.2	4.9
		NR3	2	2	4.8	7.0	5.9
Dissolved Lead	0.1 – < 1.0	NR1	1	0	<0.07	<0.07	-
		NR3	1	0	<0.07	<0.07	-
Total Lead	0.1 – < 1.0	NR1	2	2	0.6	1.3	1.0
		NR3	2	2	0.6	0.9	0.8

Constituent	2-day Antecedent Rainfall (inches)	Sample Site	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved Zinc	0.1 – < 1.0	NR1	1	1	12	12	12
		NR3	1	1	8.7	8.7	8.7
Total Zinc	0.1 – < 1.0	NR1	2	2	13	22	18
		NR3	2	2	12	18	15
Diazinon	0.1 – < 1.0	NR1	1	0	<0.01	<0.01	-
		NR3	1	0	<0.01	<0.01	-
Chlorpyrifos	0.1 – < 1.0	NR1	1	0	<0.6	<0.6	-
		NR3	1	0	<0.6	<0.6	-

- = no or insufficient data

Table 2-17: LACDPW Stormwater Monitoring for Metals, Pesticides, and Cyanide at the SCR Mass Emission Station (S29), 2002-2007

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved Aluminum	0.1 – < 1.0	11	3	<100	1390	894
	≥ 1.0	8	4	<100	3680	1086
Total Aluminum	0.1 – < 1.0	11	11	450	18000	5040
	≥ 1.0	8	8	131	19650	5672
Dissolved Copper	0.1 – < 1.0	11	11	3.32	10.60	5.80
	≥ 1.0	8	8	3.75	22.60	9.92
Total Copper	0.1 – < 1.0	11	11	7.33	50.50	25.78
	≥ 1.0	8	8	9.43	53.30	25.28
Dissolved Lead	0.1 – < 1.0	11	2	0.52	5.00	4.44
	≥ 1.0	8	5	0.44	12.50	3.32
Total Lead	0.1 – < 1.0	11	11	1.41	17.40	5.91
	≥ 1.0	8	8	1.14	39.80	17.12
Dissolved Zinc	0.1 – < 1.0	11	9	3	27	12
	≥ 1.0	8	8	12	37	26
Total Zinc	0.1 – < 1.0	11	11	11	118	54
	≥ 1.0	8	8	42	353	110
Dissolved Cadmium	0.1 – < 1.0	11	0	1.00	1.00	1.00
	≥ 1.0	8	1	0.74	1.00	0.94

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Total Cadmium	0.1 – < 1.0	11	6	0.27	1.00	0.77
	≥ 1.0	8	6	0.25	1.27	0.78
Chlorpyrifos	0.1 – < 1.0	11	0	<0.05	<0.05	-
	≥ 1.0	8	0	<0.05	<0.05	-
Diazinon	0.1 – < 1.0	11	3	<0.01	0.41	0.05
	≥ 1.0	8	5	<0.01	0.43	0.10
Cyanide	0.1 – < 1.0	11	3	<10	10	10
	≥ 1.0	8	3	<10	590	200

- = no or insufficient data

Table 2-18: USGS Water Quality Data for Selected Metals and Pesticides in the Santa Clara River at the County Line, 1951 to 1995

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved Copper	0.1 – < 1.0	4	0	-	-	-
	≥ 1.0	0	0	-	-	-
Total Copper	0.1 – < 1.0	1	1	30	30	30
	≥ 1.0	0	0	-	-	-
Dissolved Lead	0.1 – < 1.0	39	4	1	23	7.8
	≥ 1.0	4	0	-	-	-
Total Lead	0.1 – < 1.0	3	0	-	-	-
	≥ 1.0	1	0	-	-	-
Dissolved Zinc	0.1 – < 1.0	4	1	10	10	10
	≥ 1.0	0	0	-	-	-
Total Zinc	0.1 – < 1.0	1	1	150	150	150
	≥ 1.0	0	0	-	-	-
Diazinon	0.1 – < 1.0	1	1	0.02	0.02	0.02
	≥ 1.0	0	0	-	-	-

- = no or insufficient data

Metals. Table 2-15 presents average total copper, lead, zinc, and cadmium concentrations measured in the NRSP tributary stormwater monitoring. Total copper, lead, and zinc measured at tributary Sites B and C were much higher than the concentrations measured at Sites A and D. Concentrations at Site E fell in the middle of the measured range. Elevated total metal concentrations are often associated with elevated TSS levels, although this trend is not evident in

the tributary monitoring data. The average total copper concentrations at Sites B, C, and E were greater than the CTR acute copper criterion. The average total copper concentrations ranged from 10 µg/L to 175 µg/L; the CTR acute total copper criterion for a hardness concentration of greater than 400 mg/L is 52 µg/L. The average total lead and total zinc concentrations in all the tributaries were below the CTR acute criteria. The average total lead concentrations ranged from 6.1 µg/L to 95 µg/L; the CTR acute total lead criterion for a hardness concentration of greater than 400 mg/L is 480 µg/L. The average total zinc concentrations ranged from 30 µg/L to 330 µg/L; the CTR acute total zinc criterion for a hardness concentration of greater than 400 mg/L is 390 µg/L.

Average concentrations of dissolved and total copper measured in the Santa Clara River (3.6 µg/L to 9.9 µg/L, dissolved copper; 4.9 to 26 µg/L, total copper) were below the respective CTR acute criteria for the average hardness of 250 mg/L (32 µg/L, dissolved copper; 33 µg/L, total copper). Average concentrations of dissolved and total lead measured in the Santa Clara River (<0.07 µg/L to 4.4 µg/L, dissolved lead; 0.8 to 17 µg/L, total lead) were well below the respective CTR acute criteria for the average hardness of 250 mg/L (170 µg/L, dissolved lead; 260 µg/L, total lead). Average concentrations of dissolved and total zinc measured in the Santa Clara River (8.7 µg/L to 26 µg/L, dissolved zinc; 15 to 110 µg/L, total zinc) were all well below the respective CTR acute criteria for the average hardness of 250 mg/L (250 µg/L, dissolved zinc; 260 µg/L, total zinc).

Average dissolved aluminum concentrations showed a very wide range in the Santa Clara River, ranging from a low of 19 µg/L dissolved aluminum measured in small storms at station NR3 to 1,086 µg/L measured in large storms at the Los Angeles County mass emission station. Similarly, total aluminum ranged from a low of 740 µg/L dissolved aluminum measured in small storms at station NR1 to 5,672 µg/L measured in large storms at the Los Angeles County mass emission station. The National Ambient Water Quality Criteria (NAWQC) acute criterion for aluminum is 750 µg/L for a pH range of 6.5 to 9.0; the CTR does not include an aluminum criterion.

Pesticides. Chlorpyrifos was not detected in 19 samples taken at the County's mass emission station, while diazinon was detected in 8 of 19 samples with an average concentration of 0.05 µg/L in small storms and 0.10 µg/L in the larger storms. Diazinon and chlorpyrifos were not detected further downstream in the SCR during Newhall Ranch WRP wet weather sampling, but were detected in the one wet weather sample in the historical USGS data. The CTR acute criterion for diazinon is 0.17 µg/L. The diazinon criterion derived by the California Department of Fish and Game is 0.08 µg/L (Marshack, 2003).

Cyanide. Cyanide was detected in six of 19 wet weather samples at the County's mass emission station. Concentrations of cyanide ranged from below 10 µg/L to 590 µg/L. The CTR criterion for freshwater acute aquatic life protection for cyanide is 22 µg/L.

2.3.1.5. Fecal Indicator Bacteria

Pathogens such as viruses, bacteria, and protozoa that cause illness in humans are difficult to measure. Fecal indicator bacteria (FIB) such as total coliform, fecal coliform, and enterococci are commonly measured instead, and their presence indicates the presence of fecal contamination and the potential presence of associated pathogenic organisms. However, it does not indicate the source of the contamination and there are numerous natural and anthropogenic sources of pathogen indicators. Tables 2-19 through 2-22 summarize FIB data for the four datasets.

Table 2-19: Average Concentrations for Fecal Indicator Bacteria from Newhall Ranch Tributary Stormwater Monitoring, 2001

Constituent	Site A Mouth of Potrero	Site B Mouth of San Martinez Grande	Site C Long Canyon Upstream of Onion Field	Site D Mouth of Middle Canyon	Site E Middle of Chiquito
Total coliform (MPN/100ml)	40,000	>160,000	125,000	>50,000	>81,200
Fecal coliform (MPN/100ml)	4,300	953	6,300	>81,200	81,200

Table 2-20: Newhall Ranch WRP Startup Wet Weather Water Quality Data for Fecal Indicator Bacteria in the Santa Clara River, 2004 - 2006

Constituent	2-day Antecedent Rainfall (inches)	Sample Site	No. of Samples	No. of Detects	Minimum	Maximum	Average
Fecal coliform (MPN/100mL)	0.1 – < 1.0	NR1	5	4	<1	900	87
		NR3	5	4	<1	5,000	258
	≥ 1.0	NR3	1	1	≥1,600	≥1,600	≥1,600
Total coliform (MPN/100mL)	0.1 – < 1.0	NR1	5	4	<1	1,600	284
		NR3	5	4	<1	13,000	549
	≥ 1.0	NR3	1	1	≥1,600	≥1,600	≥1,600

Table 2-21: LACDPW Stormwater Monitoring for Fecal Indicator Bacteria at the SCR Mass Emission Station, 2002-2007

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum	Maximum	Average
Total coliform (MPN/100mL)	0.1 – < 1.0	11	11	17,000	1,600,000	115,590
	≥ 1.0	8	8	50,000	500,000	246,812
Fecal coliform (MPN/100mL)	0.1 – < 1.0	11	11	230	300,000	7,332
	≥ 1.0	8	8	9,000	300,000	65,275
Fecal Enterococci (MPN/100mL)	0.1 – < 1.0	11	11	800	300,000	17,907
	≥ 1.0	8	8	17,000	500,000	90,150

Table 2-22: USGS Water Quality Data for Fecal Indicator Bacteria in the Santa Clara River at the County Line, 1951 - 1995

Constituent	2-day Antecedent Rainfall (inches)	No. of Samples	No. of Detects	Minimum	Maximum	Average
Fecal coliform (CFU/100mL)	0.1 – < 1.0	3	3	80	720	427
	≥ 1.0	1	1	-	-	2,700

- = no or insufficient data

Concentrations of total and fecal coliform bacteria in wet weather flows at all tributary monitoring stations, the Newhall Ranch WRP stations, and the County's mass emission station were highly variable and sometimes very high, consistent with other stormwater data throughout the region. Fecal coliform concentrations ranged from <1 Most Probable Number per 100 milliliters (MPN/100 mL) to 300,000 MPN/100 mL. Average bacteria concentrations at the lower stations were significantly lower, but still elevated, more so during larger storms. In waters designated for water contact recreation (REC-1), the Basin Plan objective for fecal coliform is a log mean of 200/100 mL (based on a minimum of not less than 10 percent of total samples during any 30-day period), nor shall more 10 percent of the total number of samples during any 30-day period exceed 400/100 mL.

2.3.1.6. Summary

Tables 2-23 and 2-24 summarize the average values from wet weather monitoring data for all monitoring locations.

Table 2-23: Average Wet Weather Monitoring Data (2-Day Antecedent Rainfall of 0.1 - 1.0 in)

	LACDPW Mass Emission Station	NRSP Area Tributary Monitoring					Newhall Ranch WRP Startup Monitoring		USGS Wet Weather Monitoring
Constituent	***S29***	***Site A***	***Site B***	***Site C***	***Site D***	***Site E***	***NR1***	***NR3***	***USGS***
General and Conventional Parameters									
TSS (mg/L)	845	835	41,100	36,000	5,650	6,645	58	112	2,291
TDS (mg/L)	458	7,380	2,825	190	160	205	855	1,076	1,437 [1]
Hardness (mg/L)	249	2,225	1,205	147	59	107	387	475	773
Chloride (mg/L)	68	870	125	3	3	11	100	105	122
Nutrients									
Total P (mg/L)	0.60	-	-	-	-	-	0.4	0.4	1.28
Nitrate-N (mg/L)	1.15	18[2]	3.0[2]	1.6[2]	15.3[2]	2.8[2]	3.2	3.0	2.1 [2]
Nitrite-N (mg/L)	0.17	-	-	-	-	-	<0.005	<0.005	-
Ammonia-N (mg/L)	0.14	-	-	-	-	-	0.2	0.1	0.16
TKN (mg/L)	2.5	-	-	-	-	-	0.3	0.4	0.64
Metals and Pesticides									
Dissolved copper (µg/L)	5.8	-	-	-	-	-	4.6	3.6	-
Total Copper (µg/L)	26	15	175	170	10	70	4.9	5.9	30
Dissolved Lead (µg/L)	4.4	-	-	-	-	-	<0.07	<0.07	7.8
Total Lead (µg/L)	5.9	6.1	54	95	7.6	37	1	0.8	-
Dissolved Zinc (µg/L)	12	-	-	-	-	-	12	8.7	10
Total Zinc (µg/L)	54	40	330	330	30	225	18	15	150
Dissolved Aluminum (µg/L)	894	-	-	-	-	-	27	19	-
Total Aluminum (µg/L)	5,040	-	-	-	-	-	740	770	-
Diazinon (µg/L)	0.05	-	-	-	-	-	<0.01	<0.01	0.02
Chlorpyrifos (µg/L)	<0.05	-	-	-	-	-	<0.6	<0.6	-
Cyanide (mg/L)	<0.01	-	-	-	-	-	-	-	-
Indicator Bacteria									
Fecal coliform (MPN/100mL)	7,332	4,300	953	6,300	>81,200	81,200	87	258	427 [3]
Total coliform (MPN/100mL)	115,590	40,000	>1.6E5	125,000	>50,000	>81,200	284	549	-

[1] Derived from Specific Conductance, [2] Nitrate + Nitrite-N, [3]CFU/100ml, - = no or insufficient data

Table 2-24: Average Wet Weather Monitoring Data (2-Day Antecedent Rainfall >1 inch)

Constituent	LACDPW SCR Mass Emission Station	Newhall Ranch WRP Startup Monitoring	USGS Wet Weather Monitoring
	S29	*NR3*	*11108500*
General and Conventional Parameters			
TSS (mg/L)	1,635	43,360	10,711
TDS (mg/L)	216	2,100	838 [1]
Hardness (mg/L)	108	832	546
Chloride (mg/L)	24	46	61
Nutrients			
Total P (mg/L)	0.42	13	1.0
Nitrate-N (mg/L)	0.80	1.4	1.7 [2]
Nitrite-N (mg/L)	0.18	ND	
Ammonia-N (mg/L)	0.29	0.5	-
TKN (mg/L)	5.6	46	0.69
Metals and Pesticides			
Dissolved Copper (µg/L)	9.9	-	-
Total Copper (µg/L)	26	-	-
Dissolved Lead (µg/L)	3.3	-	-
Total Lead (µg/L)	17	-	-
Dissolved Zinc (µg/L)	26	-	-
Total Zinc (µg/L)	110	-	-
Dissolved Aluminum (µg/L)	1,086	-	-
Total Aluminum (µg/L)	5,672	-	-
Diazinon (µg/L)	0.10	<0.01	-
Chlorpyrifos (µg/L)	<0.05	<0.6	-
Cyanide (µg/L)	200	-	-
Indicator Bacteria			
Fecal coliform (MPN/100 mL)	65,275	>1,600	2,700 [3]
Total coliform (MPN/100 mL)	246,812	>1,600	-

[1] Derived from Specific Conductance, [2] Nitrate + Nitrite-N, [3]CFU/100ml, - = no or insufficient data

2.3.2. Dry Weather Water Quality Monitoring

Dry season base flows in the SCR through the NRSP area are perennial. Dry season base flows may include contributions from natural groundwater flows; however, discharges from the upstream Saugus and Valencia WRPs contribute the majority of base flow. Discharges from the WRPs during dry weather conditions are a source of impairing pollutants in downstream reaches, including chloride, TDS, and nitrogen compounds.

Dry weather water quality monitoring data in the SCR are available from three sources:

- LACDPW sampling at the SCR mass emission station
- USGS Water Quality Monitoring
- Newhall Ranch WRP pre-startup monitoring

These sites were described above under Wet Weather Monitoring (Section 2.3.1). The LACDPW station is in the SCR at The Old Road, above the NRSP area, while the Newhall Ranch WRP pre-startup monitoring stations are at the western boundary and downstream of the NRSP area. The USGS station is also below the NRSP area, and provides a historical perspective from samples collected between 1951 and 1995.

2.3.2.1. General Constituents

Tables 2-25 through 2-27 summarize the available dry weather monitoring data for TSS, hardness, TDS, and chloride.

Table 2-25: LACDPW Dry Weather Monitoring for Selected General Constituents at the SCR Mass Emission Station (S29), 2002-2007

Constituent	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
TSS	10	10	2	1,320	200
Hardness	10	10	330	510	420
TDS	10	10	696	942	812
Chloride	10	10	47	140	115

Table 2-26: Newhall Ranch WRP Pre-Startup Dry Weather Monitoring for Selected General Constituents in the SCR, 2004-2006

Constituent	Sample Site	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
TSS	NR1	49	48	<1	342	66
	NR3	49	48	<1	676	128
Hardness	NR1	49	49	258	568	388
	NR3	49	49	324	684	458
TDS	NR1	49	49	504	1160	845
	NR3	49	49	576	1396	936
Chloride	NR1	24	24	66	145	120
	NR3	24	24	50	157	124

Table 2-27: USGS Dry Weather Water Quality Monitoring Data for Selected General Constituents in the SCR at the County Line, 1951-1995

Constituent	No. of Samples	No. of Detects	Minimum	Maximum	Average
TSS (mg/L)	73	73	7	5,980	349
Hardness (mg/L)	220	220	42	2,400	881
Specific Conductance (uS/cm)	383	383	925	7,620	2,408
TDS (mg/L)	-	-	592[1]	4,876[1]	1,541[1]
Chloride (mg/L)	355	355	30	585	140

[1]Derived from Specific Conductance

TSS. Relatively high average TSS concentrations were observed, especially the historical data from USGS station, which may have included samples taken during times of higher erosion or larger dry weather flows. Average dry weather flow TSS concentrations observed by the Newhall Ranch WRP pre-startup monitoring were similar to those observed for small storms in wet weather monitoring. Average concentrations of TSS appeared higher at the upstream DPW mass emission station than at the downstream Newhall Ranch WRP pre-startup sites. Differences may be due to physical factors such as channel substrate material, local flow regime, and tributary influences.

Hardness, TDS and Chloride. The average concentrations of hardness, TDS, and chloride were more similar between the County's mass emission station and Newhall Ranch WRP monitoring locations. However, the USGS County Line station historically recorded higher averages (approximately double) than the baseline data observed at the County's mass emission

station and Newhall Ranch WRP monitoring locations. The baseline data suggests that the water flowing in the Santa Clara River in the proposed Project area during dry weather is very hard with high levels of other dissolved salts, including chloride. The average concentrations of TDS in the baseline data ranged from 812 mg/L to 936 mg/L, below the Basin Plan objective for TDS in Santa Clara River Reach 5 (1,000 mg/L). Average chloride concentrations in dry weather flows ranged from 115 mg/L to 124 mg/L, above the Basin Plan objective of 100 mg/L.

2.3.2.2. Nutrients

Tables 2-28 through 2-30 summarize the available dry weather monitoring data for selected nutrients.

Table 2-28: LACDPW Dry Weather Monitoring of Selected Nutrients at the SCR Mass Emission Station (S29), 2002-2007

Constituent	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved phosphorus	10	10	0.05	0.30	0.18
Total phosphorus	10	10	0.10	0.67	0.26
Nitrate-N	10	9	<0.50	1.7	1.2
Nitrite-N	10	2	<0.03	0.6	0.1
Ammonia-N	10	2	<0.10	0.8	0.1
TKN	10	10	0.3	1.3	0.6

Table 2-29: Newhall Ranch WRP Pre-Startup Dry Weather Monitoring for Selected Nutrients in the SCR, 2004-2006

Constituent	Sample Site	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Total phosphorus	NR1	49	49	0.1	1.1	0.5
	NR3	49	48	<0.008	0.8	0.5
Nitrate-N	NR1	49	49	1.0	4.9	2.8
	NR3	49	49	1.1	5.1	2.9
Nitrite-N	NR1	49	6	<0.005	0.2	0.02
	NR3	49	5	<0.005	0.2	0.02
Ammonia-N	NR1	49	34	<0.005	0.4	0.1
	NR3	49	39	<0.005	0.4	0.1
TKN	NR1	49	47	<0.04	1.0	0.4
	NR3	49	48	<0.04	1.3	0.5

Table 2-30: USGS Dry Weather Water Quality Monitoring Data for Selected Nutrients in the Santa Clara River at the County Line, 1951 - 1995

Constituent	No. of Samples	No. of Detects	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved phosphorus	48	48	0.12	2.4	1
Total phosphorus	64	64	0.23	5.9	1.13
Ammonia as N	41	41	0.01	0.62	0.18
Nitrate + Nitrite as N	47	47	1.8	7.5	4
TKN as N	20	20	0.08	1.3	0.83
Total Nitrogen	33	33	0.5	15	3.7

Phosphorus and Nitrogen. The average concentrations for total phosphorus and nitrate in dry weather flows increased downstream, while ammonia and TKN concentrations were relatively consistent from upstream to downstream. All average nutrient concentrations were higher in the historical dataset. Nutrient concentrations measured in dry weathers flows reflect the influence of the Saugus and Valencia WRPs. Lower average concentrations in the Newhall WRP startup monitoring compared with the data at the USGS gauge could be due to historically greater WRP nutrient discharge concentrations and/or less responsible use of fertilizers. Higher historic TKN concentrations could also be attributed to higher TSS concentrations, and hence particulate nutrients, observed at this site.

2.3.2.3. Metals and Pesticides

Tables 2-31 through 2-33 summarize the available dry weather monitoring data for selected metals and pesticides.

Table 2-31: LACDPW Dry Weather Monitoring for Metals, Pesticides, and Cyanide at the SCR Mass Emission Station (S29), 2002-2007

Constituent	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved copper	10	10	1.9	3.8	2.9
Total copper	10	10	6.0	33.5	15.2
Dissolved lead	10	0	<5.00	<5.00	-
Total lead	10	10	0.6	8.2	1.8
Dissolved zinc	10	7	<1.00	26.0	6.4
Total zinc	10	8	<5.00	52.2	20.7
Dissolved cadmium	10	2	<1.00	41.0	5.3
Total cadmium	10	3	0.29	72.0	8.3

Constituent	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved aluminum	10	0	<100	<100	-
Total aluminum	10	3	<100	7,500	845
Chlorpyrifos	10	0	<0.05	<0.05	-
Diazinon	10	1	<0.05	0.02	0.01
Cyanide	10	0	<10	<10	-

- = no or insufficient data

Table 2-32: Newhall Ranch WRP Pre-Startup Dry Weather Monitoring for Metals and Pesticides in the SCR, 2004-2006

Constituent	Sample Site	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved copper	NR1	10	10	3.2	4.8	4
	NR3	10	10	3	5.2	4.2
Total copper	NR1	21	21	2.3	11	5
	NR3	21	21	2.6	15	6.5
Dissolved lead	NR1	10	5	<0.07	0.7	0.2
	NR3	10	6	<0.07	0.6	0.2
Total lead	NR1	21	18	<0.07	4.6	0.9
	NR3	21	18	<0.07	5.8	1.4
Dissolved zinc	NR1	10	10	7.8	14	11
	NR3	10	10	6.2	16	10.7
Total zinc	NR1	21	21	8.5	30	15.4
	NR3	21	21	7.8	51	19.5
Dissolved aluminum	NR1	4	4	21	290	170
	NR3	4	4	14	750	289
Total aluminum	NR1	4	4	240	2,100	1,018
	NR3	4	4	330	3,300	1,685
Diazinon	NR1	21	0	<0.01	<0.01	-
	NR3	21	0	<0.01	<0.01	-

- = no or insufficient data

Table 2-33: USGS Dry Weather Water Quality Monitoring Data for Metals and Pesticides in the Santa Clara River at the County Line, 1951-1995

Constituent	No. of Samples	No. of Detects	Minimum (µg/L)	Maximum (µg/L)	Average (µg/L)
Dissolved copper (ug/L)	40	13	1	5	1.8
Total copper (ug/L)	12	6	10	40	20
Dissolved lead (ug/L)	39	4	1	23	7.8
Total lead (ug/L)	30	0	-	-	-
Dissolved Zinc (ug/L)	39	29	5	50	15.8
Total zinc (ug/L)	12	12	20	110	45
Diazinon (ug/L)	6	4	0.01	0.05	0.03

- = no or insufficient data

Metals. Concentrations of heavy metals in dry weather flows were generally low and, for the most part, reasonably similar. Total metal concentrations are related to TSS concentrations, and this is reflected in the difference between the historical data collected at the USGS site with higher TSS and the more recent data with lower TSS. Average dissolved copper concentrations were fairly similar and ranged from 1.8 to 4.2 µg/L. Average dissolved zinc concentrations were also fairly similar and ranged from 6.4 to 15.8 µg/L. Dissolved lead concentrations were slightly higher for the historical than the more recent datasets, and this is likely due to the widespread use of leaded gasoline prior to 1995.

Average concentrations of dissolved and total copper measured in dry weather flows in the baseline data (2.9 µg/L to 4.2 µg/L, dissolved copper; 5 to 15.2 µg/L, total copper) were below the respective CTR chronic criteria for a hardness greater than 400 mg/L (29 µg/L, dissolved copper; 30 µg/L, total copper). Average concentrations of dissolved and total lead measured in dry weather flows (0.2 µg/L to 7.8 µg/L, dissolved lead; 0.9 to 1.8 µg/L, total lead) were well below the respective CTR chronic criteria for a hardness greater than 400 mg/L (11 µg/L, dissolved lead; 19 µg/L, total lead). Average concentrations of dissolved and total zinc measured in dry weather flows (6.4 µg/L to 11 µg/L, dissolved zinc; 15.4 to 20.7 µg/L, total zinc) were all well below the respective CTR chronic criteria for a hardness greater than 400 mg/L (380 µg/L, dissolved zinc; 390 µg/L, total zinc).

Aluminum concentrations were only measured at the Newhall Ranch WRP Startup Monitoring stations. Average dissolved aluminum concentrations in the dry weather flows ranged from 170 µg/L to 289 µg/L. Total aluminum ranged from 845 µg/L to 1,685 µg/L. The National Ambient Water Quality Criteria (NAWQC) acute criterion for acid soluble aluminum is 750 µg/L for a pH range of 6.5 to 9.0; the CTR does not include an aluminum criterion.

Pesticides. Diazinon was detected at the upstream LACDPW site and historically at the USGS site in dry weather flows. The more extensive data set collected at NR-1 and NR-3 did not detect diazinon and this may be due to its recent phase-out by EPA for residential uses.

Cyanide. Cyanide was measured but not detected in dry weather flows at the LACDPW mass emission station.

2.3.2.4. Fecal Indicator Bacteria

Tables 2-34 through 2-36 summarize the available dry weather monitoring data for fecal indicator bacteria (FIB).

Table 2-34: LACDPW Dry Weather Monitoring at the SCR Mass Emission Station (S29), 2002-2007

Constituent	No. of Samples	No. of Detects	Minimum	Maximum	Average
Total coliform (MPN/100mL)	10	10	130	50,000	3,626
Fecal coliform (MPN/100mL)	10	10	20	5,000	165
Enterococci (MPN/100mL)	10	9	<20	1,300	218

Table 2-35: Newhall Ranch WRP Pre-Startup Dry Weather Monitoring for Indicator Bacteria in the SCR, 2004 - 2006

Constituent	Sample Site	No. of Samples	No. of Detects	Minimum	Maximum	Average
Total coliform (MPN/100mL)	NR1	49	49	23	24,000	961
	NR3	49	49	23	24,000	1,207
Fecal coliform (CFU/100mL)	NR1	49	49	23	2,300	209
	NR3	49	49	23	3,000	213

Table 2-36: USGS Dry Weather Water Quality Monitoring Data for Indicator Bacteria in the Santa Clara River at the County Line, 1951-1995

Constituent	No. of Samples	No. of Detects	Minimum	Maximum	Average
Fecal coliform (CFU/100mL)	46	46	25	980	250

The concentrations of indicator bacteria indicated highly variable but generally elevated fecal indicator bacteria concentrations in dry weather flows. The observed data were above the REC-1 Basin Plan objective for fecal coliform (log mean of 200/100 mL (based on a minimum of not

less than 10 percent of total samples during any 30-day period), nor shall more than 10 percent of the total number of samples during any 30-day period exceed 400/100 mL).

2.3.2.5. Summary

Table 2-37 summarizes the dry weather monitoring data available for the Santa Clara River in the NRSP area.

Table 2-37: Summary of Average Dry Weather Monitoring Data in the Santa Clara River

	SCR Mass Emission Station	**USGS Dry Weather Monitoring**	**Newhall Ranch WRP Startup Monitoring**	
Constituent	*S29*	*11108500*	*NR1*	*NR3*
General and Conventional Parameters				
TSS (mg/L)	200	349	66	128
Hardness (mg/L)	420	881	388	458
TDS (mg/L)	812	1541[1]	845	936
Chloride (mg/L)	115	140	120	124
Nutrients				
Total P (mg/L)	0.26	1.13	0.5	0.5
Nitrate-N (mg/L)	1.2	4[2]	2.8	2.9
Nitrite-N (mg/L)	0.1	-	0.02	0.02
Ammonia-N (mg/L)	0.1	0.18	0.1	0.1
TKN (mg/L)	0.6	0.83	0.4	0.5
Metals and Pesticides				
Dissolved copper (µg/L)	2.9	1.8	4	4.2
Total copper (µg/L)	15.2	20	5	6.5
Dissolved lead(µg/L)	<5.0	7.8	0.2	0.2
Total lead (µg/L)	1.8	ND	0.9	1.4
Dissolved zinc (µg/L)	6.4	15.8	11	10.7
Total zinc (µg/L)	20.7	45	15.4	19.5
Dissolved aluminum (µg/L)	-	-	170	289
Total aluminum (µg/L)	845	-	1018	1685
Diazinon (µg/L)	0.01	0.03	<0.01	<0.01
Chlorpyrifos (µg/L)	<0.05	-	-	-
Cyanide (mg/L)	<0.01	-	-	-

Constituent	SCR Mass Emission Station	USGS Dry Weather Monitoring	Newhall Ranch WRP Startup Monitoring	
	S29	*11108500*	*NR1*	*NR3*
Indicator Bacteria				
Fecal coliform (MPN/100 mL)	165	250 (CFU/100mL)	209	213
Total coliform (MPN/100 mL)	3,626	-	961	1207

- = no or insufficient data

2.4. Groundwater

2.4.1. Groundwater Beneficial Uses

The NRSP area is within the Basin Plan's Castaic Valley and Saugus Aquifer subbasin of the Santa Clarita Valley Groundwater Basin, East Subbasin. Beneficial uses for groundwaters for this subbasin are shown in Table 2-38.

Table 2-38: Beneficial Uses of Groundwaters

Groundwater Basin	MUN
DWR 4.07 - Eastern Santa Clara Sub-basin: Castaic Valley and Saugus Aquifer	E

E-Existing Beneficial Use
MUN: Community, military, or individual water supply systems including, but not limited to, drinking water supply
Source: Water Quality Control Plan for the Los Angeles Region (Basin Plan) (LARWQCB, 1994 as amended)

2.4.2. Existing Groundwater Quality

The NRSP subregion lies at the western end of the upper Santa Clara River hydrologic area, as defined by the California Department of Water Resources (DWR). The Santa Clara River Valley East Groundwater Subbasin lies within this hydrologic area and is the source of essentially all local groundwater used for water supply in the Santa Clarita Valley. The local groundwater supplies are obtained from relatively young surficial alluvial deposits and from an older geologic unit (the Saugus Formation) that underlies the alluvium and adjoining areas. The alluvium and the Saugus Formation are underlain by bedrock units consisting of the Pico Formation in the NRSP area and other geologic units in the eastern and northern portions of the Santa Clarita Valley. These deep bedrock units yield little water and are not considered viable for groundwater development.

The alluvial sediments lie within the portion of the Valley occupied by the Santa Clara River and also are present in side canyons that contain tributaries to the River. The alluvium consists of extensively interlayered and interfingered mixtures of gravel and sand, with variable amounts of cobbles and boulders and minor amounts of silt and clay. Due to the unconsolidated to poorly consolidated condition of the alluvium, and its lack of cementation, the alluvium has relatively

high permeability and porosity. The groundwater flow direction in the Alluvial aquifer follows the topography of the Valley and its tributaries. Groundwater recharge occurs in the eastern, northern, and southern portions of the Valley. Natural mechanisms for groundwater discharge occur at the west end of the Valley and consist of discharge to the Santa Clara River, subsurface outflow beneath the River, and evapotranspiration by deep-rooted vegetation.

The Saugus Formation is present beneath the eastern portion of the NRSP subregion and most of the Santa Clarita Valley area east of the NRSP area. The upper subunits of the Saugus Formation consist of terrestrial sediments deposited in stream channels, floodplains, and alluvial fans by ancestral drainage systems. The upper subunits are a source of groundwater supply in the Santa Clarita Valley because of their productive nature and their good water quality. Deeper subunits of the Saugus Formation were deposited in a marine environment and are subsequently not used for water supplies because of their brackish water quality and fine-grained, low-permeability nature.

Faulting and folding of the Saugus Formation and the underlying bedrock units have created a bowl-shaped structure beneath the Santa Clarita Valley. The Saugus Formation and underlying bedrock generally dip downwards from the periphery of the Valley towards the deepest portion of the "bowl" beneath the central portion of the Valley. The thickness of the Saugus Formation also is controlled by the San Gabriel fault, which is present in the eastern and northern portions of the Valley. Because of its structure and its connection with the overlying Alluvial aquifer, groundwater flow in the Saugus Formation is generally towards the center of the bowl and also towards the western portion of the Santa Clara River. Like the Alluvial aquifer, the Saugus Formation is recharged in the eastern and other peripheral portions of the Santa Clarita Valley. Groundwater discharge from the Saugus Formation occurs at the west end of the Valley in the form of groundwater discharge into the overlying Alluvial aquifer, which in turn discharges to the River in the western end of the Valley.

Alluvium. In terms of the aquifer system, there is no convenient long-term record of water quality (*i.e.*, water quality data in one or more single wells that spans several decades and continues to the present). Thus, in order to examine a long-term record of water quality in the alluvium, individual records have been integrated from several wells completed in the same aquifer materials and in close proximity to each other to examine historical trends in general mineral groundwater quality throughout the basin (Luhdorff & Scalmanini, 2005). Based on these records of groundwater quality, wells within the alluvium have experienced historical fluctuations in general mineral content, as indicated by electrical conductivity (EC), which correlates with fluctuations of individual constituents that contribute to EC. However, the historic water quality data indicates that, on a long-term basis, there has not been a notable trend and, specifically, there has not been a decline in water quality within the alluvium.

Specific conductance within the alluvium exhibits a westward gradient, corresponding with the direction of groundwater flow in the alluvium. EC is lowest in the easternmost portion of the

basin, and highest in the west, and generally exhibits an inverse correlation with precipitation and streamflow, with a stronger correlation in the easternmost portion of the basin where groundwater levels fluctuate the most. Wet periods have produced substantial recharge of higher quality (low EC) water, and dry periods have resulted in declines in groundwater levels, with a corresponding increase in EC (and individual contributing constituents) in the deeper parts of the alluvium.

The most notable groundwater quality issue in the alluvium is perchlorate contamination in a localized area situated about three miles east of the NRSP subregion. In 2002, one well (the Santa Clarita Water Division's Stadium Well), located near the former Whittaker-Bermite facility, was inactivated for municipal water supply due to detection of perchlorate slightly below the Notification Level. In early 2005, perchlorate was detected in a second well, the Valencia Water Company's Well Q2. In October 2005, Well Q2 was returned to service with wellhead perchlorate treatment under a permit from the California DHS. On-going monitoring in the alluvium north of the Whittaker-Bermite site (an ammunition manufacturing site) has shown no detections of perchlorate in any other Alluvial municipal water supply wells in this area.

Table 2-39 summarizes average metals, general chemistry, and organic compounds data for three Alluvial aquifer wells located in and near the NRSP subregion (see Figure 2-1). One well is a municipal water supply well that belongs to the Valencia Water Company (E-15) and is located in the Valencia Commerce Center area, north of the NRSP boundary. Two Newhall Ranch agricultural Alluvial aquifer wells (C and B6) were monitored twice (once each in 2000 and 2001).

Laboratory testing indicates that all constituents tested were at acceptable levels for drinking water, for all tested wells, with the exception of sulfate and iron in the agricultural supply well B6. Specifically, the average sulfate concentration (360 mg/L) exceeded the Basin Plan objective of 350 mg/L and the average iron concentration (0.4 mg/L) exceeded the secondary drinking water standard of 0.3 mg/L in Alluvial Well B6.

Tests conducted for perchlorate at the Alluvial aquifer wells listed in Table 2-39 indicated "non-detect," meaning no perchlorate was detected. Furthermore, no organic contaminants have been detected in any Alluvial aquifer wells.

Saugus Formation. Similar to the Alluvial aquifer, groundwater quality in the Saugus Formation is a key factor in assessing that aquifer as a municipal and agricultural water supply. As with the Alluvial aquifer, long-term Saugus groundwater quality data is not sufficiently extensive (few wells) to permit any basin-wide analysis or assessment of pumping-related impacts on quality. Accordingly, EC has been chosen as an indicator of overall water quality, and records have been combined to produce a long-term depiction of water quality. Water quality in the Saugus Formation historically has not exhibited the precipitation-related

fluctuations seen in the Alluvial aquifer, and based on the historical record over the last 50 years, groundwater quality in the Saugus Formation has exhibited a slight overall increase in EC.

Table 2-39 summarizes average metals, general chemistry, and organic compounds data for one Saugus aquifer wells located near the NRSP subregion (see Figure 2-1). Saugus Well 206 is a municipal water supply well that belongs to the Valencia Water Company and is located in the RMDP project area. Laboratory testing indicates that all constituents tested were at acceptable levels for drinking water in Saugus Well 206.

As with the Alluvial aquifer, the most notable groundwater quality issue in the Saugus Formation is perchlorate contamination. Since 1997, four Saugus wells located near the former Whittaker-Bermite facility (about two miles east of the Specific Plan area) have been inactivated for water supply service due to the presence of perchlorate. A fifth well in that same location showed a detection of perchlorate below the DHS reporting level of 4 µg/L. To date, in the Saugus Formation, there have been no perchlorate detections in other active municipal-supply wells located down gradient (west) of the impacted wells. The development and implementation of a cleanup plan for the former Whittaker-Bermite facility and the impacted groundwater resources is being coordinated among the Castaic Lake Water Agency (CLWA), impacted purveyors, the California Department of Toxic Substances Control (DTSC), and the Corps. For the impacted groundwater, a Final Interim Remedial Action Plan for containment and extraction of perchlorate was completed and approved by DTSC in January 2006. Design of the treatment facilities and related pipelines also was completed in 2006. Construction of these facilities to implement the pump-and-treat program and to also restore inactivated well capacity is anticipated to conclude in mid-2008, with the facilities on line by fall 2008 (Luhdorff and Scalmanini, 2006).

Table 2-39: Groundwater Monitoring Data

Parameter	Units	Basin Plan Objective / Maximum Contaminant Level	Average Concentration			
			Alluvial Well E-15	Alluvial Well C	Alluvial Well B6	Saugus Well 206
Aluminum	µg/L	1,000(2)	ND	ND	ND	ND
Arsenic	µg/L	50(2)	n/a	ND	ND	n/a
Barium	mg/L	1(2)	ND	0.02	0.03	ND
Beryllium	µg/L	4(2)	ND	n/a	n/a	ND
Cadmium	µg/L	5(2)	ND	ND	ND	ND
Chromium	µg/L	50(2)	ND	ND	ND	ND
Copper	µg/L	1,000(3)	ND	ND	ND	ND
Iron	mg/L	0.3(3)	ND	0.1	**0.4**	ND
Manganese	µg/L	50(3)	ND	ND	ND	ND
Mercury, Total	µg/L	2(2)	n/a	ND	ND	n/a
Nickel	µg/L	100(2)	ND	ND	ND	ND
Selenium	µg/L	50(2)	n/a	ND	ND	n/a
Silver	µg/L	100(3)	NA	ND	ND	n/a
Thallium	µg/L	2(2)	NA	ND	ND	n/a
Zinc	µg/L	5,000(3)	ND	ND	ND	ND

Parameter	Units	Basin Plan Objective / Maximum Contaminant Level	Average Concentration			
			Alluvial Well E-15	Alluvial Well C	Alluvial Well B6	Saugus Well 206
Alkalinity as CaCO3	mg/L	--	226	255	295	221
Boron	mg/L	1.0[1]	0.48	0.39	0.48	n/a
Chloride	mg/L	150[1]	90	57	82	45
Color	Color unit	15[3]	ND	ND	5	ND
Cyanide, total	mg/L	0.15[2]	n/a	ND	ND	n/a
Fluoride	mg/L	2.0[2]	0.8	0.7	0.8	0.2
Hardness as CaCO3	mg/L	--	499	410	510	464
MBAS	mg/L	0.5[3]	n/a	ND	ND	n/a
Nitrate as NO3	mg/L	45[1]	18.5	9.5	10.6	20.9
Nitrite as N	mg/L	1[1]	ND	ND	ND	ND
Nitrate+Nitrite as N	mg/L	10[1]	3.6	2.1	2.4	4.7
Odor	TON	3[3]	1.1	ND	ND	1
Specific Conductance	umhos/cm	900-1600[3]	1317	1150	1400	1158
Sulfate	mg/L	350[1]	314	285	**360**	293
TDS	mg/L	1,000[1]	969	760	950	861
Turbidity	NTU	5[3]	0.4	0.35	1.4	0.2
Volatile Organic Chemicals (VOCs)	µg/L	variable	ND	ND	ND	ND
Synthetic Organic Chemicals (SVOCs)	µg/L	variable	ND	ND	ND	ND

Key: **Bold** **Exceeds Standard**

-- = no applicable basin plan objective or MCL
n/a = not analyzed
ND = none detected
[1]Los Angeles Basin Plan Regional Objectives for Groundwater (Table 3-10).
[2]California Department of Public Health Primary Drinking Water MCL (Title 22 CCR Table 64431-A and Table 64444-A).
[3]California Department of Public Health Secondary Drinking Water MCL (Title 22 CCR Table 64449-A and Table 64449-B).

3. REGULATORY SETTING

3.1. Clean Water Act

In 1972, the Federal Water Pollution Control Act [later referred to as the Clean Water Act (CWA)] was amended to require National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants to waters of the United States from any point source. In 1987, the CWA was amended to require that the United States Environmental Protection Agency (USEPA) establish regulations for permitting of municipal and industrial stormwater discharges under the NPDES permit program. The USEPA published final regulations regarding stormwater discharges on November 16, 1990. The regulations require that municipal separate storm sewer system (MS4) discharges to surface waters be regulated by a NPDES permit.

In addition, the CWA requires the States to adopt water quality standards for receiving water bodies and to have those standards approved by the USEPA. Water quality standards consist of designated beneficial uses for a particular receiving water body (e.g. wildlife habitat, agricultural supply, fishing etc.), along with water quality criteria necessary to support those uses. Water quality criteria are prescribed concentrations or levels of constituents – such as lead, suspended sediment, and fecal coliform bacteria – or narrative statements which represent the quality of water that support a particular use. Because California had not established a complete list of acceptable water quality criteria, USEPA established numeric water quality criteria for certain toxic constituents in receiving waters with human health or aquatic life designated uses in the form of the California Toxics Rule ("CTR") (40 CFR 131.38).

3.2. CWA Section 303(d) - TMDLs

When designated beneficial uses of a particular receiving water body are being compromised by water quality, Section 303(d) of the CWA requires identifying and listing that water body as "impaired". Once a water body has been deemed impaired, a Total Maximum Daily Load (TMDL) must be developed for the impairing pollutant(s). A TMDL is an estimate of the total load of pollutants from point, non-point, and natural sources that a water body may receive without exceeding applicable water quality standards (with a "factor of safety" included). Once established, the TMDL allocates the loads among current and future pollutant sources to the water body.

The NRSP sub-regional projects will discharge runoff to Santa Clara River Reach 5. Table 3-1 lists the water quality impairments for the Santa Clara River, at and downstream of the NRSP location, as reported in the most recent (2006) CWA Section 303(d) List of Water Quality Limited Segments. Table 3-2 lists the 2006 Section 303(d) List of Water Quality Limited Segments Being Addressed by EPA Approved TMDLs. States are required to submit the Section 303(d) list and TMDL priorities to the EPA for approval. The 2006 Section 303(d) list was adopted by the SWRCB and approved for transmittal to EPA on October 25, 2006. The

2006 Section 303(d) list was approved by USEPA on June 28, 2007. Reach 5 of the Santa Clara River is listed for coliform bacteria and for chloride as "being addressed" in the reach. Downstream segments of the river, below the dry gap in Reach 4, are listed for total dissolved solids (TDS), toxicity, coliform bacteria, chlorinated legacy pesticides, and Toxaphene. Reach 3 is listed for ammonia and chloride as "being addressed."

The Regional Board has adopted TMDLs for nitrogen compounds (nitrate plus nitrite-nitrogen and ammonia) and chloride into the Water Quality Control Plan for Los Angeles Region (Basin Plan). The wasteload allocations for stormwater discharges into Reach 5 of the Santa Clara River are summarized in Table 3-3. Pollutant reductions are regulated through effluent limits prescribed in POTW and minor point source NPDES Permits, Best Management Practices (BMPs) required in NPDES MS4 Permits, and State Water Resource Control Board (SWRCB) Management Measures for nonpoint source discharges. The Regional Board has not yet adopted a TMDL for coliform in Reach 5.

3.3. California Toxics Rule

The California Toxics Rule (40 C.F.R. §131.38) is a federal regulation issued by the USEPA that provides water quality criteria for toxic pollutants in waters with human health or aquatic life designated uses in California. Not all waters receiving flows from the NRSP area, such as the tributaries to the Santa Clara River, are specifically designated with human health or aquatic life uses. However, the Santa Clara River does have such designated uses. Although CTR criteria do not apply directly to discharges of stormwater runoff, they can provide a useful benchmark to assess the potential impacts to the water quality of receiving waters from NRSP project stormwater runoff discharges. Here, the freshwater aquatic life criteria are used as benchmarks to evaluate the potential impacts of stormwater runoff to the NRSP projects' receiving waters. The CTR also contains human health criteria which are derived for drinking water sources and for fish consumption only. Since the human health criteria are less stringent than the aquatic life criteria for the pollutants of concern for the NRSP projects, the aquatic life criteria are used.

Table 3-1: 2006 CWA Section 303(d) Listings for the Santa Clara River Mainstem

SCR Reach or Tributary[1]	Geographic Description & Distance from Project to Upstream End of Reach	Pollutants	303(d) List Proposed TMDL Completion	Potential Sources
5	Blue Cut Gaging Station to West Pier Hwy 99 (Project location)	1) High Coliform Count	1) 2019	1) Nonpoint and Point Sources
3	Freeman diversion dam to "A" street [2] (25 miles)	1) Total Dissolved Solids	1) 2019	1) Nonpoint and Point Sources
1	Estuary to Highway 101 Bridge (30 miles)	1) Toxicity	1) 2019	1) Source Unknown
--	Estuary (40 miles)	1) ChemA[3] 2) Coliform 3) Toxaphene	1) 2019 2) 2019 3) 2019	1) Source Unknown 2) Nonpoint Source 3) Nonpoint Source

[1]SCR reaches upstream of the NRSP subregion have not been included.
[2]Reach 3 is downstream of the Dry Gap in Reach 4.
[3]ChemA suite of chlorinated legacy pesticides include: Aldrin, chlordane, Dieldrin, Endosulfan I/II, Endrin, gamma-BHC, heptachlor, heptachlor epoxide, and Toxaphene.

Table 3-2: 2006 CWA Section 303(d) List of Water Quality Limited Segments Being Addressed By EPA Approved TMDLs

Waterbody Name	Pollutants	Potential Sources	EPA Approved TMDL
Santa Clara River Reach 5	1. Chloride	1) Nonpoint/Point Source	1) 2005
Santa Clara River Reach 3	1. Ammonia 2. Chloride	1) Nonpoint/Point Source 2) Nonpoint/Point Source	1) 2004 2) 2002

Table 3-3: TMDL Wasteload Allocations for MS4 and Stormwater Sources to Santa Clara River Reach 5

Impairing Pollutant	Numeric Water Quality Objective	Wasteload Allocation
Chloride (Resolution No. 04-004)	100 mg/L.	Wasteload allocations have been adopted for the Saugus WRP and the Valencia WRP. Other NPDES discharges contribute a minor chloride load. The wasteload allocation for these point sources is **100 mg/L**. The source analysis indicates that nonpoint sources are not a major source of chloride. The load allocations for nonpoint sources is **100 mg/L**.
Nitrogen Compounds (Resolution No. 03-011)	The numeric target for NO_3-N + NO_2-N in the Nitrogen Compounds TMDL was based on achieving the existing water quality objective of 5 mg/L NO_3-N + NO_2-N. The numeric target that was used to calculate the wasteload allocations included a 10% margin of safety; thus the numeric target is 4.5 mg/L NO_3-N + NO_2-N (30-day average). The water quality objectives for ammonia in Reach 5 used in the Nitrogen Compounds TMDL are: TMDL Ammonia Water Quality Objective (mg/L as N) 1-hr average / 30-day average Reach 5 at County Line: 3.4 / 1.2 Reach 5 below Valencia: 5.5 / 2.0 Reach 5 above Valencia: 4.8 / 2.0	Concentration-based wasteloads are allocated to municipal, industrial, and construction stormwater sources regulated under NPDES permits. For stormwater Permittees discharging into Reach 5, the following wasteload allocations apply: **30-day average nitrate plus nitrite = 6.8 mg/L (NO_3-N + NO_2-N)** **1-hour average ammonia = 5.2 mg/L (NH_3 as N)** **30-day average ammonia = 1.75 mg/l (NH_3 as N)**

Freshwater aquatic life criteria for certain metals in the CTR are expressed as a function of hardness because hardness, and/or water quality characteristics that are usually correlated with hardness, can reduce the toxicities of some metals [4]. The minimum wet weather hardness value of 250 mg/L as $CaCO_3$ from USGS station 11108500 was used to approximate CTR criteria for metals. This value is likely to be more representative of conditions in the Santa Clara River within the NRSP subregion than Los Angeles County's Station 29 based on the water quality data summarized in Section 2.7 above. As per requirements of their discharge permit, the Valencia Water Reclamation Plant has a monitoring station just upstream of the NRSP subregion area. Monthly hardness values for the Santa Clara River at this station ranged from 326 to 360 mg/L as $CaCO_3$ in 2004. Other water quality comparisons to this station were not made due to lack of wet weather monitoring. The hardness value of 250 mg/L is a conservative estimate of wet weather hardness values that should occur in the NRSP subregion area, although higher values are likely to occur.

The CTR also establishes two types of aquatic life criteria: acute and chronic. Acute criteria represent the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects; chronic criteria equal the highest concentration to which aquatic life can be exposed for an extended period of time (four days) without deleterious effects. Due to the intermittent nature of stormwater runoff (especially in southern California), the acute criteria are considered to be more applicable to stormwater conditions than chronic criteria. For example, the average storm duration in the 38-year Newhall gage rainfall record is 11.3 hours. In this document, the acute CTR criteria are used as one type of benchmark to evaluate the potential ecological impacts of Project runoff on the receiving waters.

3.4. California Porter-Cologne Act

The federal CWA places the primary responsibility for the control of surface water pollution and for planning the development and use of water resources with the states, although it does establish certain guidelines for the states to follow in developing their programs and allows USEPA to withdraw control from states with inadequate implementation mechanisms.

California's primary statute governing water quality and water pollution issues with respect to both surface waters and groundwater is the Porter-Cologne Water Quality Control Act of 1970

---

[4] The toxicity of a chemical to an aquatic organism may vary according to attributes of the organism, chemical composition, and exposure environment, so that the chemical is more or less "bioavailable." Many chemicals exist in a variety of forms (chemical species), and such chemical speciation affects bioavailability because relative uptake rates can differ among chemical species and the relative concentrations of chemical species can differ among exposure conditions. Usually, metal toxicity is reduced by increased water hardness, which is composed of cations (primarily calcium and magnesium). In some cases, the apparent effect of hardness on toxicity might be partly due to complexation of the metal by higher concentrations of hydroxide and/or carbonate (increased pH and alkalinity) commonly associated with higher hardness. (USEPA, 2007)

(Porter-Cologne Act). The Porter-Cologne Act grants the State Water Resource Control Board (SWRCB) and the Regional Water Quality Control Boards (RWQCBs) power to protect water quality and is the primary vehicle for implementation of California's responsibilities under the federal Clean Water Act. The Porter-Cologne Act grants the SWRCB and the RWQCBs authority and responsibility to adopt plans and policies, to regulate discharges of waste to surface and groundwater, to regulate waste disposal sites and to require cleanup of discharges of hazardous materials and other pollutants. The Porter-Cologne Act also establishes reporting requirements for unintended discharges of any hazardous substance, sewage, or oil or petroleum product.

Each RWQCB must formulate and adopt a water quality control plan (Basin Plan) for its region. The Basin Plan must conform to the policies set forth in the Porter-Cologne Act and established by the SWRCB in its state water policy. To implement State and Federal law, the Basin Plan establishes beneficial uses for surface and groundwaters in the region, and sets forth narrative and numeric water quality standards to protect those beneficial uses. The Porter-Cologne Act also provides that a RWQCB may include within its regional plan water discharge prohibitions applicable to particular conditions, areas, or types of waste.

3.5. Basin Plan

The applicable Basin Plan (LARWQCB, 1994, as amended) provides quantitative and narrative criteria for a range of water quality constituents applicable to certain receiving water bodies and groundwater basins within the Los Angeles Region. Specific criteria are provided for the larger, designated water bodies within the region, as well as general criteria or guidelines for ocean waters, bays and estuaries, inland surface waters, and groundwaters. In general, the narrative criteria require that degradation of water quality does not occur due to increases in pollutant loads that will adversely impact the designated beneficial uses of a water body. For example, the Los Angeles Basin Plan requires that "Inland surface waters shall not contain suspended or settleable solids in amounts which cause a nuisance or adversely affect beneficial uses as a result of controllable water quality factors." Water quality criteria apply within receiving waters as opposed to applying directly to runoff; therefore, water quality criteria from the Basin Plan are utilized as benchmarks as one method to evaluate the potential ecological impacts of NRSP subregion project runoff on the receiving waters of the proposed project. Table 2-2 above lists the beneficial uses of applicable receiving surface waters.

The Basin Plan also contains water quality criteria for groundwater basins. For example, the Basin Plan requires that "Groundwaters shall not contain taste or odor producing substances in concentrations that cause nuisance or adversely affect beneficial uses." Table 2-38 above lists the beneficial uses of the applicable groundwater basin.

3.6. MS4 Permit

In 2001, the Los Angeles Regional Water Quality Control Board (LARWQCB, 2001) issued an NPDES Permit and Waste Discharge Requirements (Order No. 01-182) under the CWA and the Porter-Cologne Act for discharges of urban runoff in public storm drains in Los Angeles County. The Permittees are the Los Angeles County cities and the County (collectively "the Co-Permittees"). This permit regulates stormwater discharges from MS4s in the NRSP subregion. The NPDES permit details requirements for new development and significant redevelopment, including specific sizing criteria for treatment BMPs and flow control requirements.

To implement the requirements of the NPDES permit, the Co-permittees have developed development planning guidance and control measures that control and mitigate stormwater quality and quantity impacts to receiving waters as a result of new development and redevelopment. They are also required to implement other municipal source detection and elimination programs, as well as maintenance measures.

3.6.1. Stormwater Quality Management Program

The MS4 Permit contains the following provisions for implementation of the Stormwater Quality Management Program (SQMP) by the Co-permittees:

- General Requirements – Each Permittee is required to implement the SQMP to comply with applicable storm water program requirements and implement additional controls where necessary to reduce the discharge of pollutants in stormwater to the "maximum extent practicable" (MEP).

- BMP Implementation – Permittees are required to implement the most effective combination of BMPs for stormwater/urban runoff pollution control.

- SQMP Revision – Permittees are required to revise the SQMP to comply with regional, watershed specific requirements, and/or waste load allocations for implementation of TMDLs for impaired waterbodies.

- Responsibilities of the Principal Permittee – The responsibilities of the Los Angeles County Department of Public Works (as the Principal Permittee) include, but are not limited to, coordinating activities necessary to comply with the NPDES permit, providing personnel and fiscal resources for SQMP updates and annual reports and summaries of reports required under the SQMP, and implementing a County-wide Monitoring Program and evaluating results of the monitoring program.

- Responsibilities of Permittees – Each Permittee is required to comply with the requirements of the SQMP applicable to the discharges within its boundaries.

- Watershed Management Committees (WMCs) – WMCs are comprised of a voting representative from each Permittee within the Watershed Management Areas (WMAs).

WMCs are required to facilitate efforts and exchange of information between Permittees, establish additional goals for WMAs, prioritize pollution control efforts, monitor implementation of tasks designated for the WMA, and assess the effectiveness of and recommend revisions to the SQMP.

- Legal Authority – Permittees are granted the necessary legal authority to prohibit non-storm water discharges to the storm drain system.

The objective of the SQMP is to reduce pollutants in urban stormwater discharges to the "maximum extent practicable" in order to attain water quality objectives and to protect the beneficial uses of receiving waters in Los Angeles County. Special provisions are provided in the MS4 permit to facilitate implementation of the SQMP. These provisions include:

- BMP substitution – Substitution of site-specific BMPs is allowed provided the alternative BMP will meet or exceed pollutant reduction of the original BMP, the fiscal burden of the original BMP is substantially greater than the proposed alternative, and the alternative BMP will be implemented within a similar time period.

- Public Information and Participation Program (PIPP) – This requires the Permittee to identify how public education needs were determined, who is responsible for developing and implementing the program, and the method used to determine its effectiveness.

- Industrial/Commercial Facilities Control Program – This requires the Permittee to develop a plan for managing stormwater runoff from industrial and commercial facilities. This program will track, inspect, and ensure compliance at industrial and commercial facilities that are sources of pollutants in storm water.

- Development Planning Program – This requires the Permittee to implement a development-planning program that requires new development and redevelopment projects to minimize impacts from stormwater and urban runoff.

- Development Construction Program – This requires the Permittee to implement a program to control runoff from construction activity to minimize erosion and transportation of sediment and prevent non-stormwater discharges from equipment and vehicle washing.

- Public Agency Activities Program – This requires municipalities to evaluate existing public agency activities that have an impact on stormwater quality (such as vehicle maintenance, landscape maintenance and weed control, and construction and maintenance of streets, roads, and flood control systems) and to develop a program to reduce stormwater impacts with a schedule for implementation.

- Illicit Connections and Illicit Discharges Elimination Program – This requires each Permittee to have a plan for finding and preventing illegal connections and discharges and a mechanism for enforcing against illegal connections and discharges.

3.6.2. Standard Urban Stormwater Mitigation Plan

On March 8, 2000, the development planning program requirements, including the Standard Urban Stormwater Mitigation Plan requirements (collectively, development planning program requirements, including Standard Urban Stormwater Mitigation Pan requirements, are referred to in this report as SUSMP requirements) were approved by the RWQCB as part of the MS4 program to address stormwater pollution from new construction and redevelopment. The SUSMP contains a list of minimum BMPs that must be employed to infiltrate or treat stormwater runoff, control peak flow discharge, and reduce the post-project discharge of pollutants from stormwater conveyance systems. The SUSMP defines, based upon land use type, the types of practices that must be included and issues that must be addressed as appropriate to the development type and size. Compliance with SUSMP requirements is used as one method to evaluate significance of project development impacts on surface water runoff.

Finalized in May 2000, the County of Los Angeles' "Manual for the Standard Urban Stormwater Mitigation Plan" details the requirements for new development and significant redevelopment BMPs (Los Angeles County, 2000) (the "SUSMP Manual"). The SUSMP Manual is a model guidance document for use by Permittees and individual project owners to select post-construction BMPs and otherwise comply with the SUSMP requirements. It addresses water quality and drainage issues by specifying design standards for structural or treatment control BMPs that infiltrate or treat stormwater runoff and control peak flow discharge. BMPs are defined in the SUSMP Manual and SUSMP requirements as any program, technology, process, sizing criteria, operational methods or measures, or engineered systems, which, when implemented, prevent, control, remove, or reduce pollution. Treatment BMP sizing criteria and design guidance are also contained in the MS4 Permit and in the Manual.

One of the most important requirements within the SUSMP is the specific sizing criteria for stormwater treatment BMPs for new development and significant redevelopment projects. The SUSMP includes sizing criteria for both volume-based and flow-based BMPs. The sizing criteria options for volume-based BMPs, such as extended detention basins, are as follows:

1. The 85th percentile 24-hour runoff event storm event determined as the maximized capture stormwater volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87 (WEF, 1998); or,

2. The volume of annual runoff based on unit basin storage volume, to achieve 80% or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/Commercial (1993); or,

3. The volume of runoff produced from a 0.75 inch storm event, prior to its discharge to a stormwater conveyance system; or,

4. The volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for "treatment" (0.75 inch average for the Los Angeles County Area) that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile, 24-hour runoff event.

Stormwater treatment facilities will be designed to meet or exceed the sizing standards contained in the SUSMP Manual. Volume-based treatment control BMPs for the NRSP projects will be sized to capture and treat 80 percent of the annual runoff volume, with a drawdown time of 48 hours. This methodology utilizes historical rainfall data with continuous simulation modeling to calculate the treatment volume for each treatment control BMP and is consistent with criteria 2 above.

Flow-based BMPs, such as vegetated swales, must be designed to infiltrate or treat the maximum flow rate generated from one of the following scenarios:

1. The flow of runoff produced from a rain event equal to at least 0.2 inches per hour intensity, or

2. The flow of runoff produced from a rain event equal to at least two times the 85th percentile hourly rainfall intensity for Los Angeles County, or

3. The flow of runoff produced from a rain event that will result in treatment of the same portion of runoff as treated using volumetric standards above.

Flow-based BMPs for the NRSP projects will be sized using a rainfall intensity of 0.3 inches per hour, which will result in treatment of the same portion of runoff as treated using volumetric standards above (criteria 3).

BMP sizing for each project within the NRSP will be finalized during the design stage by the project engineer with the final project-level hydrology study, which will be prepared and approved to ensure consistency with this analysis prior to issuance of a grading permit.

Also, the SUSMP includes general design specifications for individual priority project categories. These include:

- Single-Family Hillside Home
- 100,000 square foot commercial developments
- Restaurants
- Retail gasoline outlets

- Automotive repair shops
- Parking lots

For example, commercial developments must have properly designed loading and unloading dock areas, repair and maintenance bays, and vehicle equipment wash areas. Restaurants need to have properly designed equipment and accessory wash areas. Parking lots have to be properly designed to limit oil contamination and have regular maintenance of parking lot stormwater treatment systems (e.g., storm drain filters and biofilters).

The NRSP projects are required to incorporate appropriate SUSMP requirements into project plans as part of the development plan approval process. These project plans will identify the general design specifications related to parking lots and other project features associated with the NRSP projects. BMP designs will be evaluated in the Project Water Quality Technical Report (Project WQTR) to ensure consistency with this NRSP Sub-Regional SWMP as part of the project-level CEQA analysis. All BMPs to be included in the Project per the requirements and standards of this analysis and the Project WQTR will be incorporated into the Project SUSMP prepared for each NRSP development prior to the first to occur of issuance of grading permit or recordation of final tract map. (See Section 1.0)

3.6.3. Hydromodification and Peak Flow Control

Part 4. Section D.1. of the MS4 Permit notes that increased volume, velocity, and discharge duration of stormwater runoff from developed areas may potentially accelerate downstream erosion and impair habitat-related beneficial uses in Natural Drainage Systems. As a result, Section D.1. of the Permit stipulates that Permittees shall control post-development peak storm water runoff discharge rates, velocities and durations in Natural Drainage Systems to prevent accelerated stream erosion and to protect stream habitat. Natural Drainage Systems are defined by the Permit to include the Santa Clara River.

Further, under Part 4, § D.1 of the MS4 Permit, the County and its Co-permittees were required to develop and implement by February 1, 2005, numeric criteria for peak flow control in accordance with the findings of the Peak Discharge Impact Study analyzing the potential impacts on natural streams due to impervious development. The County of Los Angeles Department of Public Works and the Southern California Storm Water Monitoring Coalition had been conducting the study, but the study was not completed in time to meet the February 1st deadline. Therefore, on January 31, 2005, the County adopted and submitted to the LARWQCB an Interim Peak Flow Standard to be in effect until such time as a final standard can be adopted based on a completed study.

The adopted Los Angeles County Interim Peak Flow Standard was derived from a similar Interim Peak Flow Standard for Ventura County approved by the LARWQCB under the SUSMP requirements provisions of the MS4 Permit. The intent of the Interim Standard, as described by

the County in the cover letter dated January 31, 2005, signed by Donald L. Wolfe transmitting the Interim Standard to Jonathan Bishop of the LARWQB, is to provide protection for natural streams to the extent supported by findings from the ongoing study, and consistent with practical construction practices.

The Interim Peak Flow Standard adopted by the County is:

> *The Peak Flow Standard shall require that all postdevelopment runoff from a 2-year, 24-hour storm shall not exceed the predevelopment peak flow rate, burned, from a 2-year, 24-hour storm when the predevelopment peak flow rate equals or exceeds five cubic feet per second. Discharge flow rates shall be calculated using the County of Los Angeles Modified Rational Method. The Peak Flow Standard shall also require that postdevelopment runoff from the 50-year capital storm shall not exceed the predevelopment peak flow rate, burned and bulked, from the 50-year capital storm.*

In its cover letter dated January 31, 2005, signed by Donald L. Wolfe, transmitting the Peak Flow Interim Standard to Jonathan Bishop of the LARWQB, the County notes that upon completion of the Peak Discharge Impact Study, new peak flow standards may be determined to be appropriate.

Per §4.D(9) of the MS4 Permit, this NRSP Sub-Regional Stormwater Mitigation Plan provides an alternative performance standard for the NRSP projects to the Interim Peak Flow Standard. The NRSP projects will be conditioned to require, as a project design feature, sizing and design of hydraulic features as necessary to control hydromodification impacts in accordance with this NSRP Sub-Regional SWMP. See further Section 5.3 below.

3.7. Construction Permits

Pursuant to the CWA Section 402(p), requiring regulations for permitting of certain stormwater discharges, the State Water Resources Control Board (SWRCB) has issued a statewide general NPDES Permit and Waste Discharge Requirements for stormwater discharges from construction sites ((NPDES No. CAS000002) California Water Resources Control Board Resolution No. 2001-046; Modification of Water Quality Order 99-08-DWQ State Water Resources Control Board (SWRCB) National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges Associated with Construction Activity (adopted by the SWRCB on April 26, 2001)).

Under this Construction General Permit, discharges of stormwater from construction sites with a disturbed area of one or more acres (effective March 2003) are required to either obtain individual NPDES permits for stormwater discharges or be covered by the Construction General Permit. Coverage under the Construction General Permit is accomplished by completing and filing a Notice of Intent with the SWRCB. Each applicant under the Construction General Permit must ensure that a Stormwater Pollution Prevention Plan (SWPPP) is prepared prior to

grading and implemented during construction. The primary objective of the SWPPP is to identify, construct, implement, and maintain BMPs to reduce or eliminate pollutants in stormwater discharges and authorized non-stormwater discharges from the construction site during construction. Compliance with the requirements of the Construction General Permit is used as one method to evaluate project construction-related impacts on surface water quality.

3.8. General Waste Discharge Requirements for Dischargers of Groundwater From Construction and Project Dewatering

The Los Angeles Regional Water Quality Control Board has issued a General NPDES Permit and General Waste Discharge Requirements (WDRs) (Order No. R4-2003-0111, NPDES No. CAG994004) governing construction-related dewatering discharges within the project development areas (the "General Dewatering Permit.") This permit addresses discharges from temporary dewatering operations associated with construction and permanent dewatering operations associated with development. The discharge requirements include provisions mandating notification, sampling and analysis, and reporting of dewatering and testing-related discharges. The General Dewatering Permit authorizes such construction-related activities so long as all conditions of the permit are fulfilled. Compliance with the requirements of the General Dewatering Permit is used as one method to evaluate project construction-related impacts on surface water quality.

3.9. NPDES Permit for the Newhall Ranch WRP

On September 6, 2007, the Regional Water Quality Control Board, Los Angeles Region, approved Order No. R4-2007-0046, NPDES Permit No. CA0064556, effective October 27, 2007. This Order serves as the NPDES Permit for point source discharges from the Newhall Ranch WRP, pursuant to section 402 of the federal Clean Water Act and chapter 5.5, division 7 of the California Water Code. The Order also serves as the Waste Discharge Requirements for the new County Sanitation District with respect to discharges to the Santa Clara River, pursuant to article 4, chapter 4, of the California Water Code. Specifically, the Order specifies limitations and discharge requirements for the Newhall Ranch WRP, including discharge prohibitions, technology-based and water quality-based effluent limitations, receiving water limitations, and other provisions such as monitoring and reporting requirements.

3.10. Discharge of Fill or Dredge Materials

Hydrologic conditions of concern addressed in this report include instream changes in sediment transport, erosion, and sedimentation, and ultimately channel stability. There is a nexus between these concerns and the stream, habitat, and species protection programs administered by the United States Army Corps of Engineers (ACOE), California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service.

Section 404 of the Clean Water Act is a program that regulates the discharge of dredged and fill material into waters of the United States, including wetlands. Activities in waters of the United States that are regulated under this program include fills for development (including physical alterations to drainages to accommodate storm drainage, stabilization, and flood control improvements), water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming and forestry. USEPA and the ACOE have issued Section 404(b)(1) Guidelines (40 CFR 230) that regulate dredge and fill activities, including water quality aspects of such activities. Subpart C at Sections 230.20 thru 230.25 contains water quality regulations applicable to dredge and fill activities. Among other topics, these guidelines address discharges which alter substrate elevation or contours, suspended particulates, water clarity, nutrients and chemical content, current patterns and water circulation, water fluctuations (including those that alter erosion or sediment rates), and salinity gradients.

Section 401 of the Clean Water Act requires that any person applying for a federal permit or license which may result in a discharge of pollutants into waters of the United States must obtain a state water quality certification that the activity complies with all applicable water quality standards, limitations, and restrictions. Subject to certain limitations, no license or permit may be issued by a federal agency until certification required by Section 401 has been granted. Further, no license or permit may be issued if certification has been denied. CWA Section 404 permits and authorizations are subject to section 401 certification by the Regional Water Quality Control Boards (RWQCBs).

This report does not analyze the habitat and wildlife impacts associated with physical alterations to waters of the United States proposed in conjunction with NRSP projects, such as dredge, fill, or bed, bank or channel improvements or stabilization measures affecting waters of the U.S. The impacts associated with these physical alterations are analyzed in detail in the biota and floodplain modification sections of the NRSP RMDP and the related EIR/EIS. As discussed in Section 4.4.2 below, this report analyzes the adverse impacts to natural drainage systems that may be caused by the Project's alteration of hydrologic conditions. The report further analyzes water quality impacts associated with the NRSP projects, to support issuance of Section 401 Water Quality Certification and to allow preparation of Section 404(b)(1) analysis for NRSP Section 404 permits.

3.11. Lake or Streambed Alteration Agreement (LSAA)

The CDFG is responsible for conserving, protecting, and managing California's fish, wildlife, and native plant resources. To meet this responsibility, the law requires the proponent of a project that may impact a river, stream, or lake to notify the CDFG before beginning the project. This includes rivers or streams that flow at least periodically or permanently through a bed or channel with banks that support fish or other aquatic life and watercourses having a surface or subsurface flow that support or have supported riparian vegetation.

Section 1602 of the Fish and Game Code requires any person who proposes a project that will substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake or use materials from a streambed to notify the CDFG before beginning the project. Similarly, under section 1602 of the Fish and Game Code, before any State or local governmental agency or public utility begins a construction project that will: 1) divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake; 2) use materials from a streambed; or 3) result in the disposal or deposition of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into any river, stream, or lake, it must first notify the CDFG of the proposed project. If the CDFG determines that the project may adversely affect existing fish and wildlife resources, a Lake or Streambed Alteration Agreement is required.

As discussed above, this report does not analyze the habitat and wildlife impacts associated with physical alterations to waters of the United States proposed in conjunction with NRSP projects, such as dredge, fill, or bed, bank or channel improvements or stabilization measures affecting waters of the U.S. The impacts associated with these physical alterations are analyzed in detail in the biota and floodplain modification sections of the RMDP and the related EIR/EIS. As discussed in Section 4.4.2 below, this report analyzes the adverse impacts to natural drainage systems that may be caused by the project's alteration of hydrologic conditions.

4. POLLUTANTS OF CONCERN AND SIGNIFICANCE CRITERIA

4.1. Surface Water Pollutants of Concern

4.1.1. Pollutants of Concern

Pollutants of concern, as defined in the Los Angeles County SUSMP Manual, consist of any pollutants that exhibit one or more of the following characteristics: current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at concentrations or loads considered potentially toxic to humans and/or flora and fauna. The pollutants of concern for the water quality analysis are those that are anticipated or potentially could be generated by the project at concentrations, based on water quality data collected in Los Angeles County from land uses that are the same as those included in the NRSP, that exhibit these characteristics. Identification of the pollutants of concern also considered Basin Plan beneficial uses and water quality objectives, CTR criteria, and current 303(d) listings and TMDLs in the Santa Clara River, as well as pollutants that have the potential to cause toxicity or bioaccumulate in the receiving waters. Appendix A lists the pollutants of concern, the basis for their selection, and the significance criteria that will be applied for each.

The following pollutants were chosen as pollutants of concern for purposes of evaluating water based upon the above considerations:

***Sediments (TSS and Turbidity)*:** Excessive erosion, transport, and deposition of sediment in surface waters are a significant form of pollution resulting in major water quality problems. Sediment imbalances impair waters' designated uses. Excessive sediment can impair aquatic life by filling interstitial spaces of spawning gravels, impairing fish food sources, filling rearing pools, and reducing beneficial habitat structure in stream channels. In addition, excessive sediment can cause taste and odor problems in drinking water supplies and block water intake structures.

***Nutrients (Phosphorus and Nitrogen (Nitrate+Nitrite-N and Ammonia-N))*:** Nutrients of concern include inorganic forms of nitrogen (nitrate, nitrite and ammonia) and phosphorus. Organic forms of nitrogen are associated with vegetative matter such as particulates from sticks and leaves. Inorganic forms of nitrogen include nitrate, nitrite and ammonia. Total Nitrogen (TN) is a measure of all nitrogen present, including inorganic and particulate forms. Phosphorus can be measured as total phosphorus (TP) or as dissolved phosphorus. Dissolved phosphorus is the more bioavailable form of phosphorus. TP is often composed mostly of soil-related particulate phosphorus. There are several sources of nutrients in urban areas, mainly fertilizers in runoff from lawns, pet wastes, failing septic systems, atmospheric deposition from industry and automobile emissions, and soil erosion. Nutrient over-enrichment is especially prevalent in

agricultural areas where manure and fertilizer inputs to crops significantly contribute to nitrogen and phosphorus levels in streams and other receiving waters. Eutrophication due to excessive nutrient input can lead to changes in algae, benthic, and fish communities; extreme eutrophication can cause hypoxia or anoxia, resulting in fish kills. Surface algal scum, water discoloration, and the release of toxins from sediment can also occur.

Various downstream reaches of the Santa Clara River are identified as impaired by ammonia and nitrate- plus nitrite-nitrogen. Evidence of impairment includes low diversity of benthic macroinvertebrates and observations of excessive algae growth. A source analysis found that the majority of ammonia and nitrate/nitrite loads are from point sources; primarily water reclamation plants (WRPs) (LARWQCB, 2003). Sources from municipal storm sewers are considered a minor source, but have a potential to cause significant local effects on water quality (LARWQCB, 2003). TMDLs have been developed and adopted into the Basin Plan for nitrogen compounds, including nitrate/nitrite and ammonia.

***Trace Metals (Aluminum, Copper, Lead, and Zinc)*:** The primary sources of trace metals in stormwater are typically commercially available metals used in transportation (e.g. automobiles), buildings, and infrastructure. Metals are also found in fuels, adhesives, paints, and other coatings. Copper, lead, and zinc are the most prevalent metals typically found in urban runoff. Other trace metals, such as cadmium, chromium, and mercury, are typically either not detected in urban runoff or are detected at very low levels (LACDPW, 2000). Metals are of concern because of the potential for toxic effects on aquatic life and the potential for groundwater contamination. High metal concentrations can lead to bioaccumulation in fish and shellfish and affect the beneficial uses of receiving waters.

Aluminum has been identified by the Los Angeles County Department of Public Works as a constituent of concern for the Santa Clara River based on monitoring conducted at mass emission Station S29 (see Section 2.3 above). In stormwater, the majority of aluminum is in the particulate phase. Its presence in stormwater is mainly due to aluminosilicate minerals found in soils, because stormwater particles are largely composed of eroded soils. Aluminum is a large component of soils and is the third most common element in the earth's crust. The average aluminum soil content is about eight percent (or 80,000 mg/kg) and suspended sediments in rivers have total aluminum contents of a similar order of magnitude. Aluminosilicates include a wide range of minerals with varying properties; some are formed during the laying down of the earth's crust and some by weathering processes. They are highly insoluble and unreactive, although aluminum can be extracted and solubilized to some degree under acidic conditions. The amount of aluminum extracted will mainly depend on the type and particle size of aluminosilicates present in the soil matrix. A study by Kobayashi and Kizu (2001) showed that only eight percent of aluminum remained in waters after passing through a 0.22 micron filter, supporting the assertion that the majority of aluminum is found in the insoluble, suspended fraction. According to the USEPA, aluminum is not considered a contaminant of potential concern to fish or aquatic organisms when surrounding soil pH is greater than 5.5 or when in

solution of a pH above 5.5 (USEPA 2003) because aluminum solubility and resultant toxicity has been linked to pH values below this standard. In general, NRSP area soils are not expected to have a pH of less than 5.5. DeClerk and Singer (2003) compared historic (1945) pH levels of agricultural soils in Southern California to 2001 conditions and found that pH levels have actually risen, from approximately 7.2 in 1945 to nearly 8.0 in 2001. As the majority of the pre-development land use consists of agriculture or open space, it is safe to assume that soil pH levels within the NRSP area will be, for the most part, above 5.5. In addition, pH in stormwater runoff is not expected to be below 5.5, as mean runoff concentrations in the Los Angeles County stormwater monitoring data ranged from 6.5 for mixed and single-family residential land uses to 7.0 for commercial land uses. In urban areas, aluminum building materials are a minor source of aluminum, as the metal is coated in unreactive aluminum oxide.

Pathogens (Bacteria, Viruses, and Protozoa) – Elevated pathogens are typically caused by the transport of domestic animal, wildlife, or human fecal wastes from the watershed. Runoff that flows over land such as urban runoff can mobilize pathogens, including bacteria and viruses. Even runoff from natural areas can contain pathogens (e.g., from wildlife). Other sources of pathogens in urban areas include pets, septic systems and leaky sanitary sewer pipes. The presence of pathogens in runoff can impair receiving waters and contaminate drinking water sources. Elevated pathogens are typically caused by the transport of animal or human fecal wastes from the watershed. Historically an indicator organism such as fecal coliform has been used for pathogens due to the difficulty of monitoring for pathogens directly. More recently, the scientific community has questioned the use of indicator organisms, as scientific studies have shown no correlation between indictor and pathogen levels and therefore total and fecal coliform may not indicate a significant potential for causing human illness (Paulsen and List, 2005). Santa Clara River Reach 5 is identified as impaired by high fecal coliform counts from point and nonpoint sources. Coliform TMDLs have not yet been developed for this river reach.

Petroleum Hydrocarbons (Oil and Grease and PAHs)**:** The sources of oil, grease, and other petroleum hydrocarbons in urban areas include spillage fuels and lubricants, discharge of domestic and industrial wastes, atmospheric deposition, and runoff. Runoff can be contaminated by leachate from asphalt roads, wearing of tires, and deposition from automobile exhaust. Also, do-it-yourself auto mechanics may dump used oil and other automobile-related fluids directly into storm drains. Petroleum hydrocarbons, such as polycyclic aromatic hydrocarbons (PAHs), can bioaccumulate in aquatic organisms from contaminated water, sediments, and food and are toxic to aquatic life at low concentrations. Hydrocarbons can persist in sediments for long periods of time and result in adverse impacts on the diversity and abundance of benthic communities. Hydrocarbons can be measured as total petroleum hydrocarbons (TPH), oil and grease, or as individual groups of hydrocarbons, such as PAHs.

Pesticides**:** Pesticides (including herbicides, insecticides and fungicides) are chemical compounds commonly used to control insects, rodents, plant diseases, and weeds. Excessive application of a pesticide in connection with agriculture cultivation or landscaping may result in

runoff containing toxic levels of its active component. Pesticides may be classified as organochlorine pesticides or organophosphorus pesticides, the former being associated with persistent bioaccumulative pesticides (e.g., DDT and other legacy pesticides) which have been banned. The Santa Clara River estuary is listed as impaired for legacy pesticides. Organophosphorus pesticides include diazinon and chlorpyrifos whose uses also are being restricted by USEPA.

***Trash & Debris*:** Trash (such as paper, plastic, polystyrene packing foam, and aluminum materials) and biodegradable organic debris (such as leaves, grass cuttings, and food waste) are general waste products on the landscape that can be entrained in urban runoff. The presence of trash & debris may have a significant impact on the recreational value of a water body and aquatic habitat. Excess organic matter can create a high biochemical oxygen demand in a water body and thereby lower its water quality. Also, in areas where stagnant water exists, the presence of excess organic matter can promote septic conditions resulting in the growth of undesirable organisms and the release of odorous and hazardous compounds such as hydrogen sulfide.

***Bioaccumulation*:** Certain pollutants, such as pesticides, selenium and mercury, have a tendency to bioaccumulate. The Basin Plan and the CTR criteria set forth toxicity objectives for receiving water levels of substances that bioaccumulate in aquatic resources to prohibit concentrations of toxic substances that are harmful to human health and adversely affect beneficial uses.

***Chloride*:** High levels of chloride in Santa Clara River Reaches 3, 5 and 6 are causing impairment of listed beneficial uses for agricultural irrigation. Irrigation of salt sensitive crops, such as avocados and strawberries, with water containing elevated levels of chloride can result in reduced crop yields. Chloride levels in some areas exceed water quality standards associated with groundwater recharge. Chloride TMDLs have been developed and adopted into the Basin Plan. The major sources of elevated chloride are dry weather discharges from WRPs, contributing about 70% of the chloride load. Minor point sources are dewatering operations, and swimming pool and water ride discharges.

Methylene Blue Activated Substances (MBAS). MBAS are related to the presence of detergents in water. Positive results may indicate the presence of wastewater or be associated with urban runoff due to commercial and/or residential vehicle washing or other outdoor washing activities. Surfactants disturb the surface tension which negatively affects insects and can also harm the gills in aquatic life.

Cyanide. Cyanide has been identified by the Los Angeles County Department of Public Works as a constituent of concern for the Santa Clara River based on monitoring conducted at mass emission Station S29 (LACDPW, 2005). Cyanide is used in electroplating, metallurgy, and mining. It is also used to make synthetic fibers, plastics, dyes, pharmaceuticals, and pesticides, including fumigants. In addition, cyanide serves as a chemical intermediate in various

production processes. Natural cyanides are produced by certain bacteria, fungi, and algae, and they are present in a number of plants and foods as cyanogenic glycosides. Man-made cyanides typically enter the environment from metal finishing and organic chemical industries. Other sources include iron and steel works, municipal waste burning, cyanide-containing pesticides, road deicers, and vehicle exhaust.

4.1.2. Other Constituents

This section discusses other constituents that are listed in the Basin Plan, but for reasons explained below, are not pollutants of concern for the NRSP subregion.

BOD (Biochemical Oxygen Demand) and Dissolved Oxygen. Adequate levels of dissolved oxygen are necessary to support aquatic life. High levels of oxygen demanding substances discharged to receiving waters can depress oxygen levels to levels of concern. Oxygen demanding substances are compounds that can be biologically degraded through aerobic processes. The presence of oxygen demanding substances can deplete oxygen supplies in waters and can contribute to algal growth. Nutrients in fertilizers and food wastes in trash are examples of likely oxygen demanding compounds to be present on the NRSP subregion site. Other biodegradable organic materials include human and animal waste and vegetative matter. Biodegradable pollutants are largely subsumed by the nutrients and trash and debris categories above, and therefore will not be discussed as a separate category.

Chemical Constituents. Chemical constituents in excessive amounts in drinking water are harmful to human health. The Basin Plan objective for chemical constituents states: "Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use." As Santa Clara River Reach 5 is not designated with a municipal water supply designated use (see Section 2.2.4 above), chemical constituents are not a pollutant of concern for the NRSP subregion.

Temperature. Increase in temperature can result in lower dissolved oxygen levels, impairing habitat and other beneficial uses of receiving waters. Discharges of wastewater can also cause unnatural and/or rapid changes in temperature of receiving waters, which can adversely affect aquatic life. Elevated temperatures are typically associated with discharges of process wastewaters or non-contact cooling waters. As the beneficial uses in the receiving waters for the NRSP subregion include warm freshwater habitat to support warm water ecosystems, temperatures of stormwater runoff in the NRSP subregion are not of concern.

Total Residual Chlorine. Total residual chlorine can be present in wastewater treatment plant discharges, or may be present in dry weather urban runoff from the emptying of swimming pools that have not been de-chlorinated. Chlorine is a strong oxidant and is therefore very toxic to aquatic life. Municipal pools and private pools in areas served by a municipal sanitary system

are required to be discharged into the sanitary system, and therefore, total residual chlorine will not be present in runoff from the NRSP projects.

Color, Taste, and Odor. The Basin Plan contains narrative objectives for color, taste, or odor that causes a nuisance or adversely affects beneficial uses. Undesirable tastes and odors in water may be a nuisance and may indicate the presence of a pollutant(s). Odor associated with water can result from decomposition of organic matter or the reduction of inorganic compounds, such as sulfate. Other potential sources of odor causing substances, such as heavy industrial processes, will not occur as part of the NRSP projects. Color in water may arise naturally, such as from minerals, plant matter, or algae, or may be caused by industrial pollutants. Project land uses will include business park uses such as light manufacturing, warehousing and distribution, not heavy industrial land uses. Therefore, color-, taste-, or odor-producing substances are not pollutants of concern for the NRSP projects.

Exotic Vegetation. Non-native (exotic) vegetation typically provides little habitat value and can out compete native vegetation that is more suitable habitat for aquatic and terrestrial organisms. The Basin Plan objective for exotic vegetation states: "Exotic vegetation shall not be introduced around stream courses to the extent that such growth causes nuisance or adversely affects designated beneficial uses." The removal of non-native plant species from natural drainages is addressed in the RMDP.

Mineral Quality: TDS, Sulfate, Boron, and SAR. Mineral quality in natural waters is largely determined by the mineral assemblage of soils and rocks near the land surface. Elevated mineral concentrations could impact beneficial uses; however, the minerals listed in the Basin Plan, except chloride and nitrogen, are not believed to be constituents of concern due to the absence of river impairments and/or, as with TDS, anticipated post-development runoff concentrations well below the Basin Plan objectives (Table 4-1). Therefore, these constituents are not considered pollutants of concern for the NRSP projects.

Table 4-1: Comparison of Mineral Basin Plan Objectives with Mean Measured Values in LA County

Mineral	Los Angeles Basin Plan Water Quality Objective for SCR Reach 5 (mg/L)	Range of Mean Concentration in Urban Runoff[1] (mg/L)
Total Dissolved Solids	1000	53 - 226
Sulfate	400	7 - 35
Boron	1.5	0.16 – 0.25
Sodium Absorption Ratio[2]	10	0.4 – 1.9

[1]Source: LACDPW, 2000. Land uses include SFR, MFR, commercial, education, transportation, light industrial, and mixed residential.
[2]Sodium adsorption ratio (SAR) predicts the degree to which irrigation water tends to enter into cation-exchange reactions in soil.

pH. The hydrogen ion activity of water (pH) is measured on a logarithmic scale, ranging from 0 to 14. While the pH of "pure" water at 25 ºC is 7.0, the pH of natural waters is usually slightly basic due to the solubility of carbon dioxide from the atmosphere. Aquatic organisms can be highly sensitive to pH. The Basin Plan objective for pH is:

> "the pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge."

Mean runoff concentrations in the Los Angeles County stormwater monitoring data ranged from 6.5 for mixed- and single-family residential land uses to 7.0 for commercial land use. Therefore, pH in the Santa Clara River is not expected to be affected by runoff discharges from the NRSP projects.

PCBs. PCBs are highly toxic persistent chemicals that have been historically released into the environment from industrial uses, such as transformers, but are no longer produced in the United States. Due to their persistence, PCBs can still be detected in urban runoff due to historic industrial sources of these chemicals. The NRSP subregion area did not historically include PCB-producing land uses. Therefore, PCBs are not a pollutant of concern for the NRSP projects.

Radioactive Substances. Radioactive substances typically occur at very low concentrations in natural waters. Some activities such as mining or certain industrial activities (e.g., energy production, fuel reprocessing) can increase the amount of radioactive substances impairing beneficial uses. The NRSP projects will not have industrial or other activities that would be a source of any radioactive substances, and development will stabilize any naturally radioactive soils, though unlikely to be present in the NRSP subregion. Therefore, radioactive substances are not a pollutant of concern for the NRSP projects.

Toxicity. Certain pollutants in stormwater runoff have the potential to be highly toxic to aquatic organisms resulting in effects such as impaired reproduction or mortality. The Basin Plan water quality objective for toxicity is:

> "All surface waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life."

Toxicity in urban runoff could be caused by ammonia, trace metals, PAHs, or pesticides. These constituents are subsumed by the pollutant of concern categories above.

4.2. Groundwater Pollutants of Concern

The NRSP projects will allow for incidental infiltration of urban runoff to groundwater after receiving treatment in the PDFs, as well as incidental infiltration of irrigation water. Research

conducted on the effects on groundwater from stormwater infiltration by Pitt *et. al.* (1994) indicate that the potential for contamination is dependent on a number of factors including the local hydrogeology and the chemical characteristics of the pollutants of concern.

Chemical characteristics that influence the potential for groundwater impacts include high mobility (low absorption potential), high solubility fractions, and abundance in runoff, including dry weather flows. As a class of constituents, trace metals tend to adsorb onto soil particles and are filtered out by the soils. This has been confirmed by extensive data collected beneath stormwater detention/retention ponds in Fresno (conducted as part of the Nationwide Urban Runoff Program (Brown & Caldwell, 1984)) that showed that trace metals tended to be adsorbed in the upper few feet in the bottom sediments. Bacteria are also filtered out by soils. More mobile constituents such as chloride and nitrate would have a greater potential for infiltration.

4.2.1. Pollutants of Concern

The pollutants of concern for the groundwater quality analysis are those that are anticipated or potentially could be generated by the NRSP projects at concentrations, based on water quality data collected in Los Angeles County from land uses that are the same as those included in the NRSP that exhibit these characteristics. Identification of the pollutants of concern for the NRSP projects considered proposed land uses as well as pollutants that have the potential to impair beneficial uses of the groundwaters below the NRSP subregion. The Los Angeles Basin Plan contains numerical objectives for bacteria, mineral quality, nitrogen, and various toxic chemical compounds, and contains qualitative objectives for taste and odor.

Nitrate+nitrite-N was chosen as the pollutant of concern for purposes of evaluating groundwater quality impacts based upon the above considerations. High nitrate levels in drinking water can cause health problems in humans. Infants can develop methemoglobinemia (blue-baby syndrome). Human activities and land use practices can influence nitrogen concentrations in groundwaters. For example, irrigation water containing fertilizers can increase levels of nitrogen in groundwater.

4.2.2. Other Constituents

Bacteria: The Basin Plan contains numeric criteria for bacteria in drinking water sources. As bacteria are removed through straining in soils (for example, as with septic tank discharges), incidental infiltration of runoff in the treatment PDFs is not expected to affect bacteria levels in groundwater. The WRP will include a disinfection process to reduce bacteria below levels of concern, and therefore bacteria in irrigation water are not expected to impact groundwater.

Chemical Constituents and Radioactivity: Drinking water limits for inorganic and organic chemicals that can be toxic to human health in excessive amounts and radionuclides are contained in Title 22 of the California Code of Regulations. These chemicals and radionuclides

are not expected to occur in the NRSP project's runoff. Title 22 specifies California's Wastewater Reclamation Criteria (WRC) and the NRSP WRP's reclaimed water must meet or exceed these criteria. These criteria apply to the treatment processes; treatment performance standards, such as removal efficiencies and effluent water quality; process monitoring programs, including type and frequency of monitoring; facility operation plans; and necessary reliability features.

Taste and Odor. The Basin Plan contains a narrative objective for taste and odor that cause a nuisance or adversely affect beneficial uses. Undesirable tastes and odors in groundwater may be a nuisance and may indicate the presence of a pollutant(s). Odor associated with water can result from natural processes, such as the decomposition of organic matter or the reduction of inorganic compounds, such as sulfate. Other potential sources of odor causing substances, such as industrial processes, will not occur as part of the Project. Therefore, taste and odor-producing substances are not pollutants of concern for the NRSP projects.

Mineral Quality: TDS, Sulfate, Chloride, and Boron. Mineral quality in groundwaters is largely influenced by the mineral assemblage of soils and rocks that it comes into contact with. Elevated mineral concentrations could impact beneficial uses; however, the minerals listed in the Basin Plan are not believed to be pollutants of concern due to the anticipated runoff concentrations and the expected mineral concentrations in Newhall Ranch WRP irrigation water, which are below the Basin Plan groundwater objectives (Table 4-2).

As required by the CWA, the Newhall Ranch WRP discharge permit includes effluent limitations that are protective of receiving water quality and designated beneficial uses (LARWQCB, 2007). Effluent limits in the WDR were developed based on the most stringent of applicable technology-based and water quality-based standards, including Basin Plan surface and groundwater objectives, CTR criteria, and applicable TMDL waste load allocations. Therefore, these constituents are not considered pollutants of concern for the Project.

Table 4-2: Comparison of Basin Plan Mineral Groundwater Objectives with Mean Measured Values in LA County Urban Runoff and Anticipated Irrigation Water Quality

Mineral	Los Angeles Basin Plan Groundwater Quality Objective[1] (mg/L)	Range of Mean Concentrations in Urban Runoff[2] (mg/L)	Anticipated Average Concentration in Effluent from the NRSP WRP[3](mg/L)
Total Dissolved Solids	1,000	53 – 237	790
Sulfate	350	7 – 35	165
Chloride	150	4 – 50	<100
Boron	1.0	0.2 – 0.3	0.69

[1]Eastern Santa Clara-Castaic Valley
[2]Source: LACDPW, 2000. Includes all monitored land uses.
[3]Source: CH2M Hill, 2007.

4.3. Hydrologic Conditions of Concern (Hydromodification)

Urbanization modifies natural watershed and stream hydrologic and geomorphic processes by introducing increased volumes and duration of flow via increased runoff from impervious surfaces and drainage infrastructure. Several studies have evaluated affects of increased runoff associated with the introduction of impervious surfaces and drainage facilities on geomorphic processes (SCCWRP, 2005a; Geosyntec, 2002; Bledsoe & Watson, 2001; Booth, 1990; Hollis, 1975; Hammer, 1972). Potential changes to the hydrologic regime may include increases in runoff volumes, frequency of runoff events, long-term cumulative duration, as well as increased peak flows. Urbanization may also introduce dry weather flows where only wet weather flows existed prior to development. These changes are referred to as "hydromodification."

Hydromodification intensifies sediment transport and often leads to stream channel enlargement and loss of habitat and associated riparian species (SCCWRP, 2005a; Geosyntec, 2002; Bledsoe & Watson, 2001; MacRae, 1992; Booth, 1990). Under certain circumstances, development can also cause a reduction in the amount of sediment supplied to the stream system, which can lead to stream channel incision and widening. These changes also have the potential to impact downstream channels and habitat integrity. A project that increases runoff due to impervious surfaces and traps sediment from upland watershed sources creates compounding effects.

A change to the project site's hydrologic regime would be considered a condition of concern if the change could have a significant impact on downstream natural channels and habitat integrity, alone or in conjunction with impacts of other projects.

4.4. Significance Criteria and Thresholds for Significance

4.4.1. Surface Water Quality Significance Thresholds

Appendix A provides the criteria for evaluating the significance of a potential impact for each pollutant of concern. These criteria and the thresholds for significance can be summarized as follows. The application of the criteria to a decision regarding significance requires an integrated or "weight of evidence" approach, rather than a decision based on any one of the individual criterion.

Thresholds of significance for surface water quality impacts have been developed based on a review of the MS4 Permit and the CEQA Guidelines, Appendix G. Significant adverse water quality impacts are presumed to occur if the proposed project would:

- Create sizeable additional sources of polluted runoff to receiving waters that would result in exceedances of receiving water quality or substantially degrade water quality in receiving waters.

- Create sizeable additional sources of polluted runoff that would violate any water quality standards or waste discharge requirements for surface water runoff.

- Create sizeable additional sources of polluted construction site runoff (including polluted discharges associated with construction activities such as materials delivery, staging or storage, vehicle or equipment fueling, vehicle or equipment maintenance, waste handling, or hazardous materials handling or storage) that would violate any water quality standards or waste discharge requirements for surface water runoff or groundwater discharge.

This report analyzes whether sizeable additional sources of polluted runoff may result from the project based on the results of water quality modeling and qualitative assessments that take into account water quality controls or BMPs that are considered Project Design Features (PDFs). Any increases in pollutant concentrations or loads in runoff resulting from the development of the project site are considered an indication of a potentially significant adverse water quality impact. If loads and concentrations resulting from development are predicted to stay the same or to be reduced when compared with existing conditions, it is concluded that the project will not cause a significant adverse impact to the ambient water quality of the receiving waters for that pollutant.

If pollutant loads or concentrations are expected to increase, then for both the post-development and construction phases, potential impacts are assessed by evaluating compliance of the project, including PDFs, with applicable regulatory requirements of the MS4 Permit, including SQMP and SUSMP requirements, the Construction General Permit, and the General Dewatering Permit. Further, post-development increases in pollutant loads and concentrations are evaluated by comparing the magnitude of the increase to relevant benchmarks, including receiving water TMDLs and receiving water quality objectives and criteria from the Basin Plan and CTR, as described below.

Receiving Water Benchmarks. Comparison of post-development water quality concentrations in the runoff discharge with benchmark TMDL waste load or load allocations for MS4 discharges establishes the likelihood that runoff would result in TMDL exceedances in receiving waters or would otherwise degrade receiving water quality.

Comparison of post-development water quality concentrations in the runoff discharge with benchmark numeric and narrative receiving water quality criteria as provided in the Basin Plan and the CTR facilitates analysis of the potential for runoff to result in exceedances of receiving water quality standards, adversely affect beneficial uses, or otherwise degrade receiving waters.

Water quality criteria are considered benchmarks for comparison purposes only, as such criteria apply within receiving waters as opposed to applying directly to runoff discharges. Narrative and numeric water quality objectives contained in the Basin Plan apply to the project's receiving waters. Water quality criteria contained in the CTR provide concentrations that are not to be exceeded in receiving waters more than once in a three year period for those waters designated

with aquatic life or human health related uses. Projections of runoff water quality are compared to the acute form of the CTR criteria (as discussed above), as stormwater runoff is associated with episodic events of limited duration, whereas chronic criteria apply to 4-day exposures which do not describe typical storm events in the NRSP subregion, which last 11 hours on average. If pollutant levels in runoff are not predicted to exceed receiving water benchmarks, it is one indication that no significant impacts will result from project development.

As there is no water quality objective or criteria for total aluminum in the Basin Plan or the CTR, the national water quality criteria recommended by the USEPA will be used for comparison (USEPA, 1988).

MS4 Permit Requirements for New Development (SUSMP). Satisfaction of MS4 Permit requirements for new development, including SUSMP requirements and SQMP requirements, and satisfaction of construction-related requirements of the Construction General Permit and General Dewatering Permit establish compliance with water quality regulatory requirements applicable to stormwater runoff.

The MS4 Permit requires that the SQMP specify BMPs that will be implemented to reduce the discharge of pollutants in stormwater to the Maximum Extent Practicable. MS4 requirements are met when new development complies with the SUSMP requirements set forth in the MS4 Permit. Under the SUSMP requirements, the effectiveness of stormwater treatment controls are primarily based on two factors - the amount of runoff that is captured by the controls and the selection of BMPs to address identified pollutants of concern. Selection and numerical sizing criteria for new development treatment controls are included in the MS4 Permit and the County SUSMP Manuals. If the project PDFs meet these criteria, and other source control and site design BMPs consistent with the SUSMP requirements are implemented, it indicates that no significant impacts will occur as the result of insufficient capacity for stormwater treatment.

Construction General Permit and General Dewatering Permit. The Construction General Permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP) that describes erosion and sediment control BMPs as well as material management/ non-stormwater BMPs that will be used during the construction phase of development. The General Dewatering Permit addresses discharges from permanent or temporary dewatering operations associated with construction and development and includes provisions mandating notification, sampling and analysis, and reporting of dewatering and testing-related discharges. To evaluate significance of construction phase project water quality impacts, we evaluate whether water quality control is achieved by implementation of BMPs consistent with Best Available Technology Economically Achievable and Best Conventional Pollutant Control Technology (BAT/BCT), as required by the Construction General Permit and the General Dewatering Permit.

4.4.2. Significance Thresholds for Hydrologic Conditions of Concern (Hydromodification Impacts)

Thresholds of significance for evaluating hydrologic impacts and conditions of concern have been developed based on a review of the MS4 Permit and the CEQA Guidelines, Appendix G. Significant adverse impacts to natural drainage systems created by altered hydrologic conditions of concern are presumed to occur if the proposed project would:

- Substantially alter the existing drainage pattern of a natural drainage, stream, or river causing substantial erosion, siltation, or channel instability in a manner that substantially adversely affects beneficial uses; or

- Substantially increase the rates, velocities, frequencies, duration and/or seasonality of flows causing channel instability and harming sensitive habitats or species in natural drainages in a manner that substantially adversely affects beneficial uses.

4.4.3. Cumulative Impacts

CEQA requires the analysis of cumulative impacts of a project when the project's incremental effects may be significant when assessed along with the effects of past projects and the effects of other current projects, and the reasonably foreseeable effects of probable future projects. The discussion of cumulative impacts must reflect the potential severity of the impacts and their likelihood of occurrence, but the discussion and analysis need not provide as great a detail as is provided for the direct effects attributable to the project alone. This report therefore analyzes the potential for cumulative water quality impacts, cumulative groundwater quality impacts, and cumulative hydrologic impacts generally in accordance with the thresholds for direct impacts discussed in Sections 4.4.1 and 4.4.2 above, and Section 4.4.4 below. See Sections 7.7, 7.8 and 7.9 below.

The cumulative analysis of all surface water quality and hydrologic impacts in this report is based primarily on "adopted plans and projections" found in the Los Angeles County Department of Public Works adopted and approved Hydrology Manual, which have been verified by reference to approved plans, including the City of Santa Clarita and County of Los Angeles adopted General Plans, as well as available empirical data for the Santa Clara River. As required by CEQA, the focus of the cumulative impacts analysis for this project will be on the project's incremental contribution to significant adverse water quality and hydrologic impacts to the SCR, taking into account the reasonably foreseeable water quality and hydrologic impacts of other projects that may develop impervious surfaces and urban land uses within the SCR watershed in accordance with adopted general plans and related projections. The cumulative impacts analysis will consider the project's incremental contribution to significant cumulative water quality and hydrologic impacts to the SCR in light of the water quality and hydrology impact mitigation achieved by certain of the PDFs. The analysis will also consider whether the project, including PDFs, and future projects, including the Newhall Ranch WRP, will comply

with specific requirements in a previously approved ordinance, plan or mitigation program (such as the Basin Plan, the CTR, the MS4 Permit, the Construction General Permit, the General Dewatering Permit, and WRP regulations and permit conditions) that have been adopted for the purpose of avoiding or substantially lessening the cumulative water quality and hydrologic impact problems within the geographic area in which the project is located.

4.4.4. Groundwater Quality Impacts

Thresholds of significance for evaluating the hydrologic and water quality impacts of the NRSP projects on groundwater have been developed based on CEQA Appendix G thresholds. Significant adverse impacts to groundwater are presumed to occur if the proposed project would:

- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge so as to cause a net deficit in aquifer volume or a lowering of the local groundwater table.

- Through changes in surface water runoff quality and quantity (including project treatment PDFs), and changes in groundwater recharge, result in a violation of any groundwater quality standards or waste discharge requirements or otherwise substantially degrade water quality.

Groundwater quality is addressed in Sections 7.8.1 and 7.8.2. Groundwater quality benchmarks were compared with post-development runoff water quality to establish the likelihood that runoff would result in a degradation of groundwater quality. Groundwater recharge is addressed in Section 7.8.3. The hydrologic effects of the NRSP projects on groundwater were examined by comparison of historical and present levels of the underlying aquifer to determine the impact of development on aquifer volume.

5. POST DEVELOPMENT SURFACE WATER QUALITY AND HYDROMODIFICATION CONTROL PROJECT DESIGN FEATURES

Project Design Features (PDFs) for surface water quality and hydrologic impacts include site design, source control, treatment control, and hydromodification control BMPs that will be incorporated into the NRSP projects and are considered a part of the projects for impact analysis. Effective management of wet and dry weather runoff water quality begins with limiting increases in runoff pollutants and flows at the source. Site design and source control BMPs are practices designed to minimize surface runoff and the introduction of pollutants into runoff. Treatment control BMPs are designed to remove pollutants once they have been mobilized by rainfall and runoff. Hydromodification control BMPs are designed to control increases in post-development runoff flows and/or volumes. This section describes the post-development site design, source control, treatment control, and hydromodification control PDFs for the NRSP projects.

5.1. SUSMP Requirements and Project Design Features

Table 5-1 summarizes the SUSMP requirements and the corresponding proposed PDFs that will be incorporated into the NRSP projects.

Table 5-1: SUSMP Requirements and Corresponding Newhall Ranch Project Design Features

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
1. Runoff Flow Control	• Control post-development peak stormwater runoff discharge rates, velocities, and duration in Natural Drainage Systems to prevent accelerated downstream erosion and to protect habitat related beneficial uses.[5] • All post-development runoff from a 2-year, 24-hour storm shall not exceed the predevelopment peak flow rate, burned, from a 2-year, 24-hour storm when the predevelopment peak flow rate equals or exceeds 5 cfs. Discharge flow rates shall be calculated using the County of Los Angeles Modified Rational Method. • Post-development runoff from the 50-year capital storm shall not exceed the predevelopment peak	• Hydromodification source controls include minimizing impervious surfaces through clustering development and using bioretention, extended detention, and other vegetated treatment control BMPs to disconnect impervious surfaces and reduce runoff volumes through evapotranspiration and infiltration. • Extended detention basins can provide hydromodification control as well as water quality treatment. • In-stream stabilization techniques will be employed in the tributaries that will receive post development NRSP project runoff to prevent accelerated erosion and to protect habitat related beneficial uses, per the Newhall Ranch RMDP. • The NRSP projects will be conditioned to require, as a design feature, sizing and design of hydraulic features as necessary to control hydromodification impacts in accordance with

[5] This requirement is from Part 4, § D.1 of the MS4 Permit.

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
	flow rate, burned and bulked, from the 50-year capital storm. • Control peak flow discharge to provide stream channel and over bank flood protection, based on flow design criteria selected by the local agency.	this NSRP Sub-Regional SWMP. • 50-year capital storm peak flow rate analysis is contained in the floodplain modification sections of the Newhall Ranch RMDP EIR.
2. Conserve Natural Areas	• Concentrate or cluster development on portions of a site while leaving the remaining land in a natural undisturbed condition • Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection • Maximize trees and other vegetation at each site, planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants • Promote natural vegetation by using parking lot islands and other landscaped areas • Preserve riparian areas and wetlands	• The NRSP clusters development into villages. Approximately 70% (8,335 acres) of the NRSP subregion will remain undeveloped. • Site clearing and grading will be limited as necessary to allow development, allow access, and provide fire protection. • Native and/or non-native/non-invasive vegetation will be utilized within the development. • The final project stormwater system will include the use of the vegetated treatment BMPs, including bioretention placed in common area landscaping in commercial and multi-family residential areas, roadway median strips, and parking lot islands (where applicable), vegetated swales, and extended detention basins. • Riparian buffers will be preserved along the Santa Clara River corridor and tributary drainages by clustering development upland and away from the River and tributary drainages.
3. Minimize Stormwater Pollutants of Concern	• Minimize to the maximum extent practicable, the introduction of pollutants of concern that may result in significant impacts, generated from site runoff of directly connected impervious areas (DCIA), to the stormwater conveyance system as approved by the building official.	• Treatment control BMPs will be selected to address the pollutants of concern for the project (see Section 5.3 below). These BMPs are designed to minimize introduction of pollutants to the Maximum Extent Practicable (MEP). • The NRSP projects will include numerous source controls, including education programs, animal waste bag stations, street sweeping and catch basin cleaning, an Integrated Pest Management (IPM) Program for common area landscaping in multi-family residential areas and commercial areas, use of native and/or non-native/non-invasive vegetation, and installation of a car wash pad in multi-family residential areas. • An education program will be implemented that includes both the education of residents and commercial businesses regarding water quality issues. Topics will include services that could affect water quality, such as carpet cleaners and

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
		others that may not properly dispose of cleaning wastes; community car washes; and residential car washing. The education program will emphasize animal waste management, such as the importance of cleaning up after pets and not feeding pigeons, seagulls, ducks, and geese. • Vegetated treatment control BMPs will allow for infiltration of treated stormwater. • Landscape watering in common areas, commercial areas, multiple family residential areas, and in parks will use efficient reclaimed water irrigation technologies with centralized irrigation controls.
4. Protect Slopes and Channels	Project plans must include BMPs consistent with local codes and ordinances and the SUSMP requirements to decrease the potential of slopes and/or channels from eroding and impacting stormwater runoff: • Convey runoff safely from the tops of slopes and stabilize disturbed slopes • Utilize natural drainage systems to the maximum extent practicable • Control or reduce or eliminate flow to natural drainage systems to the maximum extent practicable • Stabilize permanent channel crossings • Vegetate slopes with native or drought tolerant vegetation • Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion with the approval of all agencies with jurisdiction, e.g., the U.S. Army Corps of Engineers and the California Department of Fish and Game.	• The NRSP projects will provide slope stabilization to areas with significant slopes. • Natural slopes and native vegetation on slopes adjacent to the SCR will be preserved and/or, if impacted during construction, they will be restored and enhanced. Native plants will be used in all plant palettes placed on restored slopes. • Project PDFs, including swales, bioretention areas, and water quality basins (hydrologic source controls), will reduce flows to natural channels through infiltration and evapotranspiration. • The banks of the Santa Clara River at portions of this site will be stabilized primarily using buried bank stabilization per the Newhall Ranch RMDP. After the implementation of these measures and other flow control and volume reduction PDFs, the Santa Clara River will be capable of handling the expected flow regime with little or no erosion. • All outlet points to the Santa Clara River and tributaries will include energy dissipaters. • In-stream stabilization techniques will be employed in the tributaries that will receive post development NRSP project runoff to prevent accelerated erosion and to protect habitat related beneficial uses, per the Newhall Ranch RMDP. Geomorphic principles will be used to design stable, naturalistic drainages given the expected hydrologic and sediment regimes.

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
5. Provide Storm Drain System Stenciling and Signage	• All storm drain inlets and catch basins within the project area must be stenciled with prohibitive language and/or graphical icons to discourage illegal dumping. • Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the project area. • Legibility of stencils and signs must be maintained.	• All storm drain inlets and water quality inlets will be stenciled or labeled. • Signs will be posted in areas where dumping could occur. • The County, a Landscape or Local Maintenance District (LMD), Home Owners Association (HOA), or other maintenance entity would maintain stencils and signs.
6. Properly Design Outdoor Material Storage Areas	• Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the storm water conveyance system measures to mitigate impacts must be included.	• Pesticides, fertilizers, paints, and other hazardous materials used for maintenance of common areas, parks, commercial areas, and multifamily residential common areas will be kept in enclosed storage areas.
7. Properly Design Trash Storage Areas	All trash containers must meet the following structural or treatment control BMP requirements: • Trash container areas must have drainage from adjoining roofs and pavement diverter around the areas. • Trash container areas must be screened or walled to prevent offsite transport of trash.	• All outdoor trash storage areas will be covered and isolated from stormwater runoff.
8. Provide Proof of Ongoing BMP Maintenance	• Applicant required to provide verification of maintenance provisions through such means as may be appropriate, including, but not limited to legal agreements, covenants, and/or Conditional Use Permits.	• Depending on the type and location of the BMP, either the County, a Landscape or Local Maintenance District (LMD), or Home Owners Association (HOA) will be responsible for maintenance. The County will have the right, but not the duty, to inspect and maintain the BMPs that are maintained by the HOA or LMD, at the expense of the HOA or LMD, if they are not being properly maintained. • The Home Owners Associations or commercial/business owners will be responsible for operation and maintenance of site-based BMPs (such as bioretention placed in common area landscaping in multi-family residential areas and commercial areas). • Los Angeles County Department of Public Works will be responsible for maintenance of village-level and sub-regional BMPs (dry extended detention basins).

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
9. Design Standards for Structural or Treatment Control BMPs	• Post-construction Structural or Treatment Control BMPs shall be designed to mitigate (infiltrate or treat) stormwater runoff using either volumetric treatment control BMPs or flow-based treatment control BMPs sized per listed criteria (see section 3.6.2 above).	• Stormwater treatment facilities will be designed to meet or exceed the sizing standards in the LA County SUSMP requirements. • Volume-based treatment control BMPs for the NRSP projects will be designed to capture 80 percent or more of the annual runoff volume per criteria 2 of the MS4 Permit. • Flow-based BMPs will be sized using criteria 3, which will provide 80 percent capture of annual runoff volume per criteria of the MS4 Permit. • The size of the facilities will be finalized during the design stage by the Project Engineer with the final hydrology study, which will be prepared and approved to ensure consistency with this analysis prior to issuance of a final grading permit. • Types of treatment control BMPs that will be employed include extended detention basins, bioretention, vegetated swales, cartridge media filtration, and a combination thereof.
10.B.1 Properly Design Loading/ Unloading Dock Areas (100,000 ft^2 Commercial Developments)	• Cover loading dock areas or design drainage to minimize run-on and runoff of stormwater • Direct connections to storm drains from depressed loading docks (truck wells) are prohibited	• Loading dock areas will be covered or designed to preclude run-on and runoff. • Direct connections to storm drains from depressed loading docks (truck wells) will be prohibited. • Below grade loading docks for fresh food items will drain through a Treatment Control BMP applicable to the use, such as a catch basin insert. • Loading docks will be kept in a clean and orderly condition through weekly sweeping and litter control, at a minimum and immediate cleanup of spills and broken containers without the use of water.

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
10B.2. Properly Design Repair/ Maintenance Bays (100,000 ft^2 Commercial Developments)	• Repair/ maintenance bays must be indoors or designed in such a way that does not allow stormwater run-on or contact with stormwater runoff. • Design a repair/maintenance bay drainage system to capture all wash water, leaks, and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/ maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.	• Commercial areas will not have repair/maintenance bays or the bays will comply with design requirements.
10B.3. Properly Design Vehicle/ Equipment Wash Areas (100,000 ft^2 Commercial Developments)	• Self-contained and /or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer.	• Areas for washing/steam cleaning of vehicles will be self-contained or covered with a roof or overhang; will be equipped with a wash racks and with the prior approval of the sewering agency; will be equipped with a clarifier or other pretreatment facility: and will be properly connected to a sanitary sewer.
10.C. Properly Design Equipment/ Accessory Wash Areas (Restaurants)	• Self-contained, equipped with a grease trap, and properly connected to a sanitary sewer. • If the wash area is to be located outdoors, it must be covered, paved, have secondary containment, and be connected to the sanitary sewer.	• Food preparation areas shall have either contained areas or sinks, each with sanitary sewer connections for disposal of wash waters containing kitchen and food wastes. • If located outside, the containment areas or sinks shall also be structurally covered to prevent entry of storm water. Adequate signs shall be provided and appropriately placed stating the prohibition of discharging washwater to the storm drain system.

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
10.D. Properly design fueling area (Retail Gasoline Outlets)	• The fuel dispensing area must be covered with an overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. • The fuel dispensing area must be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete shall be prohibited. • The fuel dispensing areas must have a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of urban runoff. • At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.	• Retail gasoline outlets will comply with design requirements.
10.E.1. Properly design fueling area (Automotive Repair Shops)	• See requirement 10.D. above.	• Automotive repair shop fueling areas will comply with design requirements.
10.E.2. Properly design repair/maintenance bays (Automotive Repair Shops)	• See requirement 10.B.2 above.	• Automotive repair shop repair/maintenance bays will comply with design requirements.
10.E.3. Properly design vehicle/equipment wash areas (Automotive Repair Shops)	• Self-contained and/or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer or to a permitted disposal facility.	• Automotive repair shop vehicle/equipment wash areas will comply with design requirements.
10.E.4. Properly design loading/unloading dock areas (Automotive Repair Shops)	• See requirement 10.B.1. above.	• Automotive repair shop loading/unloading dock areas will comply with design requirements.

SUSMP Requirement	Criteria/ Description	Corresponding Newhall Ranch PDFs
10.F.1. Properly Design Parking Area (Parking Lots)	• Reduce impervious land coverage of parking areas • Infiltrate runoff before it reaches the storm drain system • Treat runoff before it reaches storm drain system	• Commercial and multi-family parking lots will incorporate bioretention facilities located in islands to promote filtration and infiltration of runoff. • Stormwater runoff from parking lots will be directed to treatment control BMPs, including swales, water quality basins, bioretention areas, and/or catch basin media filters in compliance with SUSMP requirements.
10.F.2 Properly Design to Limit Oil Contamination and Perform Maintenance (Parking Lots)	• Treat to remove oil and petroleum hydrocarbons at parking lots that are heavily used. • Ensure adequate operation and maintenance of treatment systems particularly sludge and oil removal	• See above. • Treatment of runoff in detention basins, bioretention areas, or catch basin inserts will be used to address oil and petroleum hydrocarbons from high-use parking lots. • The Home Owners Associations or property owners will be responsible for operation and maintenance of treatment control BMPs that serve private parking lots.
13. Limitation of Use of Infiltration BMPs	• Infiltration is limited based on design of BMP, pollutant characteristics, land use, soil conditions, and traffic. • Appropriate conditions must exist to utilize infiltration to treat and reduce stormwater runoff for the project.	• Per the LARWQCB Clarification Letter (LARWQCB, 2006), generally, the common pollutants in stormwater are filtered or adsorbed by soil, and unlike hydrophobic solvents and salts, do not cause groundwater contamination. In any case, infiltration of 1-2 inches of rainfall in semi-arid areas like Southern California where there is a high rate of evapo-transpiration, presents minimal risks. • The proposed treatment control BMPs are not considered infiltration BMPs; they allow for infiltration of fully-treated runoff only.

5.2. Low Impact/Site Design BMPs

The purpose of low impact/site design BMPs is, to the extent feasible, to mimic the natural hydrologic regime. This low impact/site design philosophy is often referred to as Low Impact Development (LID). The primary goals of low impact/site design BMPs are to maintain a landscape functionally equivalent to predevelopment hydrologic conditions and to minimize the generation of pollutants of concern.

Low impact/site design principles include:

Minimize Impervious Area/Maximize Permeability – Principles include preserving natural open space, reducing impervious surfaces such as roads, using more permeable paving materials, reducing street widths, using minimal disturbance techniques during development to avoid soil compaction, reducing the land coverage of buildings by building taller and narrower footprints,

minimizing the use of impervious materials such as decorative concrete in landscape design, and incorporating detention or infiltration into landscape design.

Minimize Directly Connected Impervious Areas (DCIAs) – Minimizing DCIA can be achieved by directing runoff from impervious areas to vegetated areas (e.g., landscaped areas or vegetated treatment control BMPs) or to infiltration BMPs.

Conserve Natural Areas – Conserving and protecting native soils, vegetation, and stream corridors helps to mimic the site's natural hydrologic regime. This may be accomplished by clustering development within portions of the site to conserve as much natural open space as possible, limiting the extent of clearing and grading of native vegetation, planting additional vegetation, using native and/or non-native/non-invasive vegetation in parking lot islands and other landscape areas, and preserving and/or restoring riparian areas and wetlands.

Select Appropriate Building Materials – Use of appropriate building materials reduces the generation and discharge of pollutants of concern in runoff (and is therefore also a source control BMP).

Protect Slopes and Channels – Protecting slopes and channels reduces the potential for erosion and preserves natural sediment supply.

5.2.1. Consideration of Spatial Scale

Low impact/site design implementation for each NRSP project will account for the different spatial scales of development. These spatial scales are listed below, from larger to smaller scale:

- Ranch scale – the Newhall Ranch Specific Plan sub-region;
- Village scale – Landmark Village, Mission Village, Homestead, Potrero Valley, Entrada, and Legacy projects;
- Land use scale – single family residential, multi-family residential, commercial, education, parks, and roadways within each project, and
- Lot or parcel scale – individual lots or parcels within each project.

5.2.2. Newhall Ranch Low Impact/Site Design BMPs

Table 5-2 below lists the low impact/site design BMPs that will be implemented by the NRSP projects at each spatial scale.

Table 5-2: Newhall Land Low Impact/Site Design BMPs

Spatial Scale	Corresponding Low Impact/Site Design BMP
1. Ranch	The NRSP clusters development into villages. Approximately 70% (8,335 acres) of the NRSP subregion will remain undeveloped Open Areas.
	A system of Open Areas will weave through the central portion of the NRSP subregion. The Open Areas include community parks, prominent ridges, bluffs, slopes, creek beds, and utility and trail system easements, and would often function as a transition between development areas. The Open Areas are designed to protect significant landforms and natural resources, and to provide an opportunity to integrate the proposed development within its natural context.
	The NRSP Land Use Plan designates a total of 5,159 acres for the River Corridor and High Country Special Management Areas (SMAs). These SMAs are designed to protect the existing natural resources within Los Angeles County's Significant Ecological Areas SEA 20 and SEA 23.
	The 976-acre River Corridor SMA is designed to protect the sensitive biological resources in SEA 23, which consists of the Santa Clara River corridor. The River Corridor SMA is to be dedicated to the Center for Natural Lands Management (CNLM), and the CNLM will assume responsibility for management of this area.
	The largest land use designation of the NRSP Land Use Plan is the 4,185-acre High Country SMA. The High Country is located in the southern portion of the sub-region and includes oak savannahs, high ridgelines, and various canyon drainages including Salt Creek, a regionally significant wildlife corridor that provides an important habitat link to the Santa Clara River. The High Country is to be dedicated in fee to a Joint Powers Authority (JPA) consisting of representatives from the County of Los Angeles, the City of Santa Clarita, and the Santa Monica Mountains Conservancy.
	To enhance the wildlife corridor movement through the High Country Special Management Area, the 1,517-acre portion of the Salt Creek watershed situated in Ventura County, which is under the ownership of Newhall Land, will be dedicated to the public. This dedication area is west of Newhall Ranch, and will be managed in the same manner as the Newhall Ranch High Country SMA.
	Two conservation easements of approximately 64 acres have been granted to CDFG for the purpose of conserving populations of spineflower that occur on the NRSP sub-region.

Spatial Scale	Corresponding Low Impact/Site Design BMP
2. Village	Impervious areas will be minimized by incorporating landscaped areas into each village. Significant portions of each village area will remain as open space or parks.
	The village-level stormwater treatment system will include the use of vegetated treatment BMPs, including bioretention, vegetated swales, and/or extended detention basins.
	In areas not subject to mass grading, the smallest site disturbance area possible will be delineated and flagged and temporary storage of construction equipment will be restricted in these areas to minimize soil compaction on site. Site clearing and grading will be limited as necessary to allow development, allow access, and provide fire protection.
	Riparian buffers will be provided along the Santa Clara River corridor and major tributaries by clustering development upland and away from the River and tributary drainages.
	Natural slopes and native vegetation on slopes adjacent to the SCR will be preserved and/or, if impacted during construction, they will be restored and enhanced.
3. Land Use	Streets, sidewalks, and parking lot aisles will be constructed to the minimum widths specified in the NRSP and in compliance with regulations for the Americans with Disabilities Act and safety requirements for fire and emergency vehicle access.
	Trails in reserve areas and some parks will be constructed with open-jointed paving materials, granular materials, or other pervious materials.
	Native and/or non-native/non-invasive vegetation that requires less watering and chemical application will be utilized within the common area landscaping in commercial areas and multi-family residential areas.
	Impervious surfaces will be minimized in common area landscape design.
	Landscape watering in common areas, commercial areas, multiple family residential areas, and parks will use efficient reclaimed water irrigation technologies with centralized irrigation controls. Efficient irrigation for common area irrigation systems will include a combination of the following techniques: • Low volume irrigation systems will be used, including low volume sprinkler heads, drip emitters, and bubbler emitters, to minimize water use. • "Smart" irrigation controllers will be installed to control the amount of time irrigation systems are operated each day. These may include satellite controlled sensors or other equally effective technology.

Spatial Scale	Corresponding Low Impact/Site Design BMP
4. Lot	Bioretention or vegetated swales will be placed within the road right-of-way in some locations.
	Runoff from most sidewalks, walkways, trails, and patios will be directed into adjacent landscaping or to vegetated swales.
	Bioretention areas or vegetated swales will collect and treat runoff from some of the industrial, commercial and multi-family residential areas. These bioretention areas will be located in parking lot islands and other on-site landscaped areas.
	Landscape areas will be determined by zoning requirements, village setback/parkway standards, and design objectives.
	Porous pavement will be used in some parking and low traffic areas.
	Building materials for roof gutters and downspouts will not include copper or zinc.
	Home builders will be encouraged to direct rooftop runoff through landscaped areas.

5.3. Treatment BMPs

The SUSMP requirements mandate that treatment controls address the pollutants of concern, which are defined in the SUSMP Manual as consisting of any pollutants that exhibit one or more of the following characteristics: current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at concentrations or loads considered potentially toxic to humans and/or flora and fauna. These parameters were considered in defining pollutants of concern for analysis. See Section 4.1 of this report. Pollutants of concern for the NRSP projects include:

- Sediments (TSS and Turbidity)
- Nutrients (Total Phosphorus, Nitrate-N + Nitrite-N, Ammonia-N, and Total Nitrogen)
- Trace Metals (Aluminum, Copper, Lead, and Zinc)
- Pathogens (Bacteria, Viruses, and Protozoa)
- Petroleum Hydrocarbons (Oil and Grease and PAHs)
- Pesticides
- Trash & Debris

- Chloride
- Methylene Blue Activated Substances (MBAS)
- Cyanide

The types of post development runoff treatment control BMPs that will be employed include, but are not limited to, extended detention basins, bioretention, vegetated swales, and cartridge media filtration devices. These treatment control BMPs are effective for treating most of the pollutants of concern based on the California Stormwater Association Stormwater BMP Handbook for New Development and Redevelopment (2003) (Table 5-2). The stormwater treatment system will be configured to achieve treatment in multiple BMP facilities for the majority of the developed areas. This "treatment train" approach, in combination with the site design and source control BMPs, will effectively address all of the pollutants of concern.

According to Table 5-3 below, treatment controls that best address the TMDL constituents nitrogen and bacteria incorporate either infiltration (e.g., infiltration basins) or biological processes that incorporate de-nitrification (e.g., wetlands). However, project conditions may limit the available surface area and the head required for wetlands and soil types for infiltration basins. Given these potential site constraints, the following treatment BMPs, which incorporate natural treatment processes that provide some infiltration but require less surface area and head were selected:

- Vegetated Swales
- Filter Strips
- Bioretention Areas
- Extended Detention Basins
- Cartridge Media Filtration (or equivalent)

Table 5-3: Treatment Control BMP Selection Matrix

Pollutant of Concern[1]	Treatment Control BMP Categories			
	Extended Detention Basins	Bioretention	Vegetated Swale/ Filter Strip	Media Filtration
Sediment	M	H	M	H
Nutrients	L	M	L	L
Trash	H	H	L	H
Trace Metals	M	H	M	H
Bacteria	M	H	L	M
Organics[2]	M	H	M	H

Source: California Stormwater Best Management Practices Handbook for New Development and Redevelopment (CASQA, 2003)
Note: H, M, L, indicates high, medium, and low removal efficiency.
[1]Chloride and MBAS are addressed with source control BMPs, as they are not treatable in typical stormwater treatment BMPs, aside through incidental infiltration.
[2]Includes pesticides and petroleum hydrocarbons.

Vegetated Swales: Vegetated swales are engineered vegetation-lined channels that provide water quality benefits in addition to conveying runoff. Swales provide pollutant removal through settling and filtration in the vegetation (often grasses) lining the channels and also provide the opportunity for volume reductions through infiltration and evapotranspiration. Swales are most effective where longitudinal slopes are small (2 percent to 6 percent), thereby increasing the residence time for treatment, and where water depths are less than the vegetation height. A conceptual illustration of a vegetated swale is shown in Figure 5-1 and photographs of existing swales are provided in Figure 5-2.

Filter Strips: Filter strips are vegetated areas designed to treat sheet flow runoff from adjacent impervious surfaces or intensive landscaped areas such as golf courses. Filter strips decrease runoff velocity, filter out sediment and associated pollutants, and provide some infiltration into underlying soils. While some assimilation of dissolved constituents may occur, filter strips are generally more effective in trapping sediment and particulate-bound metals, nutrients, and pesticides. Filter strips rely on dense turf vegetation with a thick thatch growing on a moderately permeable soil and are well suited to treat runoff from roads and highways, driveways, and small parking lots. They are also good for use as vegetated buffers between developed areas and natural drainages. A conceptual illustration of a filter strip is shown in Figure 5-3.

Bioretention: Bioretention areas are vegetated (i.e., landscaped) shallow depressions that provide storage, infiltration, and evapotranspiration, and also provide for pollutant removal (e.g. filtration, adsorption, nutrient uptake) by filtering runoff through the vegetation and soils. In bioretention areas, as well as in vegetated swales and filter strips, pore spaces and organic material in the soils help to retain water in the form of soil moisture and to promote the

adsorption of pollutants (e.g., dissolved metals and petroleum hydrocarbons) into the soil matrix. Plants utilize soil moisture and promote the drying of the soil through transpiration. A conceptual illustration of a biofiltration area is shown in Figure 5-4, and photographs of existing bioretention areas are provided in Figure 5-5.

Extended Detention Basins: Extended detention basins (EDBs) store stormwater runoff for sufficient periods of time to promote the removal of pollutants primarily through sedimentation. Dry extended detention basins are designed with outlets that detain the runoff volume from the water quality design storm for some minimum time (in this case 48 hours) to allow particulates and associated pollutants (phosphorus, trace metals, some pesticides, and other pollutants) to settle out. These basins are not designed or anticipated to contain standing water for periods in excess of 48 hours. The EDBs will also incorporate a series of gravel-filled subsurface flow trenches that will provide water quality treatment and facilitate evapotranspiration (ET) and percolation of dry weather flows and small storm events within the basin footprint. As runoff flows through the trenches, pollutant removal is achieved through settling and biological uptake of nutrients and dissolved pollutants within the wetland plants that will grow within the trenches, filtration within the trench gravel, and percolation into underlying soils. In addition, a specially constructed dry well that will support deep subsurface percolation of dry weather flows that may exceed the capacity of the gravel trenches will be provided. It is anticipated that the dry well will receive water primarily during the winter months, when ET rates are lower. A conceptual illustration of an extended detention basin is shown in Figure 5-6 and photographs of existing basins are shown in Figure 5-7.

Media Filtration: For small drainage catchments where it is not possible to direct runoff to the vegetated treatment control BMPs listed above due to proposed project grading, media filtration (or equivalent) will be used. A proprietary media filter, such as the Stormwater Management StormFilter®, is an example of this type of treatment (Figure 5-8). The StormFilter is a passive, flow-through stormwater media filtration system. The StormFilter is typically comprised of a vault (or catch basin for small drainage catchments) that houses rechargeable, media-filled cartridges that trap particulates and remove pollutants such as dissolved metals, nutrients, and hydrocarbons. During the filtering process, the treatment system also removes floating pollutants (e.g., oil and grease). The StormFilter system (or equivalent) will be placed off-line to limit resuspension of debris and sediment that will settle in the vault. A high flow bypass structure utilizing a weir or orifice to control the flow to the stormwater treatment system is used to divert flows to the treatment unit.

The typical precast StormFilter unit is composed of three bays: the inlet bay, the filtration bay, and the outlet bay. Stormwater in the inlet bay is directed through a flow spreader, which traps some floatables, oils, and surface scum, and then enters an energy dissipater and the filtration bay where treatment takes place. Stormwater flows laterally (horizontally) through the filter cartridge to a centerwell, where the flow is then directed downward to an underdrain system.

Large particles settle out in the inlet bay and filtration bay, and finer particles and other pollutants are removed as stormwater flows through the filter media in the cartridges.

Stormwater treatment facilities for the NRSP projects will be designed to meet or exceed the sizing standards contained in the SUSMP Manual. Volume-based treatment control BMPs will be sized to capture and treat 80 percent of the annual runoff volume, with a drawdown time of 48 hours. Flow-based BMPs will be sized using a minimum rainfall intensity of 0.3 inches per hour.

5.4. Hydromodification Control PDFs

A series of progressive hydromodification control measures will be used in the NRSP projects to prevent and control hydromodification impacts to the Santa Clara River and the tributaries:

- Avoid, to the extent possible, the need to mitigate for hydromodification impacts by preserving natural hydrologic conditions and protecting sensitive hydrologic features, sediment sources, and sensitive habitats.

- Minimize the effects of development through site design practices (e.g., reducing connected impervious surfaces), implementation of stormwater volume-reducing BMPs (project-based hydrologic source control), and incorporation of flow duration control into water quality treatment basins, as needed.

- Mitigate hydromodification impacts in-stream using geomorphically-based channel design.

In some cases, hydromodification control measures that provide habitat, water quality treatment, hydromodification control, and flood control in one integrated solution may be feasible.

5.4.1. Hydrologic Source Control

Disconnecting impervious areas from the drainage network and adjacent impervious areas is a key approach to protecting channel stability. Several hydrologic source controls will be included in the NRSP projects that will limit impervious area and disconnect imperviousness to avoid and minimize hydromodification impacts:

- *Site Design.* Site design PDFs that help to reduce the increase in runoff volume include the clustering of development into village areas, leaving large amounts of undeveloped open space within the NRSP subregion; routing of impervious area runoff to vegetated areas; use of native and/or non-native/non-invasive vegetation in landscaped areas; and the use of efficient irrigation systems in common area landscaped areas.

- *Treatment Controls*. The project's treatment control BMPs will also serve as hydromodification source control BMPs. Vegetated swales, filter strips, and extended

detention basins can provide volume reduction on the order of 20 to 30 percent through infiltration and evaporation. Projects will incorporate bioretention areas sized to capture and treat 80 percent of the average annual stormwater runoff from its tributary catchment and, in some cases, will not utilize underdrains. Thus, all water captured in the facilities without underdrains will be effectively removed from the project's stormwater discharges. Collectively these vegetated treatment facilities are expected to provide significant reduction in wet weather runoff. In addition these facilities will also receive and eliminate dry weather flows.

- *Storage of Excess Runoff Volume for Irrigation Reuse*. In the irrigation reuse alternative, excess flows could be directed to storage tanks or above ground water features located in parks or a golf course for irrigation reuse, or alternatively, to blend excess stormwater runoff with reclaimed water from the proposed Newhall Water Reclamation Plant for reuse.

5.4.2. Project-Based Flow Duration Control

Stream erosion/deposition and sediment transport processes are functions of the long-term cumulative effects of geomorphically significant flows. Maintaining the long-term cumulative duration of geomorphically significant flows maintains the existing capacity to transport sediment and promotes long-term stability. Flow duration control was first discussed in the literature by Derek Booth (1990), of the University of Washington. Flow duration control maintains the existing (pre-development) frequency distribution of hourly runoff as well as the total runoff volume within prescribed limits to minimize hydromodification impacts in natural receiving waters. Flow duration control is a detention basin design methodology that sets standards for on-site capture and runoff volume reduction to maintain the existing distribution of those in-stream flows which are above the critical flow for bed mobility, and as a result maintains the pre-project capacity to transport sediment and avoids creating channel instability. Flow duration control basins can also be designed to accommodate a reduction in sediment supply by reducing the frequency of sediment transporting flows. The treatment control extended detention basins can be modified to provide flow duration control in addition to water quality treatment.

5.4.3. Geomorphically-Referenced Channel Design

The hydromodification management approach for the Santa Clara River and tributaries will incorporate "geomorphically-referenced " channel design as described in SCCWRP Technical Report 450 (SCCWRP, 2005a). The goal of this approach is to preserve the natural stream channel function to the maximum extent practicable while limiting instability in stream channel morphology.

In the five tributaries that will be redesigned or enhanced within the NRSP area (Chiquito Canyon, San Martinez Grande Canyon, Lion Canyon, Long Canyon, and Potrero Canyon),

geomorphic principles will be used to design stable stream channels given the expected post-development hydrologic and sediment regimes (see Appendix G for further detail). A minimum of hard, engineered structural elements will be used within the tributary drainages so that a natural appearance will be preserved, while the new drainage channel form will remain stable and habitat will be preserved or enhanced. Examples of modified/engineered natural channels are provided in Figure 5-9.

Within the Santa Clara River, the development footprint will allow for the greatest freedom possible for "natural stream channel" activity. This includes establishing buffer zones and maintaining setbacks to allow for channel movement and adjustment to changes in energy associated with runoff.

The engineered structural elements that will be implemented where needed for the Santa Clara River and the five tributaries listed above include energy dissipation, bank stabilization, and grade stabilization structures.

Energy Dissipation. Energy dissipation at storm drain outfalls provides erosion protection in areas where discharges have the potential to cause localized stream erosion. Erosion protection will be provided at all storm drain outlets to the Santa Clara River and tributaries.

Bank Stabilization. Consistent with the Specific Plan, the RMDP proposes bank stabilization where necessary to protect against flooding and erosion pursuant to Federal Emergency Management Administration (FEMA) and Los Angeles County Department of Public Works' requirements. The bank stabilization is designed and would be constructed to retain the Santa Clara River's significant riparian habitat, to allow the river to continue to function as a regional east-west wildlife corridor, and to provide flood protection pursuant to Los Angeles County standards. Bank protection will be also be installed along portions of the five designated tributaries as required by the Los Angeles County Department of Public Works. Four types of bank protection will be utilized for the Santa Clara River and the Tributaries: 1) buried soil cement, 2) ungrouted rock rip-rap, 3) concrete gunite slope lining, and 4) turf reinforcement mats. The location of the bank stabilization will be selected so that bank protection along the river and tributaries will generally be placed in non-jurisdictional upland areas adjacent to the river or drainage. Installing bank protection in non-jurisdictional areas reduces and/or avoids impacts to the channel and has the potential to create new channel bed areas, allows for channel movement and adjustment to changes in energy associated with runoff, and increases riparian habitat. For example, buried soil cement bank stabilization is proposed on the north side of the Santa Clara River near its confluence with Castaic Creek, and it would be installed on agricultural lands north of the existing river channel. The land located between the existing river channel and the newly created stabilized bank would be excavated, widening the existing river channel in that location. This condition is repeated along the northern bank of the Santa Clara River in several locations

Grade Stabilization Structures. Grade stabilization structures will be installed in Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon to prevent long term degradation, downcutting, and incision of the channel bed. The number of grade stabilization structures to be used within each drainage will be determined based on the expected post development hydrologic and sediment regime (see Appendix G for further discussion). The number of structures will be limited so that a natural appearance will be preserved, while enough grade stabilization structures will be provided to ensure channel stability and habitat preservation and/or enhancement.

Although Lion Canyon will not receive post-development storm flows from NRSP developed area, grade stabilization structures will also be installed in Lion Canyon. Existing conditions within Lion Canyon include deep channel incision as a result of stormwater runoff from historically disturbed portions of the NRSP area due to agriculture, grazing, and oil and gas operations. In order to stabilize and restore the Lion Canyon drainage, a geomorphic channel design will utilize grade and bank stabilization techniques and limited grading to enhance and restore the Lion Canyon drainage. The Lion Canyon restoration will also include plantings of upland and riparian vegetation to enhance the habitat-related beneficial uses.

The tributary channels will designed at the project level and the preliminary channel designs will be described in the Project Water Quality Technical Report for the project in which the tributary channel will be affected, as follows: the Homestead WQTR will include Chiquito Canyon, San Martinez Grande Canyon, and Long Canyon; the Potrero Village WQTR will include Potrero Canyon; and the Mission Village WQTR will include the lower portion of Lion Canyon. Lion Canyon would also be affected by the neighboring Legacy Village Project, and therefore Lion Canyon will also be addressed in the Legacy Village WQTR.

5.4.4. Hydromodification Control Performance Standard

For direct discharges to the Santa Clara River, NRSP projects will incorporate hydrologic source controls that will limit impervious area and disconnect imperviousness to avoid and minimize hydromodification impacts. The NRSP projects' development footprints will establish buffer zones and maintain setbacks to allow for channel movement and adjustment to changes in energy associated with runoff. The engineered structural elements that will be implemented include energy dissipation structures at all outfalls and buried soil cement bank stabilization in selected locations as required by the County of Los Angeles Department of Public Works.

The choice of a hydromodification control approach for each tributary drainage will be dictated by the strategies that are appropriate given the conditions of each drainage and its contributing watershed. Consequently, a suite of on-site and in-stream control approaches will be applied for each tributary drainage to provide a comprehensive solution that avoids, minimizes, and mitigates potential increases in runoff due to land use change. Further discussion is provided in Appendix G of this report.

The project-level tributary drainage designs will be based on modeled pre- and post-development hydrology, hydraulics, and sediment transport capacity of flows in each drainage using the project-level land plans and drainage concepts, including planned hydromodification source controls. The assessment of tributary drainage stability will address the long-term cumulative effect of all sediment-transporting and erosive flows using continuous hydrologic modeling and analysis. Continuous hydrologic modeling incorporates the full distribution of rainfall events in the record and uses in-stream flow duration as a basis for work and sediment transport computations. This state-of-the-art analytical technique assesses all of the "geomorphically significant flows" regardless of their magnitude, and does not assume one size storm adequately characterizes all the important hydrologic conditions. The approach considers frequent sediment transporting flows, wet years and droughts, back-to-back storms, and antecedent conditions.

The project-level hydrology, hydraulics, and sediment transport capacity analysis will identify the necessary longitudinal slope required to maintain the existing sediment transport capacity for drainages determined to be stable in the existing condition. For those channel segments that are determined to be currently unstable, the longitudinal slope necessary to restore channel stability will be determined. Channel design will incorporate stable slopes for the predicted post-development flows in each tributary drainage through a combination of installing grade control structures and/or by changes in channel cross section geometry such as widening the channel and/or adding sinuosity.

The MS4 Permit (§4.D.1) states that "…The Permittees shall control post-development peak storm water runoff discharge rates, velocities, and duration (peak flow control) in Natural Drainage Systems (i.e., mimic pre-development hydrology) to prevent accelerated stream erosion and to protect stream habitat…" The erosion potential analysis, discussed further in Appendix G, provides a metric, Ep, which measures the potential impact of modified flows on stream stability and excessive erosion, and has been developed as a means to define an in-stream performance standard and a "significance test" of the effectiveness of proposed hydromodification control strategies. An equivalently effective, similarly geomorphically-referenced approach may be developed and applied in the future in place of the erosion potential approach.

Using the Ep approach as a point of reference, the following performance standard has been defined for discharges from the NRSP projects to the drainages tributary to the Santa Clara River:

> *The erosion potential (Ep) of stormwater discharges from the Project shall be maintained within 20% of the target value in the tributary drainages that will receive post-development flows. The target erosion potential (Ep) will consider changes in sediment supply.*

The hydromodification performance standard will be met for all of the NRSP projects from the point of discharge to the tributary drainage channel downstream to the confluence of the tributary

drainage with the Santa Clara River, and shall be achieved through on-site or in-stream controls, or a combination thereof.

5.5. Operation and Maintenance

Depending on the type and location of the BMP, either the County, a Landscape Maintenance District (LMD), Geologic Hazard Abatement District (GHAD), Home Owners Association (HOA), or other similar government or quasi-government agency will be responsible for maintenance. LMD(s), GHAD(s), or other similar government or quasi-government agency would be formed prior to turnover of stormwater facilities, prior to the first home sale. Maintenance and inspection agreements will be established as the treatment facilities are approved and built. HOA maintenance agreements will incorporate a list of HOA responsibilities. The LMD(s), GHAD(s), or other similar government or quasi-government agency will have a mechanism and staffing to monitor, maintain, and enforce BMP maintenance. The County will have the right to inspect and maintain the BMPs that are maintained by the HOA, LMD, GHAD, or other similar agency at the expense of the HOA, LMD, GHAD, or other similar agency, if they are not being properly maintained.

Table 5-4 lists the operation and maintenance (O&M) activities for the primary treatment control PDFs and the frequencies at which O&M activities will be conducted. BMP maintenance will be conducted in compliance with maintenance requirements established in the Los Angeles County Stormwater BMP Design and Maintenance Manual.

5.5.1. Monitoring

A Memorandum of Understanding (MOU) and Water Resource Monitoring Program have been entered into between Newhall Land, the United Water Conservation District, and the Upper Basin Water Purveyors. This monitoring program will result in a database addressing water usage in the Saugus Formation and Alluvial Aquifer over various representative water cycles. The parties to the MOU intend to utilize this database to further identify surface water and groundwater impacts on the Santa Clara River Valley. Newhall Land, in coordination with LARWQCB staff, will select a representative location upstream and downstream of the Newhall Ranch Specific Plan and sample surface and groundwater quality. Sampling from these two locations would begin upon approval of the first subdivision map and be provided annually to the LARWQCB and Los Angeles County for the purpose of monitoring water quality impacts of the Specific Plan over time. If the sampling data results in the identification of significant new or additional water quality impacts resulting from the Specific Plan which were not previously known or identified, additional mitigation shall be required at the subdivision map level. A to-be-formed district (GHAD, Drainage Benefit Assessment (DBA), or other special district), formed prior to the first home sale, will conduct monitoring within the Newhall Land subregion and will report to the Los Angeles County Department of Public Works.

Table 5-4: Water Quality BMP Operation and Maintenance Activities

Treatment Control BMP	Operation & Maintenance Category	Activities	Frequency	Maintenance Responsibility
Dry Extended Detention Basin	Routine Facility Maintenance	• Facility inspection • Trash and debris removal • Minor sediment removal • Vector Control	• Annually prior to wet season. • After major storm events (>0.75 in/24 hrs) if spot checks of some basins indicate widespread damage/ maintenance needs. • Remove minor sediment accumulation from inlet or outlet when affecting inlet/outlet conditions.	• LACDPW
	Vegetation/ Landscape Maintenance	• Integrated Pest/Plant Management • Minor Vegetation Removal/ Thinning • Irrigation System Adjustment	• Monthly (or as dictated by agreement between County/HOA/LMD and landscape contractor)	
	Major Maintenance	• Structural repairs • Major vegetation removal/ planting • Major sediment removal	• As needed (infrequently) • Major sediment removal as needed; approximately every 10 to 20 years.	
Vegetated Swales/ Filter Strips	Routine Facility Maintenance	• Facility inspection • Trash and debris removal • Minor sediment removal • Vector Control	• Annually prior to wet season. • After major storm events if spot checks of some basins indicate widespread damage/ maintenance needs. • Remove minor sediment accumulation from inlet or outlet when affecting inlet/outlet conditions.	• Home Owners Associations or commercial/ business owners will be responsible for maintenance of site-based BMPs • LACDPW will be responsible for maintenance of BMPs within public ROW
	Vegetation/ Landscape Maintenance	• Integrated Pest/Plant Management • Minor Vegetation Removal/ Thinning	• Monthly (or as dictated by agreement between County/HOA/LMD and landscape contractor)	
	Major Maintenance	• Major vegetation removal/ planting • Major sediment removal	• As required (annually or less frequently)	

Treatment Control BMP	Operation & Maintenance Category	Activities	Frequency	Maintenance Responsibility
Bioretention	Routine Facility Maintenance	• Facility inspection • Trash and debris removal • Minor sediment removal	• Annually prior to wet season. • After major storm events if spot checks of some basins indicate widespread damage/ maintenance needs. • Remove minor sediment accumulation from inlet or outlet when affecting inlet/outlet conditions.	• Home Owners Associations or commercial/ business owners will be responsible for maintenance of site-based BMPs • LACDPW will be responsible for maintenance of BMPs within public ROW
	Vegetation/ Landscape Maintenance	• Integrated Pest/Plant Management • Minor Vegetation Removal/ Thinning • Irrigation System Adjustment • Mulching	• Monthly (or as dictated by agreement between County/HOA/LMD and landscape contractor)	
	Major Maintenance	• Major vegetation removal/ planting	• As needed (infrequently)	
Media Filtration	Routine Facility Maintenance	• Facility Inspection • Trash and Debris Removal • Minor Sediment Removal	• Typically twice per year depending on the accumulation rate	• Home Owners Associations or commercial/ business owners will be responsible for maintenance of site-based BMPs • LACDPW will be responsible for maintenance of BMPs within public ROW
	Major Maintenance	• Major sediment removal • Cartridge/ Media Replacement	• Typically biannually depending on accumulation rate	

The Newhall Ranch WRP NPDES Permit (Order No. R4-2007-0046) requires that a watershed-wide monitoring program be developed for the Santa Clara River watershed under the leadership of the LARWQCB and the stakeholder groups developing salt and nutrient TMDLs. The goals

of the watershed-wide monitoring program include evaluating or assessing compliance with receiving water objectives, trends in surface water quality, impacts to beneficial uses, the health of the biological community, data needs for modeling contaminants of concern, and attaining the goals of the TMDLs under implementation in the Santa Clara River watershed. Until the watershed-wide monitoring program is developed, Newhall Land will continue to monitor water quality in the Santa Clara River per the requirements of the Newhall Ranch WRP NPDES Permit. The Newhall Ranch WRP NPDES permit monitoring program, which includes three Santa Clara River sampling locations, requires semi-annual sampling until the Newhall Ranch WRP begins discharge; once discharge from the WRP commences, more frequent sampling is required. The Newhall Ranch WRP receiving water monitoring program includes chemical, toxicity, and bioassessment monitoring in the Santa Clara River.

6. WATER QUALITY ANALYSIS APPROACH

6.1. Water Quality Model Description

A water quality model was used to estimate pollutant loads and concentrations in project area stormwater runoff for certain pollutants of concern for pre-development conditions and post-development conditions with PDFs. Table B-6 in Appendix B lists the NRSP pre- and post-development land uses as well as the land use category used in the water quality model, percent impervious value, and runoff coefficient equation used for the land uses. High country areas and the Santa Clara River corridor will not be impacted by the proposed development and therefore were not included in the water quality modeling. The modeled project area, 7,003 acres, includes the developed portion of the NRSP subregion as well as adjoining natural slopes and open space areas. Therefore, the loads and concentrations presented in Section 7 are not representative of the pollutant loads and concentrations in runoff from the entire NRSP area, but only from the developed portion of the NRSP subregion and adjoining natural slopes and open space areas. The remaining area within the NRSP subregion will be preserved as open space, so runoff water quality from these areas will not be impacted by project development. Although the absolute value of the loads from the entire NRSP subregion are not provided, the predicted *change* in pollutant loads is representative of the entire NRSP subregion because the loads from the open space areas remain unchanged. In general, the pollutant concentrations are not representative of the runoff from the entire NRSP subregion, as the predicted pollutant concentrations are lower from open space than from the other land uses for all of the pollutants of concern except for TSS, which is higher from open space. The concentrations presented in Section 7 for nutrients and trace metals are therefore conservative (i.e., higher than would actually occur after mixing with runoff from open areas).

The water quality model is one of the few models that takes into account the observed variability in stormwater hydrology and water quality. This is accomplished by characterizing the probability distribution of observed rainfall event depths, the probability distribution of event mean concentrations, and the probability distribution of the number of storm events per year. These distributions are then sampled randomly using a Monte Carlo Approach to develop estimates of mean annual loads and concentrations.

A detailed description of the water quality model is presented in Appendix B. The following summarizes major features of the water quality model:

- *Rainfall Data*: The water quality model estimates the volume of runoff from storm events. The storm events were determined from 32 years (1969 - 2002) of hourly rainfall data measured at the National Climatic Data Center (NCDC) Newhall rain gage that incorporates a wide range of storm events. The rainfall analysis that is incorporated in the water quality model requires rainfall measurements at one hour intervals and a period of record that is at least 20 to 30 years in length.

- *Land Use Runoff Water Quality*: The water quality model estimates the concentration of pollutants in runoff from storm events based on existing and proposed land uses. The pollutant concentrations for various land uses, in the form of Event Mean Concentrations (EMCs), were estimated from data collected in Los Angeles County. The Los Angeles County database was chosen for use in the model because: (1) it is an extensive database that is quite comprehensive, (2) it contains monitoring data from land use specific drainage areas, and (3) the data is representative of the semi-arid conditions in southern California.

- *Pollutant Load*: The pollutant load associated with each storm is estimated as the product of the storm event runoff times the event mean concentration. For each year in the simulation, the individual storm event loads are summed to estimate the annual load. The mean annual load is then the average of all the annual loads.

- *PDFs Modeled*: The treatment PDFs included in the water quality modeling were swales for the majority of the Landmark Village project area and dry extended detention basins for the remaining developed areas within the NRSP subregion. Although vegetated swales, bioretention areas, and other low impact/site design BMPs will be incorporated into the NRSP projects, these PDFs were not modeled as it is unknown at this time where they may be located within the specific project areas. Detention basins have been modeled as the water quality treatment PDF for the majority of the NRSP subregion, as this PDF represents the minimum level of treatment that will be provided in all of the NRSP projects. The low impact/site design BMPs will provide for greater volume and pollutant load reduction than the modeled treatment control PDFs. The model also does not take into account the source control PDFs (e.g., street sweeping and catch basin inserts) that would also improve water quality. In this respect, the modeling results are conservative, i.e., tend to overestimate pollutant loads and concentrations.

- *Treatment Effectiveness*: The water quality model estimates mean pollutant concentrations and loads in stormwater following treatment. The amount of stormwater runoff that is captured by the treatment BMPs was calculated for each storm event, taking into consideration the intensity of rainfall, duration of the storm, and duration between storm events. The mean effluent water quality for treatment BMPs was based on the International Stormwater BMP Database (ASCE/EPA, 2003). The International Stormwater BMP Database was used because it is a robust, peer reviewed database that contains a wide range of BMP effectiveness studies that are reflective of diverse land uses. An analysis of the monitored inflow and outflow data contained in the International Stormwater BMP Database showed a volume reduction on the order of 38 percent for biofilters and 30 percent for extended detention basins (Strecker et al, 2004). Based on this analysis, a conservative estimate of 25 percent of the inflow to the vegetated swales and 20 percent of the inflow to extended detention basins was assumed to infiltrate and/or evapotranspire in the water quality model. These assumptions regarding volumetric losses were also used to assess the quantity of dry weather flows that would be captured in the treatment BMPs (see Section 7.8.2).

BMP effectiveness studies in the International Stormwater BMP database infrequently monitor aluminum; therefore, insufficient effluent data were available to model the removal effectiveness of treatment control BMPs for this water quality constituent. The total aluminum content of a water sample will be directly related to the concentrations of the suspended particulate matter. The aluminum content of the suspended solids is likely to directly reflect the composition of the source materials (e.g., the catchment soils). Therefore, it would be expected and is assumed that total aluminum concentrations and loads would be reduced proportionally to removal of suspended solids by project BMPs. In order to estimate the reduction in total aluminum load and concentration (dissolved aluminum was assumed to pass through BMPs without removal), TSS removal was used as a surrogate.

- *Bypass Flows*: The water quality model takes into account conditions when the treatment facility is full and flows are bypassed.

- *Representativeness to Local Conditions*: The water quality model utilizes runoff water quality data obtained from tributary areas that have a predominant land use, and as measured prior to discharge into a receiving water body. Currently such data are available from stormwater programs in LA County, San Diego County, and Ventura County, although the amount of data available from San Diego County and Ventura County is small in comparison with the LA County database. Such data is often referred to as "end-of-pipe" data to distinguish it from data obtained in urban streams, for example.

6.2. Pollutants Modeled

The appropriate form of data used to address water quality are flow composite storm event samples, which are a measure of the average water quality during the event. To obtain such data usually requires automatic samplers that collect data at a frequency that is proportionate to flow rate. The pollutants of concern for which there are sufficient flow composite sampling data in the Los Angeles County database are:

- Total Suspended Solids (sediment)
- Total Phosphorus
- Nitrate-Nitrogen, Nitrite-Nitrogen, Ammonia, and Total Nitrogen (TN)
- Dissolved Copper
- Total Lead
- Dissolved Zinc

- Total Aluminum
- Chloride

The other pollutants of concern, such as pathogens, hydrocarbons, pesticides, and trash and debris, are not amenable to this type of sampling either because of short holding times (e.g., pathogens), difficulties in obtaining a representative sample (e.g., hydrocarbons), or low detection levels (e.g., pesticides). These pollutants were addressed qualitatively using literature information and best professional judgment due to the lack of statistically reliable monitoring data for these pollutants (see Section 6.3 below).

6.3. Qualitative Impact Analysis

Post development stormwater runoff water quality impacts associated with the following pollutants of concern were addressed based on literature information and professional judgment because available data were not deemed sufficient for modeling:

- Turbidity
- Pathogens (Bacteria, Viruses, and Protozoa)
- Hydrocarbons (Oil and Grease, Polycyclic Aromatic Hydrocarbons)
- Pesticides
- Trash and Debris
- Methylene Blue Activated Substances (MBAS)
- Cyanide

Human pathogens are usually not directly measured in stormwater monitoring programs because of the difficulty and expense involved; rather, indicator bacteria such as fecal coliform or certain strains of *E. Coli* are measured. Unfortunately, these indicators are not very reliable measures of the presence of pathogens in stormwater, in part because stormwater tends to mobilize pollutants from many sources, some of which contain non-pathogenic bacteria. For this reason, and because holding times for bacterial samples are necessarily short, most stormwater programs do not collect flow-weighted composite samples that potentially could produce more reliable statistical estimates of concentrations. Fecal coliform or *E. Coli* are typically measured with grab samples, making it difficult to develop reliable EMCs. Total coliform and fecal bacteria (fecal coliform, fecal streptococcus, and fecal enterococci) were detected in stormwater samples tested in Los Angeles County at highly variable densities (or most probable number, MPN) ranging between several hundred to several million cells per 100 ml (LACDPW, 2000).

Hydrocarbons are difficult to measure because of laboratory interference effects and sample collection issues (hydrocarbons tend to coat sample bottles). Hydrocarbons are typically measured with single grab samples, making it difficult to develop reliable EMCs.

Pesticides in urban runoff are often at concentrations that are below detection limits for most commercial laboratories and therefore there are limited statistically reliable data available on pesticides in urban runoff. Pesticides were not detected in Los Angeles County monitoring data for land use-based samples, except for diazinon and glyphosate which were detected in less than 15 percent and 7 percent of samples, respectively (LADPW, 2000).

Turbidity, trash and debris, MBAS, and cyanide are not typically included in routine urban stormwater monitoring programs. Turbidity is not typically included in post-construction treatment control BMP effectiveness studies. Several studies conducted in the Los Angeles River basin have attempted to quantify trash generated from discrete areas, but the data represent relatively small areas or relatively short periods, or both. MBAS was included in the land use-based monitoring data, but not enough data is available for modeling purposes. Cyanide was not included in the Los Angeles County land use-based monitoring program.

Also addressed qualitatively are potential water quality impacts from runoff and dewatering discharges during construction (Section 7.4), potential water quality impacts due to pollutant bioaccumulation (Section 7.5), and dry weather runoff water quality impacts (Section 7.6).

7. IMPACT ASSESSMENT

The modeled pollutant impact assessment is presented in Section 7.1 and the qualitative analyses of the remaining pollutants of concern follow in Section 7.2. Analyses of dry weather impacts and compliance with NPDES Permit requirements and construction-related requirements of the Construction General Permit and Dewatering General Permit follow the pollutant-by-pollutant impact assessment. Also included is a discussion of other considerations, including operation and maintenance, vector control, bioaccumulation, and hydrologic impacts. The analysis of cumulative impacts to surface water, groundwater, and hydromodification is also provided. A weight of evidence approach is employed using the various thresholds and significance criteria discussed in Section 4.4

7.1. Post Development Stormwater Runoff Impact Assessment for Modeled Pollutants of Concern

In this section, model results for each pollutant are evaluated in relation to the following significance criteria: (1) comparison of post-development versus pre-development stormwater quality concentrations and loads; (2) comparison with MS4 Permit, Construction General Permit, and General Dewatering Permit requirements for new development; and (3) evaluation in light of receiving water benchmarks. Pursuant to the third criterion, predicted runoff pollutant concentrations in the post-development condition, with runoff treatment PDFs, are compared with benchmark receiving water quality criteria as provided in the Basin Plan and the CTR and TMDL waste load allocations. The water quality criteria and waste load allocations are considered benchmarks for comparison purposes only, since they do not apply directly to runoff from the NRSP projects, but the comparison provides useful information to evaluate potential impacts. A weight of evidence approach is employed in this analysis considering the various significance criteria.

Results from the water quality model for significance criterion 1 are reported in a series of tables, organized by constituent, showing predicted mean annual pollutant loads (lbs/yr) and mean annual concentrations. Projections are made for two conditions: (1) existing condition, and (2) developed condition with PDFs.

Note that the modeling results account for pollutant reductions in the extended detention basins and vegetated swales only and do not account for the pollutant reductions that will occur due to low impact/site design PDFs and source control PDFs. Because not all BMPs are modeled, the model results predict greater water quality impacts than are likely to occur from the NRSP projects.

Following the table comparing post-development and pre-development water quality loads and concentrations for each constituent is a table comparing the post-development (with PDFs) runoff quality to the benchmark water quality objectives and criteria and TMDL waste load

allocations for downstream reaches of the Santa Clara River. Water quality observed in the Santa Clara River is also included on these tables as a benchmark.

7.1.1. Stormwater Runoff Volume

Table 7-1 shows the predicted changes in stormwater runoff mean annual volume. The mean annual runoff volume is expected to increase substantially with development. The increase can be explained by the change in percent imperviousness associated with urbanization, as runoff volume is directly proportional to percent imperviousness. In the pre-development condition, the majority of the land use is open space and agriculture with assumed imperviousness values of one percent and two percent, respectively. A small percentage of the pre-developed land area (three percent) is developed oil and gas pads with an imperviousness of 60 percent. In contrast, the post-development condition has urban land uses with much higher imperviousness including single family residential with an assumed imperviousness of 42 percent, multi-family residential with an assumed imperviousness of 68 percent, and commercial land use with an assumed imperviousness of 91 percent.

Project PDFs include site design, source control, and treatment control BMPs in compliance with the SUSMP requirements. Most of the site design PDFs, especially the minimization of impervious area and the conservation of approximately 8,335 acres of open space areas within the NRSP subregion, reduce the impacts of the proposed development on increases in stormwater runoff volume. The treatment control PDFs will allow for some runoff volume reduction as well. Based on BMP monitoring data in the International Stormwater BMP Database, a 20 percent reduction in stormwater runoff volume was assumed to occur in the dry extended detention basins and 25 percent volume reduction in vegetated swales. The modeling does not account for volume reductions that would occur in low impact/site design BMPs or in basins designed for hydromodification control, which would significantly lessen the increase in post-development runoff volume.

Table 7-1: Predicted Average Annual Stormwater Runoff Volumes

Site Conditions	Average Annual Stormwater Runoff Volume (acre-ft)
Existing	838
Developed with PDFs	2839
Change	2001

7.1.2. TSS

Comparison of Pre- and Post-Project Conditions: Table 7-2 shows the predicted average annual TSS concentration and loads. Conversion from the predominately pre-development open space

and agricultural land uses to the post-development urban land use (with treatment) will reduce the average TSS concentration and loads in stormwater runoff.

Table 7-2: Predicted Average Annual TSS Concentration and Loads

Site Conditions	Average Annual TSS Concentration (mg/L)	Average Annual TSS Load (tons/yr)
Existing	402	458
Developed with PDFs	60	232
Change	-342	-226

Comparison with Water Quality Criteria: The predicted average annual TSS concentration in stormwater runoff from the total modeled area with PDFs is compared to water quality criteria and the range of observed concentrations in the Santa Clara River in Table 7-3. Predicted TSS load and concentration declines with development and is at the low end of the range of observed concentrations in Santa Clara River Reach 5. Based on the comprehensive site design, source control, and treatment control strategy, and the comparison with available in-stream data and basin plan benchmark objectives, the TSS in stormwater runoff will not cause a nuisance or adversely affect beneficial uses in the receiving waters.

Table 7-3: Comparison of Predicted TSS Concentrations with Water Quality Criteria and Observed Concentrations in Santa Clara River Reach 5

Predicted Average Annual TSS Concentration (mg/L)	LA Basin Plan Water Quality Objectives	California Toxics Rule Criteria	Range of Observed[1] Concentrations in Santa Clara River Reach 5 (mg/L)
60	Water shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses	NA	32 – 6,591

[1] Range of concentrations observed in the Santa Clara River during wet weather (Stations S29, NR1, and NR3, see Section 2.3.1).
NA – not applicable

7.1.3. Total Phosphorus

Comparison of Pre- and Post-Project Conditions: Table 7-4 shows the predicted average total phosphorus (TP) concentration and annual loads. Because much of the total phosphorus load is associated with sediments, and the sediment concentrations are predicted to decrease with development, the average annual TP concentration is also predicted to decrease. Because post-

development flows are expected to increase significantly, the average annual TP load is expected to remain constant even though the TP concentration is expected to decrease.

Table 7-4: Predicted Average Annual Total Phosphorus Concentration and Annual Load

Site Conditions	Average Annual Total Phosphorus Concentration (mg/L)	Average Annual Total Phosphorus Load (tons/yr)
Existing	1.0	1.1
Developed with PDFs	0.3	1.1
Change	-0.7	0.0

Comparison with Water Quality Criteria: There are no numeric objectives for TP in the LA Basin Plan. A narrative objective for biostimulatory substances in the LA Basin Plan states: "waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses." The low predicted TP concentrations in project stormwater discharges will not promote (i.e., increase) algae growth and therefore comply with the narrative objective for biostimulatory substances in the LA County Basin Plan. As shown in Table 7-5, the predicted total phosphorus concentration is at the low end of the range of observed concentrations in Santa Clara River Reach 5.

Table 7-5: Comparison of Predicted Total Phosphorus Concentration with Water Quality Criteria and Observed Concentrations in Santa Clara River Reach 5

Predicted Average Annual Total Phosphorus Concentration (mg/L)	LA Basin Plan Water Quality Objectives	California Toxics Rule Criteria	Range of Observed[1] Concentrations in Santa Clara River Reach 5 (mg/L)
0.3	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses	NA	0.18 – 13.4

[1] Range of concentrations observed in the Santa Clara River during wet weather (Stations S29, NR1, and NR3, see Section 2.3.1).
NA – not applicable

Based on the comprehensive site design, source control, and treatment control strategy and the comparison with available in-stream monitoring data and Basin Plan benchmark objectives, potential impacts associated with total phosphorus are predicted to be less than significant.

7.1.4. Nitrogen Compounds

Comparison of Pre- and Post-Project Conditions: The predicted average nitrate-nitrogen plus nitrite-nitrogen, ammonia, and total nitrogen concentrations and annual loads are summarized in Table 7-6 through Table 7-8, respectively. Average loads and concentrations of all forms of nitrogen are predicted to decrease, except for average annual ammonia load, which is predicted to increase and the annual total nitrogen load, which is predicted to remain constant. The decrease in nitrate-nitrogen plus nitrite-nitrogen load and nitrate-nitrogen plus nitrite-nitrogen, ammonia, and total nitrogen concentrations can be attributed to higher nitrite-, nitrate-, and ammonia-nitrogen EMCs observed in monitoring data from agricultural land uses versus urbanized land uses, along with nitrogen reductions in the treatment control PDFs. Although ammonia concentrations are predicted to decrease, ammonia loads are predicted to increase due to the increase in runoff volume. Similarly, the average annual TP load is expected to remain constant even though the TP concentration is expected to decrease due to the increase in runoff volume.

Table 7-6: Predicted Average Annual Nitrate-N + Nitrite-N Concentration and Load

Site Conditions	Average Annual Nitrate+Nitrite-Nitrogen Concentration (mg/L)	Average Annual Nitrate+Nitrite-Nitrogen Load (tons/yr)
Existing	4.7	5.4
Developed with PDFs	0.6	2.5
Change	-4.1	-2.9

Table 7-7: Predicted Average Annual Ammonia-N Concentration and Load

Site Conditions	Average Annual Ammonia-N Concentration (mg/L)	Average Annual Ammonia-N Load (tons/yr)
Existing	0.7	0.7
Developed with PDFs	0.5	1.8
Change	-0.2	1.1

Table 7-8: Predicted Average Annual Total Nitrogen-N Concentration and Load

Site Conditions	Average Annual Total Nitrogen Concentration (mg/L)	Average Annual Total Nitrogen Load (tons/yr)
Existing	8.0	9.1
Developed with PDFs	2.4	9.1
Change	-5.6	0

Comparison with Water Quality Criteria: Predicted nitrogen compound concentrations are compared to Basin Plan objectives and observed concentrations in Table 7-9. Average annual stormwater concentration of ammonia is predicted to be considerably less than the waste load allocation for Santa Clara River Reach 5 and the Basin Plan objective, and within the range of observed concentrations. Likewise, the average annual stormwater concentration of nitrate-N plus nitrite-N is predicted to be considerably less than the TMDL waste load allocation or the Basin Plan water quality objective and within the range of observed concentrations for this reach of the Santa Clara River.

There are no numeric objectives for Total Nitrogen in the LA Basin Plan. A narrative objective for biostimulatory substances in the LA Basin Plan states: "waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses." The low predicted Total Nitrogen concentrations in project stormwater discharges will not promote (i.e., increase) aquatic growth and therefore comply with the narrative objective for biostimulatory substances in the LA Basin Plan. As shown in Table 7-9, the predicted total nitrogen concentration is in the range of observed concentrations in Santa Clara River Reach 5.

Based on the comprehensive site design, source control, and treatment control strategy, and the comparison with available in-stream monitoring data and benchmark Basin Plan objectives and waste load allocations, potential impacts associated with nitrogen compounds are predicted to be less than significant.

Table 7-9: Comparison of Predicted Nitrogen Compound Concentrations with Water Quality Objectives, TMDLs, and Observed Concentrations in Santa Clara River Reach 5

Nutrient	Predicted Average Annual Concentration (mg/L)	Basin Plan Water Quality Objectives[1] (mg/L)	Wasteload Allocations for MS4 Discharges into the Santa Clara River Reach 5 (mg/L)	Range of Observed[2] Concentrations in Santa Clara River Reach 5 (mg/L)
Nitrate-N + Nitrite-N	0.6	5	6.8[3]	0.5 – 4.8
Ammonia-N	0.5	2.2[4]	1.75[5]	<0.005 – 1.1
Total Nitrogen	2.4	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses	NA	<0.04 – 46[6]

[1] There are no CTR criteria for nitrogen compounds. The biostimulatory substances water quality objective is included because excessive nutrients can contribute to excessive aquatic growth.
[2] Range of concentrations observed in the Santa Clara River during wet weather (Stations S29, NR1, and NR3, see Section 2.3.1).
[3] 30-day average.
[4] 4-day average, ELS present, 90th percentile pH and temperature pairing observed at USGS Monitoring Station 11108500.
[5] 30-day average in Reach 5 below Valencia.
[6] Observed values for TKN (ammonia plus organic nitrogen).

7.1.5. Metals

Comparison of Pre- and Post-Project Conditions: Projected loads and concentrations for the trace metals copper, lead, zinc, and aluminum are presented in through Tables 7-10 through 7-13. Except for aluminum and lead, the projections are for the dissolved form of the metal, as it is the dissolved form to which the CTR criteria apply. Due to consistently low concentrations of dissolved lead in the available stormwater runoff data, it was not possible to develop reliable EMC parameters for most land uses for modeling the dissolved fraction of lead. This constituent was therefore modeled as the total recoverable metal. Copper, lead, and zinc are the most prevalent metals typically found in urban runoff. Other trace metals, such as cadmium, chromium, and mercury, are typically not detected in urban runoff or are detected at very low levels (LA County, 2000).

Post-development trace metal loads are predicted to increase compared to pre-development conditions; while post-development trace metal concentrations are predicted to decrease. These results can be explained by the difference in EMC values observed in representative monitoring data from agriculture and light industrial land uses (used in the model for portions of project area in the predeveloped condition) and the post-developed urban condition (see Appendix B, Table B-11, for the land use-based EMC values employed in the model). Runoff volumes will increase with development and the change in land use will decrease runoff metals concentrations for most proposed land uses.

Project PDFs include site design, source control, and treatment control BMPs in compliance with the SUSMP requirements. Specific site design PDFs that will be implemented to minimize increases in trace metals include directing drainage from impervious areas to bioretention areas and the selection of building material for roof gutters and downspouts that do not include copper or zinc. Source control PDFs that target metals include education for property owners, BMP maintenance, and street sweeping private streets and parking lots. The treatment control BMPs will also reduce trace metals in the runoff from the proposed development. Only the effects of the treatment control PDFs are reflected in the model results.

Table 7-10: Predicted Average Annual Dissolved Copper Concentration and Load

Site Conditions	Average Annual Dissolved Copper Concentration (µg/L)	Average Annual Dissolved Copper Load (lbs/yr)
Existing	11	25
Developed with PDFs	9	72
Change	-2	47

Table 7-11: Predicted Average Total Lead Concentration and Annual Load

Site Conditions	Average Annual Total Lead Concentration (µg/L)	Average Annual Total Lead Load (lbs/yr)
Existing	12	27
Developed with PDFs	7	55
Change	-5	28

Table 7-12: Predicted Average Annual Dissolved Zinc Concentration and Load

Site Conditions	Average Annual Dissolved Zinc Concentration (µg/L)	Average Annual Dissolved Zinc Load (lbs/yr)
Existing	104	236
Developed with PDFs	42	324
Change	-62	88

Table 7-13: Predicted Average Annual Total Aluminum Concentration and Load

Site Conditions	Average Annual Total Aluminum Concentration (µg/L)	Average Annual Total Aluminum Load (lbs/yr)
Existing	873	1,991
Developed with PDFs	555	4,288
Change	-318	2,297

Comparison with Water Quality Criteria: A narrative objective for toxic substances in the LA Basin Plan states: "all waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life."

The CTR criteria are the applicable water quality objectives for protection of aquatic life. The CTR criteria are expressed for acute and chronic (4-day average) conditions; however, only acute conditions were considered to be applicable for stormwater discharges because the duration of stormwater discharge is consistently less than 4 days. The CTR criteria are calculated on the basis of the hardness of the receiving waters. Lower hardness concentrations result in lower, more stringent CTR criteria. The minimum hardness value (250 mg/L as $CaCO_3$) observed in the Santa Clara River at the USGS Station 11108500 during wet weather was used as a conservative estimate; the mean observed hardness value was 660 mg/L as $CaCO_3$.

For aluminum, the National Ambient Water Quality Criteria (NAWQC) acute criterion (750 µg/L for a pH range of 6.5 to 9.0) was used as a benchmark, as the CTR does not include aluminum. Although the NAWQC criterion is in the form of acid soluble aluminum (USEPA, 1988), the available monitoring data are for either dissolved aluminum or total aluminum. Acid soluble aluminum (which is operationally defined as the aluminum that passes through a 0.45 µm membrane filter after the sample has been acidified to a pH between 1.5 and 2.0 with nitric acid) represents the forms of aluminum toxic to aquatic life or that can be readily converted to toxic forms under natural conditions. The acid soluble measurement does not measure forms of aluminum, such as aluminum that is occluded in minerals, clays, and or is strongly sorbed to particulate matter, that are not toxic and are not likely to become toxic under natural conditions. As acid soluble aluminum data is not available, total aluminum has been used in order to be conservative.

Comparison of the predicted runoff metal concentrations and the acute CTR criteria for dissolved copper, total lead, and dissolved zinc and the NAWQC criterion for aluminum are shown in Table 7-14, along with the range of observed concentrations in Santa Clara River Reach 5. Although the trace metal loadings are predicted to increase, the comparison of the post-developed with PDFs condition to the benchmark CTR and NAWQC values shows that all of the trace metal concentrations are below the benchmark water quality criteria. As shown in Table 7-14, the predicted trace metal concentrations are in the range of observed concentrations in Santa Clara River Reach 5 except for dissolved zinc which is slightly higher.

Table 7-14: Comparison of Predicted Trace Metal Concentrations with Water Quality Criteria and Observed Concentrations in Santa Clara River Reach 5

Metal	Predicted Average Annual Concentration (µg/L)	California Toxics Rule Criteria[1] (µg/L)	Range of Observed[2] Concentrations in Santa Clara River Reach 5 (µg/L)
Dissolved Copper	9.3	32	3.3 – 22.6
Total Lead	7.1	260	0.6 – 40
Dissolved Zinc	42	250	3 – 37
Total Aluminum	555	750	131 – 19,650

[1] Hardness = 250 mg/L, based on minimum observed value at USGS Station 11108500. Lead criteria is for total recoverable lead. NAWQC aluminum criteria for pH 6.5 – 9.0.
[2] Range of concentrations observed in the Santa Clara River during wet weather (Stations S29, NR1, and NR3, see Section 2.3.1).

Based on the comprehensive site design, source control, and treatment strategy and the comparison with the instream water quality monitoring data and benchmark water quality criteria, the NRSP projects will not have significant impacts resulting from trace metals.

7.1.6. Chloride

Comparison of Pre- and Post-Project Conditions: Table 7-15 shows the predicted average annual chloride concentration and load. Due to the conversion from agricultural to urban land-uses and the associated EMCs, annual chloride concentration is predicted to decrease when compared to the existing conditions, although the average annual chloride load is predicted to increase due to increased runoff volume.

Table 7-15: Predicted Average Annual Chloride Concentration and Load

Site Conditions	Average Annual Chloride Concentration (mg/L)	Average Annual Chloride Load (tons/yr)
Existing	20	23
Developed with PDFs	14	52
Change	-6	29

Comparison with Water Quality Criteria: The predicted chloride concentration in post-development project runoff is compared to the LA Basin Plan water quality objective and the range of observed concentrations in Santa Clara River Reach 5 in Table 7-16. The predicted average annual chloride concentration in stormwater runoff is at the low end of the range of observed concentrations for this pollutant and is well below the Santa Clara River Reach 5 Basin Plan water quality objective and the TMDL waste load allocation for Santa Clara River Reach 5 (100 mg/L for both). Based on the comprehensive site design, source control, and treatment control strategy, and comparison with benchmark receiving water criteria and instream monitoring data, the NRSP projects are not expected to have significant water quality impacts resulting from chloride.

Table 7-16: Comparison of Predicted Chloride Concentrations with Water Quality Criteria and Observed Concentrations in Santa Clara River Reach 5

Pollutant	Predicted Average Annual Concentration (mg/L)	LA Basin Plan Water Quality Objectives[1] (mg/L)	Range of Observed[2] Concentrations in Santa Clara River Reach 5 (mg/L)	Wasteload Allocations for MS4 Discharges into the Santa Clara River Reach 5 (mg/L)
Chloride	14	100	3 - 121	100

[1] There are no CTR criteria for chloride.
[2] Range of concentrations observed in the Santa Clara River during wet weather (Stations S29, NR1, and NR3, see Section 2.3.1).

7.2. Post Development Stormwater Impact Assessment for Pollutants and Basin Plan Criteria Addressed Without Modeling

7.2.1. Turbidity

Turbidity is a measure of suspended matter that interferes with the passage of light through the water or in which visual depth is restricted (Sawyer et al, 1994). Turbidity may be caused by a wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. In lakes or other waters existing under relatively quiescent conditions, most of the turbidity will be due to colloidal and extremely fine dispersions. In rivers under flood conditions, most of the turbidity will be due to relatively coarse dispersions. Erosion of clay and silt soils may contribute to in-stream turbidity (see discussion of hydromodification impacts in Section 7.9 below). Organic materials reaching rivers serve as food for bacteria, and the resulting bacterial growth and other microorganisms that feed upon the bacteria produce additional turbidity. Nutrients in runoff may stimulate the growth of algae, which also contribute to turbidity.

Discharges of turbid runoff are primarily of concern during the construction phase of development. Construction-related impacts are addressed in Section 7.4 below. The Construction Stormwater Pollution Prevention Plan must contain sediment and erosion control BMPs pursuant to the Construction General Permit, and those BMPs must effectively control erosion and discharge of sediment, along with other pollutants, per the Best Available Technology Economically Achievable and Best Conventional Pollutant Control Technology (BAT/BCT) standards[6]. Additionally, fertilizer control and non-visible pollutant monitoring and trash control BMPs in the SWPPP will combine to help control turbidity during the construction phase.

In the post-development condition, placement of impervious surfaces will serve to stabilize soils and to reduce the amount of erosion that may occur from the NRSP projects during storm events,

---

[6] BAT/BCT are Clean Water Act technology-based standards that are applicable to construction site stormwater discharges. Federal law specifies factors relating to the assessment of BAT including: age of the equipment and facilities involved; the process employed; the engineering aspects of the application of various types of control techniques; process changes; the cost of achieving effluent reduction; non-water quality environmental impacts (including energy requirements); and other factors as the Administrator deems appropriate. Clean Water Act §304(b)(2)(B). Factors relating to the assessment of BCT include: reasonableness of the relationship between the costs of attaining a reduction in effluent and the effluent reduction benefits derived; comparison of the cost and level of reduction of such pollutants from the discharge from publicly owned treatment works to the cost and level of reduction of such pollutants from a class or category of industrial sources; the age of the equipment and facilities involved; the process employed; the engineering aspects of the application of various types of control techniques; process changes; non-water quality environmental impact (including energy requirements); and other factors as the Administrator deems appropriate. Clean Water Act §304(b)(4)(B). The Administrator of U.S. EPA has not issued regulations specifying BAT or BCT for construction site discharges.

and will therefore decrease turbidity in the runoff (see also hydromodification impacts discussed in section 7.9 below). Project PDFs, including source controls (such as common area landscape management and common area litter control) and treatment control BMPs in compliance with the SUSMP requirements, will prevent or reduce the release of organic materials and nutrients (which might contribute to algal blooms) to receiving waters. As shown in Section 7.1 above, post-development nutrients in runoff are not expected to cause significant water quality impacts. Based on implementation of the Project PDFs and the construction-related controls outlined in Section 7.4, runoff discharges from the NRSP projects will not cause increases in turbidity which would result in adverse affects to beneficial uses in the receiving waters. Based on these considerations, the water quality impacts of the NRSP projects on turbidity are considered less than significant.

7.2.2. Pathogens

Pathogens are viruses, bacteria, and protozoa that can cause illness in humans. Identifying pathogens in water is difficult as the number of pathogens is exceedingly small, thereby requiring sampling and filtering large volumes of water. Traditionally water managers have relied on measuring "pathogen indicators," such as total and fecal coliform, as an indirect measure of the presence of pathogens. Although such indicators were considered reliable for sewage samples, indicator organisms are not necessarily reliable indicators of viable pathogenic viruses, bacteria, or protozoa in stormwater because coliform bacteria, in addition to being found in the digestive systems of warm-blooded animals, are also found in plants and soil. Certain pathogen indicators can multiply in the field if the substrate, temperature, moisture, and nutrient conditions are suitable. Paulsen and List summarize the debate over the use of pathogenic indicators and point out that scientific studies show no correlation between fecal coliform densities and gastrointestinal illness in swimmers, therefore coliform may not indicate a significant potential for causing human illness (Paulsen and List, 2005, provided in Appendix D). In a recent field study conducted by Schroeder *et. al.*, pathogens (in the form of viruses, bacteria, or protozoa) were found to occur in 12 of 97 samples taken, but the samples that contained pathogens did not correlate with the concentrations of indicator organisms (Schroeder *et. al.* 2002). Most researchers who have correlated human illness to fecal indicator bacteria levels have conducted epidemiological studies in waters receiving point inputs of treated or raw sewage; few epidemiological studies have tested the health effects of exposure to water receiving direct and recent stormwater runoff. Thus there is no explicit documentation of the health effects of stormwater based on epidemiological studies (WERF, 2007).

There are numerous sources of pathogen indicators, including birds and other wildlife, as well as domesticated animals and pets, soils, and plant matter. Anthropogenic sources may include poorly functioning septic systems, cross-connections between sewer and storm drains, and the utilization of outdoor areas for human waste disposal by people without access to indoor sanitary facilities.

It is recognized that natural levels of bacteria are present in the Project's receiving waters and that control of such natural sources is not required nor desired by regulatory agencies. For example, the LARWQCB TMDL for bacteria in the Malibu Creek watershed makes provisions for background levels of bacteria associated with natural sources (LARWQCB, 2004). Bacteria TMDLs have not been developed for the Santa Clara River.

Data collected from undeveloped watersheds or watersheds with little development indicate that bacterial standards are often exceeded. For example, monitoring data obtained by Los Angeles County (LACDPW, 2000) for vacant land use showed a mean fecal coliform concentration of 1,397 MPN/100 mL in 21 samples (compared to the REC1 water quality criteria of 400 MPN/100 mL). The USEPA has recognized that routine exceedances of ambient water quality criteria due to natural sources of pollution occur. In response, the USEPA has recommended changes to designated uses as the most appropriate way to address these situations (Paulsen and List, 2005). The monitoring data collected in the tributaries of the Santa Clara River showed a range of fecal coliform concentrations from 953 MPN/100 mL to greater than 81,200 MPN/100 mL (see Table 2-19).

The USEPA has compiled an extensive database on stormwater data collected as part of its program to regulate stormwater (Pitt et al, 2003). These data were drawn from 65 programs in 17 states throughout the United States. The data indicate that median fecal concentrations range from about 4,500 to 7,700 MPN/100 mL for a range of commercial and residential land uses, compared to a median value of around 3,000 MPN/100 mL for open space and vacant land. These data represent urban areas that in general do not have source and treatment controls, and therefore are not indicative of runoff from the proposed Specific Plan build-out.

Runoff from agricultural watersheds involving horticulture and row cropping is known to similarly contain relatively high levels of indicator bacteria. Data from a stormwater drain serving an agricultural watershed with predominantly row crops in Ventura County showed similar median fecal coliform levels (~ 7,000 MPN/100 mL) to that found for general urban runoff (Ventura County, 2005). Agricultural land and open space areas likely share some of the same wildlife sources, but livestock may be present as well. These data indicate that wildlife, livestock, plants and/or soils can be a very important source of pathogens and/or pathogen indicators such as fecal coliform.

Additionally, a study conducted by PBS&J in coastal watersheds near Laguna Beach in Orange County (PBS&J, 1999) found that indicator bacteria concentrations in receiving waters downstream from the developed/urban watersheds were not significantly different than concentrations in receiving waters downstream from undeveloped watersheds. Additional analysis conducted by Paulsen and List (Paulsen and List, 2005) further supported these findings. These studies suggest that the development under the Specific Plan would not result in appreciable changes in pathogen levels in the receiving waters compared to the existing conditions.

The primary sources of fecal coliform from the Specific Plan development would likely be sediment, pet wastes, wildlife, and regrowth in the storm drain itself. Other sources of pathogens and pathogen indicators, such as cross connections between sanitary and storm sewers, are unlikely given modern sanitary sewer installation methods and inspection and maintenance practices.

The levels of bacteria in runoff from the Specific Plan projects would be reduced by:

- source controls, and
- treatment controls.

The most effective means of controlling pet wastes and wastes from human interaction with wildlife is through source control, specifically education of pet owners, education regarding feeding of waterfowl near waterbodies, providing products and disposal containers that encourage and facilitate cleaning up after pets, and storm drain cleaning practices. These BMPs are described in Section 5 Project Design Features.

Although, there are limited data on the effectiveness of extended detention basins to treat pathogen indicators, the treatment processes known to be occurring in extended detention basins involve sunlight (ultraviolet light) degradation, sedimentation, and infiltration, all of which can reduce pathogen concentrations and loads. Many of the proposed detention basins are to be located on relatively infiltrative soils and pathogen removal by filtration is a common and effective practice in wastewater treatment. The Center for Watershed Protection maintains a National Pollutant Removal Performance Database that indicates that removal performance for pathogen indicators in various types of extended detention basins ranged between 70 to 80 percent (CWP, 2000).

In addition to treatment by extended detention, bioretention areas and vegetated swales are proposed. Bioretention relies on filtration through an amended sand soil layer for water quality treatment, while vegetated swales provide sediment removal through settling and allow for infiltration of low flows. Again, filtration and infiltration are effective means of treating pathogen indicators. The city of Austin, Texas conducted a number of studies on the effectiveness of sedimentation/filtration treatment systems for treating stormwater runoff (City of Austin, 1990; CWP, 1996). Most of the structures were designed to treat one-half inch of runoff. Data from four sand filters indicated a range of removals from 37 percent to 83 percent for fecal coliform, and 25 percent to 81 percent for fecal streptococci. Research on the use of filtration to remove bacteria also has been conducted in Florida by the Southwest Florida Water Management District (Kurz, 1999). Significant reductions in total and fecal coliform bacteria and the other indicators were observed between inflow and outflow samples for sand filtration. Percent reductions were measured using flow-weighted sampling techniques. Total coliform bacteria removals were less than 70 percent, and fecal coliform bacteria reduction varied from 65 percent

to 100 percent. In a literature summary, the USEPA reported typical pathogen removal for infiltration basins and trenches as 65 to 100 percent (USEPA, 1993).

In summary, stormwater discharges from the Project could potentially exceed the REC-1 Basin Plan standard for fecal coliform and therefore impacts from indicator bacteria may be significant prior to mitigation. However, although such fecal indicator bacteria were considered reliable for sewage samples, indicator organisms are not necessarily reliable indicators of viable pathogenic viruses, bacteria, or protozoa in stormwater because coliform bacteria, in addition to being found in the digestive systems of warm-blooded animals, are also found in plants and soil. Potential post-development pathogen sources include natural sources, and it is recognized that natural levels of bacteria are present in the Project's receiving waters and that control of such natural sources is not required nor desired by regulatory agencies. Anthropogenic sources include leaking septic and sewer systems and pet wastes. The Specific Plan projects will not include septic systems and the sewer system will be designed to current standards which minimizes the potential for leaks. The proposed Specific Plan development, consistent with the MS4 permit requirements, includes a comprehensive set of source and treatment control BMPs selected to manage pollutants of concern, including pathogens and pathogen indicators. With this series of BMPs, Specific Plan build-out would not result in substantial changes in pathogen levels in the receiving waters compared to existing conditions, and potential water quality impacts related to pathogens are considered less than significant.

7.2.3. Hydrocarbons

Various forms of hydrocarbons (oil and grease) are common constituents associated with urban runoff; however, these constituents are difficult to measure and are typically measured with grab samples, making it difficult to develop reliable EMCs for modeling. Based on this consideration, hydrocarbons were not modeled but are addressed qualitatively.

Hydrocarbons are a broad class of compounds, most of which are non-toxic. Hydrocarbons are hydrophobic (low solubility in water), have the potential to volatilize, and most forms are biodegradable. A subset of hydrocarbons, Polynuclear Aromatic Hydrocarbons (PAHs) can be toxic depending on the concentration levels, exposure history, and sensitivity of the receptor organisms. Of particular concern are those PAH compounds associated with transportation-related sources.

Although the concentration of hydrocarbons in runoff is expected to increase slightly under post-development conditions due to the increase in roadways, driveways, parking areas, and vehicle use, the PDFs are expected to prevent appreciable increases in hydrocarbon concentrations from leaving the project sites. Source control PDFs that address petroleum hydrocarbons include educational materials on used oil programs, carpooling, and public transportation alternatives to driving; BMP maintenance; and street sweeping private streets. Although vehicle emissions and leaks are the primary source of hydrocarbons in urban areas, it is anticipated that vehicles in the

proposed development will in general be well maintained and newer models which will help to limit emissions and leaks. Lastly, the parking lot site design, source controls, treatment BMPs and vegetation and soils within the treatment control PDFs will adsorb the low levels of emulsified oils in stormwater runoff, preventing discharge of hydrocarbons and visible film in the discharge or the coating of objects in the receiving water.

The majority of PAHs in stormwater adsorb to the organic carbon fraction of particulates in the runoff, including soot carbon generated from vehicle exhaust (Ribes et al, 2003). For example, a stormwater runoff study by Marslek *et. al.* (1997) found that the dissolved-phase PAHs represented less than 11 percent of the total concentration of PAHs. Consequently, the extended detention basins, bioretention areas, and vegetated swales proposed as PDFs, which are designed to treat pollutants through settling, filtration, and infiltration, will be effective at treating PAHs.

Los Angeles County conducted PAH analyses on 27 stormwater samples from a variety of land uses in the period 1994-2000 (Los Angeles County, 2000). For those land uses where sufficient samples were taken and were above detection levels to estimate statistics, the mean concentrations of individual PAH compounds ranged from 0.04 to 0.83 µg/L. The reported means were less than the acute toxicity criteria available from the literature (Suter and Tsao, 1996). Moreover, the Los Angeles County data do not account for any treatment, whereas the treatment in the PDFs should result in a reduction in hydrocarbon concentrations inclusive of PAHs. This makes it very unlikely that impacts will occur to the receiving water due to hydrocarbon loads or concentrations. On this basis, the effect of the NRSP projects on petroleum hydrocarbon levels in the receiving waters post-development is considered less than significant.

During the construction phase of the NRSP projects, hydrocarbons in site runoff could result from construction equipment/vehicle fueling or spills. Construction related impacts are addressed in Section 7.4 below. However, pursuant to the Construction General Permit, the Construction Stormwater Pollution Prevention Plan must include BMPs that address proper handling of petroleum products on the construction site, such as proper petroleum product storage and spill response practices, and those BMPs must effectively prevent the release of hydrocarbons to runoff per the Best Available Technology Economically Achievable and Best Conventional Pollutant Control Technology standards. PAH that are adsorbed to sediment during the construction phase would be effectively controlled via the erosion and sediment control BMPs. For these reasons, construction-related water quality impacts related to hydrocarbons are considered less than significant.

7.2.4. Pesticides

Pesticides can be of concern where past farming practices involved the application of persistent organochlorine pesticides. Legacy pesticides Chlordane, Dieldrin, DDT, and Toxaphene are of particular concern, as TMDLs have been established for these pesticides in the Santa Clara River

estuary, approximately 40 miles downstream of the NRSP subregion and this reach of the river. Historical pesticides should no longer be discharged in the watershed except in association with erosion of sediments to which these pollutants may have adhered in the past. Required remedial grading along with the placement of impervious surfaces will stabilize soils and prevent their transport from the development sites, actually reducing the potential for discharge of sediments to which historical pesticides may have adsorbed in pre-development conditions.

In the post-developed condition, pesticides will be applied to common landscaped areas and residential lawns and gardens. Pesticides that have been commonly found in urban streams include the organophosphate pesticides chlorpyrifos and diazinon (Katznelson and Mumley, 1997). However, only 0 to 13% of the samples in the LA County database had detectable levels of diazinon (depending on the land use) while levels of chlorpyrifos were below detection limits for all land uses in all samples taken between 1994 and 2000 (LA County, 2000). Other pesticides presented in the database were seldom measured above detection limits. Furthermore, these data represent flows from areas without treatment controls, unlike the NRSP projects which incorporate treatment control PDFs.

Diazinon and chlorpyrifos are two pesticides of concern due to their potential toxicity in receiving waters. The USEPA has banned all indoor uses of diazinon in 2002 and stopped all sales for all outdoor non-agricultural use in 2003 (USEPA, June, 2002)[7]. With no agricultural uses planned for the proposed Project, diazinon would not be used in the NRSP projects. The USEPA is also phasing out all indoor and outdoor residential uses of chlorpyrifos and has stopped all non-residential uses where children may be exposed. Use of chlorpyrifos in the NRSP subregion is not expected, with the possible exception of emergency fire ant eradications until such time as reasonable alternative products are available and only with appropriate application practices in accordance with the golf course and landscape pesticide management program.

---

[7] Changes to the use of chlorpyrifos include reductions in the residue tolerances for agricultural use, phases out nearly all indoor and outdoor residential uses, and also stops non-residential uses where children may be exposed. In Orange County, residential use accounts for around 90% of total chlorpyrifos (USEPA, June 2002). Retail sales of chlorpyrifos were stopped by December 31, 2001, and structural (e.g. construction) uses will be phased out by December 31, 2005. Some continued uses will be allowed, for example public health use for fire ant eradication and mosquito control will be permitted by professionals.

Permissible uses of diazinon will also be restricted. All indoor uses are prohibited (as of 12/2002) and retailers were required to end sales for indoor use on December, 2002. All outdoor non-agricultural uses were phased out by December 31, 2004. Therefore it is likely that the USEPA agreement will eliminate most of the use of diazinon within the NRSP area. The use of diazinon for many agricultural crops has been eliminated (USEPA 2001), while some use of this chemical will continue to be permitted for some agricultural activities.

Diazinon had long been one of the most commonly used pesticides on the market (SFBRWQCB, 2005) before its use was phased-out. Although the U.S. Environmental Protection Agency's actions eliminated most urban diazinon uses by the end of 2004, phasing out diazinon likely has increased post-2004 reliance on alternative pesticides and encouraged new pesticides to enter the marketplace.

The San Francisco Regional Water Quality Control Board commissioned a study, Insecticide Market Trends and Potential Water Quality Implications, to evaluate pesticide use trends as they relate to water quality. In 2003, on the basis of current and projected pesticide use and possible water quality risks, the report considered the pesticide alternatives of potential concern for water quality to be pyrethrums; parathyroid's (bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, and permethrin); carbaryl; malathion; and imidacloprid (SFBRWQCB, 2003). A more recent study also identified lambda cyhalothrin (a pyrethroid) and fipronil among pesticides of interest (SFEP, 2005).

The water quality risks posed by a pesticide relate to the quantity of the pesticide used, its runoff characteristics, and its relative toxicity in water and sediment. As urban diazinon applications are phased out, the use of some alternatives may inadvertently pose new water quality risks. Given what is known about alternative pesticide use trends, pyrethroids may be the alternatives that pose the greatest concerns for water quality (SFBRWQCB, 2005). Although pyrethroids tend to be toxic to Ceriodaphnia dubia test organisms at concentrations in water comparable to diazinon, pyrethroids do not dissolve well in water but instead adhere well to surfaces, including particles in the environment (SFBRWQCB, 2005). At equilibrium, pyrethroid concentrations in sediment are reported to be about 3,000 times greater than dissolved concentrations in water (SFBRWQCB, 2005). Thus, BMPs targeting reductions and removal of sediment loads will be effective to reduce and remove pyrethroids as well.

Source control measures such as education programs for owners, occupants, and employees in the proper application, storage, and disposal of pesticides are the most promising strategies for controlling the pesticides that will be used post-development. Structural treatment controls are less practical because of the variety of pesticides and wide range of chemical properties that affect their ability to treat these compounds. However, most pesticides, including historical pesticides that may be present at the site, are relatively insoluble in water and therefore tend to adsorb to the surfaces of sediment, which will be stabilized with development, or if eroded, will be settled or filtered out of the water column in the water quality treatment PDFs. Thus, treatment in the bioretention, vegetated swales, and extended detention basin should achieve some removal of pesticides from stormwater as TSS is reduced.

For common area landscaping in commercial areas, multi-family residential areas, and parks, an Integrated Pest Management (IPM) Program will be incorporated. The goal of an IPM is to keep pest levels at or below threshold levels, reducing risk and damage from pest presence, while eliminating the risk from the pest control methods used. IPM programs achieve these goals

through the use of low risk management options by emphasizing use of natural biological methods and the appropriate use of selective pesticides. IPM programs also incorporate environmental consideration by implementing procedures that minimize intrusion and alteration of biodiversity in ecosystems.

While pesticides are subject to degradation, they vary in how long they maintain their ability to eradicate pests. Some break down almost immediately into nontoxic byproducts, while others can remain active for longer periods of time. While pesticides that degrade rapidly are less likely to adversely affect non-targeted organisms, in some instances it may be more advantageous to apply longer-lasting pesticides if it results in fewer applications or smaller amounts of pesticide use. As part of the Integrated Pest Management program, careful consideration will be made as to the appropriate type of pesticides for use in the NRSP subregion. While pesticide use is likely to occur due to maintenance of landscaped areas, particularly in the residential portions of the development, careful selection, storage and application of these chemicals for use in common areas per the IPM Program will help prevent adverse water quality impacts from occurring. Additionally, as discussed above, removal of sediments in the PDFs will also remove sediment-adsorbed pesticides.

Based on the incorporation of site design, source control, and treatment control BMPs pursuant to SUSMP requirements and the use of an Integrated Pest Management Program, potential post-development impacts associated with pesticides are expected to be less than significant.

Transport of legacy pesticides adsorbed to existing site sediments may be a concern during the construction phase of development. Construction-related impacts are addressed in Section 7.4 below. The Construction Stormwater Pollution Prevention Plan must contain sediment and erosion control BMPs pursuant to the Construction General Permit, and those BMPs must effectively control erosion and the discharge of sediment along with other pollutants per the BAT/BCT standards. Based on these sediment controls, construction-related impacts associated with pesticides are expected to be less than significant.

7.2.5. Trash and Debris

Urban development tends to generate significant amounts of trash and debris. Trash refers to any human-derived materials including paper, plastics, metals, glass and cloth. Debris is defined as any organic material transported by stormwater, including leaves, twigs, and grass clippings (DLWC, 1996). Debris can be associated with the natural condition. Trash and debris is often characterized as material retained on a 5-mm mesh screen. It contributes to the degradation of receiving waters by imposing an oxygen demand, attracting pests, disturbing physical habitats, clogging storm drains and conveyance culverts and mobilizing nutrients, pathogens, metals, and other pollutants that may be attached to the surface. Sources of trash in developed areas can be both accidental and intentional. During wet weather events, gross debris deposited on paved surfaces can be transported to storm drains, where it can be eventually discharged to receiving

waters. Trash and debris can also be mobilized by wind and transported directly into waterways, imposing an oxygen demand on the water body as organic matter decomposes.

Urbanization could significantly increase trash and debris loads if left unchecked. However, the PDFs, including source control and treatment BMPs, will minimize the adverse impacts of trash and debris. Source controls such as street sweeping, public education, fines for littering, and storm drain stenciling can be effective in reducing the amount of trash and debris that is available for mobilization during wet and dry weather events. Common area litter control will include a litter patrol, covered trash receptacles, emptying of trash receptacles in a timely fashion, and noting trash violations by tenants/homeowners or businesses and reporting the violations to the owner/HOA for investigation. Catch basin inserts will be provided for parking lots. The PDFs will remove or prevent the release of floating materials, including solids, liquids, foam, or scum, from runoff discharges and will prevent impacts on dissolved oxygen in the receiving water due to decomposing debris. Based on these considerations, post-development trash and debris is not expected to significantly impact the receiving waters of the NRSP projects.

During the construction phase, there is potential for an increase in trash and debris loads due to lack of proper contractor good housekeeping practices at the construction site. Per the Construction General Permit, the SWPPP for the site will include BMPs for trash control (catch basin inserts, good housekeeping practices, etc.). Compliance with the Permit Requirements and inclusion of these BMPs, meeting BAT/BCT, included in the SWPPP will mitigate impacts from trash and debris to a level less than significant. See Section 7.4 below for a full discussion of Construction Related Impacts.

7.2.6. Methylene Blue Activated Substances (MBAS)

MBAS, which is related to the presence of detergents in runoff, may be incidentally associated with urban development due to commercial and/or residential vehicle washing or other outdoor washing activities. Surfactants disturb the surface tension which affects insects and can affect gills in aquatic life.

The presence of soap in project runoff will be controlled through the source control PDFs, including a public education program on residential and charity car washing, and the provision of a car wash pad connected to sanitary sewer in the multi-family residential areas. Other sources of MBAS, such as cross connections between sanitary and storm sewers, are unlikely given modern sanitary sewer installation methods and inspection and maintenance practices. Therefore, MBAS are not expected to significantly impact the receiving waters of the NRSP projects.

7.2.7. Cyanide

The information on cyanide levels in urban stormwater is relatively sparse. The incidence of detection of cyanide in urban stormwater is relatively low, except in some special cases. In the

Nationwide Urban Runoff Project (NURP), cyanide was detected in runoff from four cities out of a total of 15 cities that participated in the monitoring program (USEPA 1983). Overall, cyanide was detected in 23 percent of the urban runoff samples collected (16 out of a total of 71 samples), at concentrations ranging from 2 to 33 µg/L (Cole *et. al.* 1984). Of the 71 samples, only 3 percent (i.e., 2) exceeded the freshwater acute guideline of 22 µg/L (USEPA 1983). The predominant sources of cyanides found in urban runoff samples were reported to be products of gasoline combustion and anti-caking ingredients in road salts (Cole *et. al.* 1984).

A review of highway runoff (Colman *et. al.* 2001) suggested that deicing salts are the main source of cyanide in highway runoff. It has been estimated that approximately two million pounds of sodium ferrocyanide, which is used as an anticaking agent in road salts during the winter in the northeastern United States, are washed off from roads into streams and storm sewers (USEPA 1981; Gaffney *et. al.* 1987). Information on the quality of snow packs and snow melt support the premise that deicing salts are the major source of cyanide in stormwater. For example, concentrations of cyanide in snow packs ranged up to 314 µg/L in Milwaukee and Syracuse (Novotny *et. al.* 1999). An urban stream receiving snow melt in Milwaukee had an average cyanide concentration of 31 µg/L (<2 – 45 µg/L). Two urban streams in Syracuse had average cyanide concentrations of 8 µg/L (<2 – 27 µg/L) and 48 µg/L (<2 – 167 µg/L), respectively. Reconsidering the NURP findings, three of the four cities which detected cyanide are within the snowbelt, and may have used deicing salts containing anti-caking agents. One (Austin, Texas) presumably does not.

In contrast to these relatively high concentrations associated with deicing salts, runoff from cities which do not use deicing salts or from northern cities outside the snow season has lower concentrations of cyanides. The City of Fresno NURP study (Brown & Caldwell, 1984) found undetectable cyanide (< 10 µg/L) in 19 grab samples of stormwater runoff from four watersheds with different land uses. Highway runoff from three urban sites in Michigan had average cyanide concentrations ranging from 5.8 – 9.3 µg/L. Samples were collected from June through October, which was outside the season where deicing salts might be used. Traffic volumes were high and ranged from 40,000 to 120,000 vehicles per day.

It is highly probable that the reported concentrations which exceed the freshwater acute guideline in urban stormwater are associated with the use of deicing salts containing the de-caking agent ferrocyanide. In situations where deicing salts are not being used, and where vehicle exhaust may be the dominant source, concentrations are much less (e.g., typically < 10 µg/L), even with high traffic volumes. Anti-caking agents will not be a source of cyanide in urban stormwater in the NRSP subregion, and the forgoing discussion suggests that concentrations in stormwater runoff from the NRSP projects may reach concentrations of magnitude of approximately 10 µg/L, but are highly unlikely to exceed the acute CTR criteria of 22 µg/L.

The detectable concentrations observed in the Santa Clarita River at the mass emission station S29 (average of 10 µg/L) may be in part due to untreated urban stormwater runoff from the City

of Santa Clarita. However, other sources are likely to be more significant. A potential source is cyanide from burnt catchments. For example, cyanide concentrations in run-off obtained from an area that had been burned in a wildfire that occurred in Tennessee and North Carolina averaged 49 µg/L (Barber *et. al.* 2003). Higher cyanide concentrations were reported in run off from a wild fire that occurred in New Mexico, with an average value of 80 µg/L.

In addition to the expected relatively low level of cyanide in untreated stormwater, cyanide in runoff from the NRSP projects would be readily removed by biological uptake, degradation by microorganisms, and by volatilization in the treatment PDFs, especially the dry extended detention basins. Therefore cyanide is not expected to significantly impact the receiving waters of the NRSP projects.

7.3. MS4 Permit Requirements for New Development as Defined in the SUSMP

Project Design Features (PDFs) include site design, source control, and treatment control BMPs in compliance with the SUSMP requirements, as described in Section 5.1 and summarized in Table 5-1. Treatment control PDFs will treat runoff from the entire urban portion of the NRSP subregion. Sizing criteria contained in the MS4 Permit and the SUSMP requirements will be met for all treatment control BMPs.

In summary, the proposed site design, source control, and treatment control PDFs have been selected based on:

- effectiveness for addressing pollutants of concern in project runoff, resulting in insignificant water quality impacts;
- sizing and outlet design consistent with the MS4 Permit and SUSMP requirements;
- additional design guidance consistent with the California BMP Handbook: New Development and Redevelopment, other literature, and best professional judgment;
- hydrologic and water quality modeling to verify performance;
- meeting mean annual percent capture criteria contained in the California BMP New Development Manual; and
- providing specific O&M requirements to inspect and maintain the facilities.

On this basis, the proposed PDFs meet the MS4 Permit requirements for new development.

7.4. Construction-Related Impacts

The potential impacts of construction activities, construction materials, and non-stormwater runoff on water quality during the construction phase focus primarily on sediment (TSS and

turbidity) and certain non-sediment related pollutants. Construction-related activities that are primarily responsible for sediment releases are related to exposing soils to potential mobilization by rainfall/runoff and wind. Such activities include removal of vegetation from the site, grading of the site, and trenching for infrastructure improvements. Environmental factors that affect erosion include topographic, soil, and rainfall characteristics. Non sediment-related pollutants that are also of concern during construction relate to construction materials and non-stormwater flows and include construction materials (e.g., paint, stucco, etc); chemicals, liquid products, and petroleum products used in building construction or the maintenance of heavy equipment; and concrete-related pollutants.

Construction impacts due to project development, including the borrow source activities and in-stream construction elements, will be minimized through compliance with the Construction General Permit. This permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP), which must include erosion and sediment control BMPs that will meet or exceed measures required by the Construction General Permit, as well as BMPs that control the other potential construction-related pollutants. Erosion control BMPs are designed to prevent erosion, whereas sediment controls are designed to trap sediment once it has been mobilized. A SWPPP will be developed as required by, and in compliance with, the Construction General Permit and the County of Los Angeles Standard Conditions. The General Permit requires the SWPPP to include a menu of BMPs to be selected and implemented based on the phase of construction and the weather conditions to effectively control erosion and sediment to the BAT/BCT. The following types of BMPs from the Stormwater Best Management Practice Handbook - Construction (CASQA 2003) will be implemented during construction (CASQA Handbook BMP numbers are indicated in parenthesis):

- Erosion Control (EC-3 through EC-7 and WE-1)

  - Physical stabilization through hydraulic mulch, soil binders, straw mulch, bonded fiber matrices, and erosion control blankets (i.e., rolled erosion control products).
  - Limiting the area and duration of exposure of disturbed soils.
  - Soil roughening of graded areas (through track walking, scarifying, sheepsfoot rolling, or imprinting) to slow runoff, enhance infiltration, and reduce erosion.
  - Vegetation stabilization through temporary seeding to establish interim vegetation.
  - Wind erosion (dust) control through the application of water or other dust palliatives as necessary to prevent and alleviate dust nuisance.

- Sediment Control

  - Perimeter protection to prevent discharges through silt fences, fiber rolls, gravel bag berms, sand bag barriers, and straw bale barriers (SE-1, 5, 6, 8 and 9).
  - Storm drain inlet protection (SE-10).
  - Resource (Environmentally Sensitive Area) protection through silt fences, fiber rolls, gravel bag berms, sand bag barriers, and straw bale barriers (SE-1, 5, 6, 8, and 9).

- Sediment capture through sediment traps, storm drain inlet protection, and sediment basins (SE-3, 10, and 2).
- Velocity reduction through check dams, sediment basins, and outlet protection/velocity dissipation devices (SE-2, 4, and 10).
- Reduction in off-site sediment tracking through stabilized construction entrance/exit, construction road stabilization, and entrance /exit tire wash (TE-1, 2 and 3).

- Waste and Materials Management

  - Management of the following types of materials, products, and wastes: solid, sanitary, concrete, hazardous and equipment-related wastes (MW-1, 2, and 4 through 10 and NS-8 through 10).
  - Protection of soil stockpiles through covers, the application of water or soil binders, and perimeter control measures (MW-3).

- Non-stormwater Management

  - BMPs or good housekeeping practices to reduce or limit pollutants at their source before they are exposed to stormwater, including such measures as: water conservation practices, vehicle and equipment cleaning and fueling practices (NS-1 through 16).

- Training and Education

  - Training of individuals responsible for SWPPP preparation, implementation, and permit compliance, including contractors and subcontractors.
  - Signage (bilingual, if appropriate) to address SWPPP-related issues (such as site clean up policies, BMP protection, washout locations, etc).

- Maintenance, Monitoring and Inspections

  - Performing routine site inspections and inspections before, during (for storm events > 24 hours), and after storm events.
  - Implementing maintenance and repairs of BMPs as indicated by routine and storm-event inspections.
  - Preparation and implementation of a Sampling and Analysis Plan for non-visible pollutants.

These construction site management BMPs will be implemented within the NRSP subregion during the dry season and wet season as follows:

7.4.1.1. Dry Season Construction Phase BMPs

a. Wind erosion BMPs (dust control).
b. Soil roughening of graded areas (track walking, scarifying, sheepsfoot rolling, or imprinting).

c. Sediment control BMPs at the down gradient site perimeter and all operational storm drain inlets internal to the planning area.
d. Off-site tracking BMPs.
e. Appropriate waste management and materials pollution BMPs.
f. Appropriate non-storm water BMPs to prevent or reduce the contamination of stormwater by construction activities and materials.
g. A "weather triggered" action plan to deploy standby erosion and sediment control BMPs to protect exposed portions of the site within 48 hours of a predicted storm event.
h. Sufficient standby BMP materials to implement the above action plan.
i. Deployment of post-construction erosion control BMPs as soon as practicable.

7.4.1.2. Wet Season Construction Phase BMPs

In addition to the dry season BMPs noted above:

a. Limiting the area and duration of exposure of disturbed soil areas. This may be accomplished by retention of natural vegetation in areas not scheduled for immediate grading, phasing the grading, and stabilizing disturbed areas quickly.
b. Implementation of an effective combination of erosion and sediment control measures on all disturbed areas.
c. Sufficient standby BMP materials to implement the above weather triggered action plan.

The Construction General Permit does not recognize a wet season by dates; therefore, the wet season requirements will be implemented year round if there is a storm event predicted.

The significance criteria for the project construction phase is implementation of BMPs consistent with Best Available Technology Economically Achievable and Best Conventional Pollutant Control Technology (BAT/BCT), as required by the Construction General Permit and the general waste discharge requirements in the Dewatering General Permit. The projects will reduce or prevent erosion and sediment transport and transport of other potential pollutants from the project site during the construction phase through implementation of BMPs meeting BAT/BCT in order to prevent or minimize environmental impacts and to ensure that discharges during the project construction phase will not cause or contribute to any exceedance of water quality standards in the receiving waters. These BMPs will assure effective control of not only sediment discharge, but also of pollutants associated with sediments, such as and not limited to nutrients, heavy metals, and certain pesticides, including legacy pesticides. In addition, compliance with BAT/BCT requires that BMPs used to control construction water quality are updated over time as new water quality control technologies are developed and become available for use. Therefore, compliance with the BAT/BCT performance standard ensures mitigation of construction water quality impacts over time.

Construction on the project sites may require dewatering and non-stormwater related discharges. For example, dewatering may be necessary for the construction of bridge abutments, bank stabilization, and outfall protection; if groundwater is encountered during grading; or to allow discharges associated with testing of water lines, sprinkler systems and other facilities.

In general, the Construction General Permit authorizes construction dewatering activities and other construction related non-stormwater discharges as long as they (a) comply with Section A.9 of the General Permit; (b) do not cause or contribute to violation of any water quality standards, (c) do not violate any other provisions of the General Permit, (d) do not require a non-stormwater permit as issued by some RWQCBs, and (e) are not prohibited by a Basin Plan provision. Full compliance with applicable local, state and federal water quality standards by the applicant would assure that potential impacts from dewatering discharges are not significant.

An additional Project Design Feature will be implemented to protect receiving waters from dewatering and construction related non-stormwater discharges. Such discharges will be implemented in compliance with the Los Angeles RWQCB's General Waste Discharge Requirements (WDRs) under Order No. R4-2003-0111, NPDES No. CAG994004 governing construction-related dewatering discharges within the Project development areas. Typical BMPs for construction dewatering include infiltration of clean groundwater; on-site treatment using suitable treatment technologies; on-site or transport offsite for sanitary sewer discharge with local sewer district approval; or use of a sedimentation bag for small volumes of localized dewatering. Compliance with these WDRs constitutes a PDF, further assuring that the impacts of these discharges are not significant.

On this basis, the impact of project construction-related runoff is considered less than significant.

7.5. Pollutant Bioaccumulation

Certain pollutants have the potential to accumulate in treatment BMP vegetation and soils, potentially increasing the risk of exposure to wildlife and the food chain. Factors that could affect the extent of potential bioaccumulation include:

- The bioavailability of the pollutant;
- Conditions in the soils (*e.g.*, pH, acid-volatile sulfide concentration, organic content) that affect the form and bioavailability of the pollutant;
- The efficiency by which pollutants in the soils enter the plant community, the storage of these pollutants in plant tissues that are edible, and the utilization of the plants as a food source by animals;
- The type of habitats, organisms attracted to these habitats, and their feeding habits; and

- System design and maintenance.

The primary pollutants of concern with regard to bioaccumulation are mercury and selenium. However, as indicated by the water quality monitoring conducted by LACDPW at the Santa Clara River mass emission station S29 (LACDPW, 2005), selenium and mercury are not naturally present at levels of concern in this watershed. Since these pollutants would not be introduced during Specific Plan build-out, bioaccumulation of selenium and mercury is not expected.

The potential for bioaccumulation impacts from the Specific Plan projects' treatment control facilities, such as bioretention, vegetated swales, and extended detention basins, would be minimal. Since the tributary areas to the BMPs are largely impervious, very little coarse solids and associated pollutants are expected to be generated. The vegetation in the facilities would trap sediments and pollutants in the soils, which contain bacteria that metabolize and transform trace metals, thereby reducing the potential for these pollutants to enter the food chain. The facilities do not provide open water areas and are not likely to attract waterfowl.

Bioaccumulation of pollutants in the Santa Clara River would not be significant due to the low predicted concentrations of pollutants such as trace metals, which are predicted to be below the benchmark CTR criteria in the treated runoff. Also, sediments in the Santa Clara River are transported downstream in the wet season by storm flows, and therefore do not accumulate.

On this basis, the potential for bioaccumulation and adverse effects on waterfowl and other species is considered less than significant.

7.6. Dry Weather Runoff

While there are no specific requirements in the MS4 Permit and the SUSMP requirements to treat dry weather discharges from the NRSP project area, pollutants in dry weather flows could also be of concern because dry weather flow conditions occur throughout a large majority of the year, and because some of the TMDLs in downstream reaches of the Santa Clara River are applicable for dry weather conditions (e.g., nutrients and chloride).

Dry weather flows are typically low in sediment because the flows are relatively low and coarse suspended sediment tends to settle out or is filtered out by vegetation. As a consequence, pollutants that tend to be associated with suspended solids (e.g., phosphorus, some bacteria, some trace metals, and some pesticides) are typically found in very low concentrations in dry weather flows. The focus of the following discussion is therefore on constituents that tend to be dissolved, e.g., nitrate and trace metals, or constituents that are so small as to be effectively transported, e.g., pathogens and oil and grease.

In order to minimize the potential generation and transport of dissolved constituents, landscaping in public and common areas will utilize drought tolerant vegetation that requires little watering

and chemical application. Landscape watering in common areas, commercial areas, multiple family residential areas, and in parks will use efficient irrigation technology utilizing evapotranspiration sensors to minimize excess watering.

In addition, educational programs and distribution of materials (source controls) will emphasize appropriate car washing locations (at commercial car washing facilities or the car wash pad in the multi-family residential areas) and techniques (minimizing usage of soap and water), encourage low impact landscaping and appropriate watering techniques, appropriate swimming pool dechlorination and discharge procedures, and discourage driveway and sidewalk washing. Illegal dumping will be discouraged by stenciling storm drain inlets and posting signs that illustrate the connection between the storm drain system and the receiving waters and natural systems downstream.

The bioretention areas, vegetated swales, and the extended detention basins will provide treatment for and infiltrate dry weather flows and small storm events. Water cleansing is a natural function of vegetation, offering a range of treatment mechanisms. Sedimentation of particulates is the major removal mechanism. However the performance is enhanced as plant materials allow pollutants to come in contact with vegetation and soils containing bacteria that metabolize and transform pollutants, especially nutrients and trace metals. Plants also take up nutrients in their root system. Some pathogens would be removed through ultraviolet light degradation. Any oil and grease will be effectively adsorbed by the vegetation and soil within the low flow wetland vegetation. Dry weather flows and small storm flows will infiltrate into the bottom of the basin after receiving treatment in the low flow wetland vegetation.

The treatment control PDFs, without consideration of additional volume reductions potentially achieved in hydromodification controls, will infiltrate or evapotranspire all expected dry weather runoff (see Section 7.9.2 below). It is expected that no dry weather discharge will occur to the Santa Clara River or tributaries. A special exception to the complete infiltration of dry weather flows in the treatment control PDFs would be if it is desired to direct treated dry weather flows from the treatment control PDFs to mitigation habitat adjacent to the tributaries in order to support that habitat. In that case, the treatment PDFs may be lined, and treated dry weather flows would be directed to and fully contained within the mitigation habitat. Based on source control PDFs reducing the amount of dry weather runoff and treatment control PDFs capturing and treating the dry weather runoff that does occur, the impact from dry weather flows is considered less than significant.

7.7. Summary of Surface Water Quality Impacts

7.7.1. Direct Impacts

While runoff volume; ammonia, trace metal, and chloride loads; and dissolved zinc concentration are predicted to increase, concentrations of all modeled constituents (except for

dissolved zinc) are predicted to decrease under proposed conditions when compared to existing conditions. The modeled concentrations in runoff from developed areas with PDFs are below all benchmark water quality objectives and criteria and TMDL waste load allocations for the Santa Clara River and are addressed by a comprehensive site design, source control, and treatment control strategy, and compliance with SUSMP, Construction General Permit, and General De-Watering Permit requirements.

Concentrations of hydrocarbons are expected to increase, while concentrations of pathogens, pesticides, and trash and debris may or may not increase under proposed conditions when compared to existing conditions, but none of the qualitatively assessed constituents are expected to significantly impact receiving waters due to the implementation of a comprehensive site design, source control, and treatment control strategy in compliance with the MS4 Permit requirements, Construction General Permit, and General De-Watering Permit requirements. Therefore potential impacts from the NRSP projects on receiving water quality are not expected to be significant.

7.7.2. Cumulative Impacts

This section defines the geographic area of potential impact for the cumulative impacts analysis, and evaluates impacts from probable future projects together with the incremental effects of the proposed NRSP projects to determine effects on water quality and hydromodification within this geographic area. The model results presented below are used in addition to consideration of the other projects reflected in adopted plans and projections for areas tributary to Santa Clara River Reach 5 to get a better overall assessment of cumulative water quality effects on the Santa Clara River.

The geographic area for evaluating cumulative impacts includes the unincorporated area of Los Angeles County west of The Old Road to the Ventura County line. This geographic area includes the Newhall Ranch subregion, the Entrada subregion, the Legacy Village subregion, and the Valencia Commerce Center, as well as existing development in the Six Flags Magic Mountain area and the existing Valencia Water Reclamation Plant.

The proposed Entrada Project site is located directly east of the NRSP area and west of Interstate 5 (Figure 2-1). Entrada is bounded by the Santa Clara River to the east and north, the Mission Village Project within the NRSP to the west, and the Westridge Project to the south. The existing Six Flags Magic Mountain Theme Park is located adjacent to the NRSP and Entrada. The Entrada Project proposes development of single and multi-family residential units, commercial/retail uses, and a hotel on 813 acres. The project also includes private recreational facilities and various trail and road improvements.

The proposed Legacy Village Project is located south of the NRSP area, bordering the Mission Village and Homestead Projects, and north of Stevenson Ranch. The 1,750 acre Legacy Project

proposes construction of residential areas and commercial space. Over 1,000 acres of open space will be incorporated into the Legacy Village Project, including 50 acres of parks and trails.

The remaining unbuilt portions of the Valencia Commerce Center are located approximately one-half mile upstream of the confluence of Castaic Creek and the Santa Clara River. Approximately 4 million square feet of building floor area will be developed over the next five to ten years. Additionally, bank stabilization improvements to Castaic Creek and Hasley Creek would be constructed in conjunction with these remaining phases of the Commerce Center.

Urban runoff from the NRSP, Entrada, Legacy Village, and the Valencia Commerce Center project areas will discharge to the Santa Clara River after treatment. Each of the projects will utilize vegetated swales, bioretention areas, and/or dry extended detention basins, as well as a full suite of site design and source control BMPs, to address pollutants of concern in stormwater runoff and dry weather discharges from the proposed projects. Urban runoff from the Magic Mountain Theme Park and the Valencia WRP currently drains to the Santa Clara River and will continue to do so in proposed conditions without any anticipated change to stormwater management controls.

The combined effect on modeled pollutant loads and concentrations of the NRSP, Entrada, Legacy Village, and the Valencia Commerce Center proposed projects and the existing Magic Mountain Theme Park and Valencia WRP are summarized in Tables 7-17 and 7-18 below, respectively. Note that only stormwater impacts from runoff from the Valencia WRP site are included in modeled loads and concentrations; wastewater discharges are not included. As shown in Table 7-17, when considered cumulatively, runoff volumes and loads of TKN, total nitrogen, total phosphorus, metals, and chloride are predicted to increase from the NRSP, Entrada, Legacy Village, and Valencia Commerce Center projects, while pollutant loads are expected to decrease for TSS and nitrate-N + nitrite-N. Pollutant concentrations from the combined projects are predicted to decrease for all modeled parameters (Table 7-18). Increases in pollutant loadings are not anticipated to be significant based on the fact that predicted pollutant concentrations are well below benchmark water quality standards and TMDL wasteload allocations and are primarily within the range of observed concentrations in Santa Clara River Reach 5 (Table 7-19).

Table 7-17: Predicted Average Annual Combined Runoff Volume and Pollutant Loads for the NRSP, Legacy Village, Entrada, and Valencia Commerce Center Projects

Modeled Parameter	Units	Development Condition		Change
		Existing	Developed w/ PDFs	
Volume	acre-ft	1245	3968	2723
Total Suspended Solids	tons	483	302	-181
Nitrate-N + Nitrite-N	tons	5.4	3.3	-2.1
Total Kjeldahl Nitrogen	tons	5.2	9.6	4.4
Total Nitrogen	tons	10.6	12.9	2.3
Total Phosphorus	tons	1.3	1.5	0.2
Total Aluminum	lbs	4030	7396	3366
Dissolved Aluminum	lbs	732	1508	776
Dissolved Copper	lbs	39	99	60
Total Lead	lbs	37	77	40
Dissolved Zinc	lbs	477	670	193
Chloride	tons	44	93	49

7-18: Predicted Average Annual Combined Pollutant Concentrations for the NRSP, Legacy Village, Entrada, and Valencia Commerce Center Projects

Modeled Parameter	Units	Development Condition		Change
		Existing	Developed w/ PDFs	
Total Suspended Solids	mg/L	285	56	-229
Nitrate-N + Nitrite-N	mg/L	3.2	0.6	-2.6
Total Kjeldahl Nitrogen	mg/L	3.1	1.8	-1.3
Total Nitrogen	mg/L	6.3	2.4	-3.9
Total Phosphorus	mg/L	0.8	0.3	-0.5
Total Aluminum	ug/L	1191	685	-506
Dissolved Aluminum	ug/L	216	140	-76
Dissolved Copper	ug/L	12	9	-3
Total Lead	ug/L	11	7	-4
Dissolved Zinc	ug/L	141	62	-79
Chloride	mg/L	26	17	-9

Table 7-19: **Comparison of Predicted Pollutant Concentrations for the NRSP, Entrada, Legacy Village, and Commerce Center 26363 Projects with Water Quality Criteria and Observed Concentrations in Santa Clara River Reach 5**

Modeled Parameter	Units	Predicted Average Annual Concentration	TMDL/ LA Basin Plan Water Quality Objectives	California Toxics Rule Criteria [1]	Wasteload Allocations for MS4 Discharges into the Santa Clara River Reach 5	Range of Observed [2] Concentrations in Santa Clara River Reach 5
Total Suspended Solids	mg/L	56	Water shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses	NA	NA	32 – 6,591
Nitrate-N + Nitrite-N	mg/L	0.6	5	NA	6.8 [3]	0.5 – 4.8
Total Ammonia	mg/L	0.5	2.2 [4]	NA	1.75 [5]	<0.005 – 1.1
Total Nitrogen	mg/L	2.4	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses	NA	NA	<0.04 – 46 [6]
Total Phosphorus	mg/L	0.3		NA	NA	0.18 – 13.4
Dissolved Copper	µg/L	9	NA	32	NA	3.3 – 22.6
Total Lead	µg/L	7	NA	260	NA	0.6 – 40
Dissolved Zinc	µg/L	62	NA	250	NA	3 – 37
Total Aluminum	µg/L	685	NA	750	NA	131 – 19,650
Chloride	mg/L	17	100	NA	100	3 - 121

[1] Hardness = 250 mg/L, based on minimum observed value at USGS Station 11108500. Lead criteria is for total recoverable lead. NAWQC aluminum criteria for pH 6.5 – 9.0.
[2] Range of concentrations observed in the Santa Clara River during wet weather (see Section 2.3.1).
[3] 30-day average.
[4] 4-day average, ELS present, 90th percentile pH and temperature pairing observed at USGS Monitoring Station 11108500.
[5] 30-day average in Reach 5 below Valencia.
[6] Observed values for TKN (ammonia plus organic nitrogen).
NA – not applicable

As discussed above, the anticipated quality of effluent expected from the NRSP projects' PDFs will not contribute concentrations of pollutants of concern that would be expected to cause or

contribute to a violation of the water quality standards in the NRSP projects' receiving waters. Therefore, the NRSP projects' incremental effects on surface water quality are not expected to be significant.

The NRSP projects' surface runoff water quality, after PDFs, both during construction and post-development, is predicted to comply with adopted regulatory requirements that are designed by the LARWQCB to assure that regional development does not adversely affect water quality, including: MS4 Permit and SUSMP requirements; Construction General Permit and General Dewatering Permit requirements; and benchmark Basin Plan water quality objectives, CTR criteria, and TMDLs. Any future urban development occurring in the Santa Clara River watershed must also comply with these requirements. By extrapolating the results of the direct and cumulative impact analysis modeling done for this NRSP Sub-Regional Stormwater Mitigation Plan, it can be predicted that analysis of other proposed development combined with existing conditions would have similar water quality results. Therefore, cumulative impacts on surface water quality of receiving waters from the NRSP projects and future urban development in the Santa Clara Watershed are addressed through compliance with the MS4 Permit and SUSMP requirements; Construction General Permit and General Dewatering Permit requirements; and benchmark Basin Plan water quality objectives, CTR criteria, and TMDLs, which are intended to be protective of beneficial uses of the receiving waters. Based on compliance with these requirements designed to protect beneficial uses, cumulative water quality impacts are mitigated to a level that is less than significant.

7.7.2.1. Impacts of Newhall Ranch Reclaimed Water on Santa Clara River Water Quality and Hydrology

In an average rainfall year, all tertiary treated wastewater from the Newhall Ranch WRP would be reclaimed for irrigation, except in the months of October through March. During these months, approximately 286 to 1,025 acre-feet of tertiary-treated wastewater would not be needed to meet non-potable demand and would therefore be discharged to the Santa Clara River. The water quality and hydrologic impacts associated with the discharge of tertiary treated reclaimed water to the Santa Clara River were previously analyzed at the project-level in the Newhall Ranch Specific Plan Revised Draft EIR (Impact Sciences, 1999) as well as the Newhall Ranch Specific Plan Revised Additional Analysis (Impact Sciences, 2003). The conclusions from this project-level impact analysis are summarized below.

Title 22 of the California Administrative Code (Title 22) specifies California's Wastewater Reclamation Criteria (WRC) and all reclaimed water in California must meet or exceed these criteria. These criteria apply to the treatment processes; treatment performance standards, such as removal efficiencies and effluent water quality; process monitoring programs, including type and frequency of monitoring; facility operation plans; and necessary reliability features.

The water quality of the Newhall Ranch WRP discharge will have to comply with federal CWA requirements as specified in a Waste Discharge Requirement (WDR) that must be obtained from the LARWQCB. As required by the CWA, this permit will include effluent limitations for discharges to the Santa Clara River that will be protective of receiving water quality and designated beneficial uses. Effluent limits in the WDR will be developed based on the most stringent of applicable technology-based and water quality-based standards, including Basin Plan objectives, CTR criteria, and applicable TMDL waste load allocations.

As discussed in Final EIR Section 5.0, Subsection 5.2, Flood, the approximately 286 to 1,025 acre-feet of tertiary-treated wastewater that might be discharged to the river from October through March would not represent a significant increase in the volume of floodwaters or in the annual average river flow.

Based on required compliance with State and Federal water quality requirements and the project-level analysis contained in the Newhall Ranch Specific Plan Revised Draft EIR and the Newhall Ranch Specific Plan Revised Additional Analysis, no significant impacts related to discharge of Newhall Ranch reclaimed water would occur on Santa Clara River water quality or hydrology.

7.8. Groundwater Impacts

7.8.1. Direct Groundwater Quality Impacts

Discharge from the NRSP projects' developed areas to groundwater will occur in three ways: (1) through general infiltration of irrigation water, (2) through incidental infiltration of urban runoff in the proposed treatment control and hydromodification control PDFs after treatment, and (3) infiltration of urban runoff, after treatment in the PDFs, in the Santa Clara River, which is the primary recharge zone for groundwater in the Santa Clara Valley. Groundwater quality will be fully protected through implement of the NRSP projects' site design, source control, and treatment control PDFs prior to discharge of project runoff to groundwater.

Per the LARWQCB Clarification Letter (LARWQCB, 2006), generally, the common pollutants in stormwater are filtered or adsorbed by soil, and unlike hydrophobic solvents and salts, do not cause groundwater contamination. In any case, infiltration of one to two inches of rainfall in semi-arid areas like Southern California where there is a high rate of evapotranspiration presents minimal risks.

The pollutant of concern with respect to groundwater is nitrate-N plus nitrite-N. The Basin Plan groundwater quality objective for nitrate-nitrogen plus nitrite-nitrogen is 10 mg/L (which is more stringent than the objective for nitrate-nitrogen alone (10 mg/L) and for nitrite-nitrogen alone (1 mg/L)). The predicted nitrate-nitrogen plus nitrite-nitrogen concentration in runoff after treatment in the project PDFs is 0.6 mg/L, which is well below the groundwater quality objective.

Wastewater generated by the Specific Plan projects will be treated in the Newhall Water Reclamation Plant (WRP). Treatment at the Newhall Ranch WRP will consist of screening, activated sludge secondary treatment with membrane bioreactors, nitrification/denitrification, ultraviolet disinfection, and partial reverse osmosis. Discharges from the Newhall Ranch WRP treatment facility are permitted by a NPDES Permit and Waste Discharge Requirements (WDRs) issued by the LARWQCB in October 2007 (LARWQCB, 2007). Treated effluent from the Newhall Ranch WRP will be used to supply distribution of recycled water throughout the Specific Plan area in the form of irrigation of landscaping and other approved uses. The Newhall Ranch WRP Permit contains effluent limitations that will control the amount of conventional, non-conventional, and toxic pollutants discharged to the receiving waters. These effluent limits are a combination of technology-based limits (per 40 CFR section 122.44(a)) and water quality-based limits (per 40 CFR section 122.44(d)). The effluent limitation contained in the Newhall Ranch WRP Permit for nitrate-N plus nitrite-N is 5 mg/L and the limitation for nitrite-N is 0.9 mg/L (average monthly). As the Basin Plan groundwater quality objective for nitrate-nitrogen plus nitrite-nitrogen is 10 mg/L or 1 mg/L for nitrite-nitrogen, the Newhall Ranch WRP irrigation water supply that will serve the NRSP projects will be well below the groundwater quality objectives.

On this basis, the potential for the NRSP projects to adversely affect groundwater quality is considered less than significant.

7.8.2. Cumulative Groundwater Quality Impacts

As discussed above, the anticipated quality of runoff discharges from the NRSP projects' developed areas and irrigation to groundwater will not contribute loads or concentrations of pollutants of concern that would be expected to cause or contribute to a violation of the groundwater quality standards. By extrapolating these results to existing and proposed development throughout the watershed and based on a review of adapted plans and projections, it is concluded that no adverse cumulative effects would occur to groundwaters. Therefore, the NRSP projects' incremental effects on groundwater quality are not expected to be significant.

The NRSP projects' discharges to groundwater, after PDFs, both during construction and post-development, is predicted to comply with adopted regulatory requirements that are designed by the LARWQCB to assure that regional development does not adversely affect water quality, including: MS4 Permit and SUSMP requirements; Construction General Permit and General Dewatering Permit requirements; and benchmark Basin Plan groundwater quality objectives. Any future urban development occurring in the Santa Clara River watershed must also comply with these requirements. Therefore, cumulative impacts on groundwater quality from the proposed Project and future urban development in the Santa Clara Watershed are addressed through compliance with the MS4 Permit and SUSMP requirements, Construction General Permit requirements, General Dewatering Permit requirements, and benchmark Basin Plan

groundwater quality objectives, which are intended to be protective of beneficial uses of the groundwater. Based on compliance with these requirements designed to protect beneficial uses, cumulative groundwater quality impacts are mitigated to a level that is less than significant.

7.8.3. Groundwater Recharge Impacts

7.8.3.1. Direct Project Impacts

In a groundwater basin, the effect of urbanization on recharge to underlying groundwater is dependent on land uses, water uses, vegetative cover, and geologic conditions. Groundwater recharge from undeveloped lands occurs from precipitation alone, whereas areas that are developed for agricultural or urban land uses receive both precipitation and irrigation of vegetative cover. In an urban area, groundwater recharge occurs directly beneath irrigated lands and in drainages whose bottoms are not paved or cemented. A memorandum prepared by CH2M Hill entitled "Effect of Urbanization on Aquifer Recharge in the Santa Clarita Valley" (Appendix E) discusses the general effects of urbanization on groundwater recharge and the specific effects in the Santa Clarita Valley.

Currently the site is irrigated agricultural land. As a result, in the existing condition recharge occurs within the Project site from irrigation and precipitation. On one hand, development of the site will introduce impervious surface over approximately 30 percent of the NRSP subregion, which will tend to reduce recharge. In addition, development of agricultural lands will eliminate agricultural irrigation as a source of recharge. On the other hand, development of the site will increase runoff volume discharged after treatment to the Santa Clara River, whose channel is predominantly natural and consists of vegetation and coarse-grained sediments (rather than concrete). The porous nature of the sands and gravels forming the streambed will allow for significant infiltration to occur to the underlying groundwater. Also, the Project will introduce landscaping, irrigation, and PDFs designed to infiltrate runoff. These project effects will increase groundwater recharge from the Project. On balance, it is unlikely that the NRSP projects will result in a significant change in groundwater recharge in the project vicinity. Based on the above discussion, the NRSP projects' impact on groundwater recharge is considered less than significant.

7.8.3.2. Cumulative Impacts

Increased urbanization in the Valley has resulted in the irrigation of previously undeveloped lands. The effect of irrigation is to maintain higher soil moisture levels during the summer than would exist if no irrigation were occurring. Consequently, a greater percentage of the fall/winter precipitation recharges groundwater beneath irrigated land parcels than beneath undeveloped land parcels. In addition, urbanization in the Santa Clarita Valley has occurred in part because of the importation of State Water Project (SWP) water, which began in 1980. SWP water use has increased steadily, reaching nearly 44,500 acre-feet (AF) in 2003. Two-thirds of this water is

used outdoors, and a portion of this water eventually infiltrates to groundwater. The other one-third is used indoors and is subsequently routed to local water reclamation plants (WRPs) and then to the Santa Clara River (after treatment). A portion of this water flows downstream out of the basin, and a portion infiltrates to groundwater.

Records show that groundwater levels and the amount of groundwater in storage were similar in both the late 1990s and the early 1980s, despite a significant increase in the urbanized area during these two decades. This long-term stability of groundwater levels is attributed in part to the significant volume of natural recharge that occurs in the streambeds, which do not contain paved, urban land areas. On a long term historical basis, groundwater pumping volumes have not increased due to urbanization, compared with pumping volumes during the 1950s and 1960s when water was used primarily for agriculture. Also, the importation of SWP water is another process that contributes to recharge in the Valley. In summary, urbanization has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the Valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the Valley.

Based on the above discussion, the cumulative impact on groundwater recharge is considered less than significant.

7.9. Hydromodification Impacts

Development typically increases impervious surfaces on formerly undeveloped (or less developed) landscapes, reducing the capture and infiltration of rainfall. The result is that, as a watershed develops, a larger percentage of rainfall becomes runoff during any given storm. In addition, runoff reaches the stream channel more efficiently due to the development of storm drain systems, so that the peak discharge rates for rainfall events and floods are higher for an equivalent event than they were prior to development. Further, the introduction of irrigation and other dry weather flows can change the seasonality of runoff reaching natural receiving waters. These changes, in turn, affect the stability and habitat of natural drainages, including the physical and biological character of these drainages. This process, termed “hydromodification” (SCCWRP, 2005a) is addressed in this section.

Significant adverse hydromodification impacts are presumed to occur if the proposed project would:

- Substantially alter the existing drainage pattern of a natural drainage, stream, or river causing substantial erosion, siltation, or channel instability; or
- Substantially increase the rates, velocities, frequencies, duration and/or seasonality of flows causing channel instability and harming sensitive habitats or species in natural drainages in a manner that substantially adversely affects beneficial uses.

Natural or naturalized drainages[8] which will receive flows from developed areas within the NRSP subregion are: the Santa Clara River, Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon. Flows from developed areas within the NRSP subregion will not be discharged to the other tributaries shown on Figure 2-3. Therefore, this analysis addresses the potential for hydromodification impacts to the Santa Clara River, Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon as a result of the NRSP projects.

The physical alteration of natural drainages, such as bank protection, energy dissipaters, and bridge abutments, are not impacts created by changes in runoff seasonality, volume, duration, or flow associated with development. Instead, these types of alterations are physical alterations to the stream bed and bank, with associated effects on stream habitat and species. These type of effects are analyzed in the Newhall Ranch Resource Management and Development Plan and Spineflower Conservation Plan Draft Joint Environmental Statement and Environmental Impact Report (SCH #2000011025).

7.9.1. Wet Weather Flows

7.9.1.1. Direct Impacts to the Santa Clara River and Tributaries

The NRSP projects would develop approximately 31 percent (3,665 acres) of the total 11,999 acre NRSP area. The size of the NRSP area in comparison to both the 1,618 square mile total Santa Clara River watershed area and the expected total impervious area in the watershed in the existing conditions and at build-out is small. It is estimated, based on the land use data provided by LACDPW from adopted General Plans within the watershed, that the NRSP projects will comprise approximately five percent of the total impervious area in the Santa Clara River watershed above the NRSP area at ultimate planned build-out for the watershed. See Section 4.4.3 above for information regarding adopted plans and projections used to derive build-out assumptions for the watershed.

Three strategies will be used in the NRSP projects to prevent and control hydromodification impacts to the Santa Clara River and the Tributaries:

- Project-based hydrologic source control,
- Project-based flow duration control, and
- Geomorphically-referenced channel design.

---

[8] The term naturalized drainage means a drainage with some geomorphically-referenced engineering, but which retains natural bed and/or bank throughout the drainage, thereby retaining certain natural functions and habitat.

Geosyntec Consultants has developed and used a state-of-the-art analytical technique to evaluate and address hydromodification impacts that result from watershed development (see Appendix G for further detail). This unique approach has been developed to provide a more accurate comparison of the changes that take place in stormwater runoff, stream flows, and sediment transport characteristics due to watershed development than traditional hydrologic analysis methodologies. Hydromodification control PDFs developed with this methodology are intended to protect the tributaries Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon (the "Tributaries") from excessive erosion and degradation by discharges from the NSRP projects. Direct and indirect discharges to the Santa Clara River from the NRSP projects are not expected to cause channel instability (Balance Hydrologics, 2005, see further *Cumulative Impacts* below), particularly with design controls that will protect the stability and integrity of the Tributaries.

Three hydromodification control management approaches are available to protect the Tributaries:

1. Hydromodification control using hydrologic source control and flow duration control basins only (called "on-site control").

2. Hydromodification control using naturalized in-stream grade stabilization (or drop) structures to provide an equilibrium slope that maintains the existing sediment transport capacity (called "in-stream control").

3. Hydromodification control using a combination of on-site control and in-stream control.

The choice of a hydromodification management approach or approaches will be dictated by the strategies that are appropriate given the conditions of each channel and its contributing watershed within the NRSP project and the standards and criteria set forth in this report. Consequently, a suite of the above management approaches will be applied to provide a comprehensive solution to managing potential increases in runoff to the Tributaries due to land use change.

Hydromodification control PDF selection for each NRSP project will be finalized at the time of Project Water Quality Technical Report preparation subject to the requirement that the final hydromodification control PDFs selected for each project shall meet or exceed the hydromodification control performance standard set forth below. The Project Water Quality Technical Report will provide project-level information and detail concerning how the provisions of this NRSP Sub-Regional SWMP will be implemented within the area covered by the individual Project Water Quality Technical Report.

The following performance standard has been defined for discharges from the NRSP projects to the Tributaries:

The erosion potential (Ep) of stormwater discharges from the Project shall be maintained within 20% of the target value in the tributary drainages that will receive post-development flows. The target erosion potential (Ep) will consider changes in sediment supply.

The hydromodification performance standard will be met for all of the NRSP projects as follows:

1. The NRSP projects shall provide hydromodification controls for discharges to the tributary drainages as needed to meet the performance criteria stated above, as further prescribed in 2) and 3) below.

2. Hydromodification controls shall consist of on-site or in-stream controls, or a combination thereof.

3. In-stream controls shall be designed to achieve the hydromodification performance standard from the point of discharge to the drainage channel downstream to the confluence of the tributary drainage with the Santa Clara River.

7.9.1.2. Project-based Hydrologic Source Control

Disconnecting impervious areas from the drainage network and adjacent impervious areas is a key approach to protecting channel stability. Several hydrologic source controls will be included in the NRSP projects that will limit impervious area and disconnect imperviousness:

Low Impact/Site Design PDFs. Low impact/site design PDFs will help to reduce the increase in runoff volume, including the clustering of development into village areas, leaving large amounts of undeveloped open space within the NRSP subregion; routing of impervious area runoff to vegetated areas; use of native and drought tolerate plants in landscaped areas; and the use of efficient irrigation systems in common area landscaped areas. The reduction in runoff volume attributable to some of these low impact/site design PDFs were not quantified in the runoff modeling, so these PDFs will reduce the predicted increase in runoff volumes discussed below. These measures will help to protect the stability of both the Santa Clara River and the Tributaries and to avoid and minimize direct impacts to those drainages.

Treatment Controls. The projects' treatment control PDFs will also serve as hydromodification source control BMPs. Vegetated BMPS such as vegetated swales, filter strips, extended detention basins, and bioretention areas with underdrains can provide volume reduction on the order of 20 to 30 percent through infiltration and evaporation. Some bioretention areas, if site conditions are suitable, may not utilize underdrains. In these cases, all water captured in the bioretention areas without underdrains would be effectively removed from the project's stormwater discharges. Collectively, these vegetated treatment facilities are expected to provide significant reduction in wet weather runoff. In addition, these facilities will also receive and eliminate dry weather flows.

The increase in impervious surface within the NRSP area is predicted to increase the average annual stormwater runoff volume from the project area by approximately 2,001 acre-feet per year, after accounting for the estimated 20 percent volume reduction in the proposed treatment control PDFs (see Section 7.1 above). The hydromodification control PDFs discussed below, on-site controls and geomorphically-referenced in-stream controls, will be implemented such that direct impacts to the Santa Clara River or the Tributaries from the increased runoff volume are avoided, minimized, and mitigated.

7.9.1.3. Project-based On-Site Control

Flow duration control basins for on-site control, discussed in Appendix G, would be sized to ensure no change in cumulative duration of flows greater than the critical flow for bed or bank mobility. Appendix G presents a set of normalized sizing charts developed for the Specific Plan area that can be used to estimate the unit total storage volume and capture volume (acre-inches per acre of tributary area) based on the imperviousness of the flow duration basin's tributary catchment area and the tributary area soil type (or infiltration rate). These sizing charts are intended for planning purposes only. At the time that Project Water Quality Technical Reports are prepared, flow duration control facilities, if utilized, would be sized using more detailed project level information. This sizing would maintain the standard for assuring no change in the cumulative duration of flows greater than critical flow for bed/bank mobility. Flow duration control basins may be used alone or in conjunction with in-stream hydromodification controls (geomorphically-referenced channel design) to prevent exceedances of the critical flow to the Tributaries.

7.9.1.4. Geomorphically-Referenced Channel Design

The hydromodification management approach for the Santa Clara River and the Tributaries will incorporate "geomorphically-referenced river engineering" for in-stream controls as described in SCCWRP Technical Report 450 (SCCWRP, 2005a). The goal of this approach is to preserve the appearance of the natural stream channel to the maximum extent practicable while maintaining stability in stream channel morphology. In the Tributaries, geomorphic principles will be used in combination with on-site controls to design stable stream channels given the expected hydrologic and sediment regimes of each tributary. A minimum of hard, engineered structural elements will be used within the stream channel so that a natural appearance will be preserved while the new stream channel form can remain stable.

Within the Santa Clara River, the development footprint will allow for the greatest freedom possible for "natural stream channel" activity. This includes establishing buffer zones and maintaining setbacks to allow for channel movement and adjustment to changes in energy associated with runoff.

The engineered structural elements that will be implemented include energy dissipation, bank stabilization, and grade stabilization structures, described below.

- *Energy Dissipation*. Erosion protection will be provided in areas where discharges have the potential to cause stream erosion. Erosion protection will be provided at all storm drain outlets to the Santa Clara River and the Tributaries.

- *Bank Stabilization*. Bank protection will be installed along portions of the Santa Clara River and the Tributaries where necessary to protect against flooding and erosion pursuant to Federal Emergency Management Administration (FEMA) and Los Angeles County Department of Public Works' requirements. The locations for the bank stabilization will be selected so that bank protection along the river would generally be placed in non-jurisdictional upland areas adjacent to the river. Installing bank protection in non-jurisdictional areas reduces and/or avoids impacts to the river and has the potential to create new riverbed areas, allows for channel movement and adjustment to changes in energy associated with runoff, and increases riparian habitat.

- *Grade Stabilization Structures.* Grade stabilization structures will be installed in four Tributaries (Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon) to maintain sediment equilibrium and protect the channel bed and banks from hydromodification impacts. Grade stabilization structures will also be installed in Lion Canyon in order to stabilize and restore the drainage. The grade stabilization structures are intended to create stable drainage channels that will support in-channel habitat following project implementation.

7.9.1.5. Conclusion

In summary, although Project runoff volumes, flow rates, and durations will increase, potential impacts of hydromodification (i.e., the potential to cause erosion, siltation, or channel instability) will be minimized by the Project PDFs in the following ways:

- Project low impact/site design and on-site treatment and flow duration control PDFs will avoid and/or minimize increases in runoff volume from the development area, the preferred method for controlling hydromodification impacts from new development (SCCWRP, 2005a).

- Concentrated flows will be mitigated with energy dissipaters at the discharge points to the Santa Clara River and to the Tributaries. The Santa Clara River and Tributary banks will be protected primarily with vegetated buried bank stabilization in non-jurisdictional upland areas adjacent to the river. This type of biostabilization technique is the preferred approach for bank stabilization (SCCWRP, 2005a). In the Tributaries, geomorphic principles will be used in combination with on-site controls to design stable stream channels given the expected hydrologic and sediment regimes of each tributary. A minimum of hard, engineered structural elements will be used within the stream channel

so that a natural appearance will be preserved while the new stream channel form can remain stable.

Hydromodification control PDFs, including a combination of on-site controls and/or in-stream controls designed to meet the performance standard set forth in this Report and by reference to the framework set forth in Appendix G, will protect the Santa Clara River and Tributaries from excessive erosion and degradation by discharges from the NSRP projects. For this reason, the wet weather direct hydromodification impacts of the NRSP projects with PDFs on the Santa Clara River and the Tributaries are considered less than significant.

7.9.1.6. Cumulative Impacts

The assessment of direct hydromodification impacts to the Tributaries above constitutes a cumulative analysis for those drainages because it takes into account total permissible development within each Tributary watershed.

As identified in the MS4 Permit, increased volume, velocity, and discharge duration of stormwater runoff from the cumulative existing and future developed areas in watersheds of natural drainages, including the Santa Clara River, has the potential to accelerate downstream erosion and impair stream habitat. Given the very large size of the Santa Clara River watershed, the contribution of the NRSP projects to cumulative hydromodification impacts to the Santa Clara River is difficult to assess quantitatively. Therefore, a qualitative assessment that references total predicted development per adopted General Plans and projections for the Santa Clara River watershed is provided below.

Effect of Watershed Impervious Area

The limited hydromodification impact research to date has focused on empirical evidence of channel failures in relationship to directly connected impervious area (DCIA) or total impervious area. However, more recent research has established the importance of size of watershed, channel slope and materials, and climatic and precipitation patterns (SCCWRP 2005a, Balance Hydrologics 2005 (provided in Appendix F)). Impervious area that drains directly to a storm drain system and then to the receiving water is considered “directly connected,” whereas impervious area that drains through vegetation or to infiltration facilities is considered “disconnected.”

Booth and Jackson (1997) reported finding a correlation between loss of channel stability and increases in DCIA. In Washington State, streams were found to display the onset of degradation when the DCIA increases to ten percent or more, and a lower imperviousness of five percent was found to cause significant degradation in sensitive watersheds (Booth and Jackson, 1997). The Center for Watershed Protection (Schuler and Holland, 2000) described the impacts of urbanization on stream channels and established thresholds based on total imperviousness within the tributary drainage area. It states “a threshold for urban stream stability exists at about 10

percent imperviousness." It further states that a "sharp threshold in habitat quality exists at approximately 10 percent to 15 percent imperviousness." These studies, however, addressed changes in a very different climatic region than Southern California.

Geosyntec's work in the San Francisco Bay area's Santa Clara Valley (Geosyntec, 2004) also evaluated the relationship between imperviousness and stream channel degradation in an area that had predominately directly connected impervious areas. Geosyntec found similar results to those published by Booth and Schuler, where channel erosion was observed at approximately six to nine percent imperviousness for two separate watershed systems. More recent studies conducted by Geosyntec in this same watershed area showed that levels as low as two to three percent total imperviousness could lead to stream channel degradation, depending on channel characteristics. This region also has different climatic characteristics than Southern California.

Although physical degradation of stream channels in semi-arid climates of California may be detectable when watershed imperviousness is between three and five percent, not all streams will respond in the same manner (SCCWRP, 2005b). Management strategies need to account for differences in stream type, stage of channel adjustment, current and expected amount of basin imperviousness, and existing or planned hydromodification control strategies.

The absolute measure of watershed imperviousness that could cause stream instability in the Santa Clara River depends on many factors, including watershed area, land cover, and soil type; development impervious area and connectedness; reduced sediment yield; longitudinal slope of the river; channel geometry; and local boundary materials, such as bed and bank material properties and vegetation characteristics. Based on land use data provided by the County of Los Angeles (see Section 4.4.3 above), the estimated cumulative level of percent impervious area at build-out in the Santa Clara River watershed upstream from the NRSP area is nine percent.

Effect of Catchment Drainage Area

The Southern California Coastal Water Research Project (SCCWRP) found signs of hydromodification impacts in Southern California streams when watershed percent imperviousness was around two to three percent for streams with a catchment drainage area of less than five square miles (mi^2) (SCCWRP, 2005a). Recognizing that their findings were based on the type and size of catchments that were measured, the researchers in the SCCWRP study attempted to develop a framework by which their results could be extended to other stream types. They developed a classification system based on watershed characteristics, stream channel characteristics (including level of vegetative development), and stream channel resistance, and suggested these features could be important in selecting management strategies and approaches to control hydromodification impacts. The Level 1 classification is based on watershed characteristics that include the size, shape, and topography of the watershed.

The catchment drainage area (CDA) is stated to be the most obvious differentiator among watersheds, as this is likely to have the greatest effect on runoff. The SCCWRP study focused on small watersheds (< 5 mi^2), whereas the CDA of the Santa Clara River at the Los Angeles County line, near the western edge of the NRSP area (the Upper Watershed), is about 640 mi^2. Based on the differences in CDA, the SCCWRP findings with respect to CDA would not be applicable to the Santa Clara River. Information in the SCCWRP report, based in part on the work of Zielinski (2002), suggests that smaller watersheds are more responsive and sensitive to changes in land use, whereas larger watersheds (> 30 mi^2) were said to be less responsive to land use changes. Geosyntec's work in the San Francisco Bay area found significant hydromodification impacts on streams of watersheds that were 40 mi^2 in size; however, this is still substantially smaller than the Santa Clara River watershed at the Los Angeles County line. Given the large CDA for the Santa Clara River, the river is likely less responsive to potential hydromodification effects, but channel morphology must still be examined to determine the level and potential significance of Santa Clara River response.

Application to the Santa Clara River

Balance Hydrologics assessed the potential effects of the planned cumulative urbanization within the Santa Clara River upstream of the County line (the upper watershed) on channel morphology by examining historical changes in the Santa Clara River channel pattern in response to different types of major disturbance using historical rainfall and other relevant records and aerial channel photography (Balance Hydrologics, 2005 (provided in Appendix F)). The findings of this analysis are summarized below.

The Santa Clara River is a dynamic, episodic system. Understanding the magnitude of geomorphic change over the course of recent history in response to natural and human disturbances in the watershed is a key factor in assessing the potential response to future urbanization within the watershed.

For example, the report examines the construction of Castaic Dam in the 1974 (affecting approximately 30 percent of the Santa Clara River watershed above Castaic Creek), which cut off a significant supply of sediment to the Santa Clara River. This change, however, does not appear to have had an effect on the channel dimensions of the Santa Clara River mainstem. The width of the active corridor as well as the general form of the channel are generally consistent before and after construction of the dam. It appears that the Santa Clara River had enough buffering capacity to absorb this change. The report finds that the depletion of sediment supply to the mainstem, which would typically be expected to cause erosive effects, did not, in fact, result in those effects, perhaps because reductions in sediment were offset by additional available sediment stored in the basin in the upper watershed as a result of movement along the San Gabriel fault.

Similarly, the report examines the amount of vegetation within the Santa Clara River corridor, which appears to have generally increased since the 1960s, likely due to the increase in available summer flows due to the Valencia and Saugus Water Reclamation Plants' discharges. However, this vegetation does not seem to provide enough erosion resistance to maintain a "stable" channel capable of withstanding regular 're-sets', large events that completely alter the form of the Santa Clara River channel which occur at intervals averaging about a decade, or much less than the expected lifetime of the riparian woodlands which do get established. Despite heavy vegetation on the channel banks near the NRSP area and in areas of ground-water upwelling, the stream still responds to large events by a general widening and/or shift of the active channel within the River corridor.

After studying the response of the river to several different anthropogenic and natural disturbances, the report concludes that the Santa Clara River, as with many streams in semi-arid southern California, is highly episodic. Concepts of "normal" or "average" sediment-supply and flow conditions have limited value in this "flashy" environment, where episodic storm and wildfire events have enormous influence on sediment and storm flow conditions. In these streams, a large portion of the sediment movement events can occur in a matter of hours or days. Other perturbations which can potentially affect channel geometry appear to have transitory or minor manifestations. For example, effects on the channel width due to the 1980s levee construction were barely discernible by the first few years of the 21st century, probably mostly due to morphologic compensation associated with the storm events in the mid- to late-1990s. As a result, channel morphology, stability, and character of the Santa Clara River is almost entirely determined by the "reset" events that occur within the watershed.

Fluvial Study

Additional study of the Santa Clara River has been performed by Pacific Advanced Civil Engineering, Inc., who prepared a comprehensive fluvial analysis for Santa Clara River through the NRSP area (PACE, 2006) for LACDPW. A river fluvial analysis is the study of the river bed and bank sediment movement over time and as a result of flow in the river and changes in the tributary watershed.

The fluvial analysis had three distinct components:

1. Analysis of long term trends of river bed and bank sediment build-up (aggredation) or removal (degradation) was performed. More than 80 years of available historic topographic mapping of the river indicated no real trend of aggredation or degradation in the study reach.

2. General (capital storm event) aggredation/degradation calculations were performed to determine the expected fluvial response of the river to the LACDPW design storm event (>140,000 cfs). US Army Corps of Engineers computer modeling software (SAM) was

used to evaluate existing and proposed project conditions. Only minor variations in the fluvial response were shown in the modeling.

3. Local aggredation/degradation resulting from river curvature, bridges, river bed material, and various other components were considered and estimates of aggredation and degradation were calculated.

To complete the fluvial analysis, long term, general, and local aggredation/degradation components were added together to obtain the total aggredation/degradation for each river section within the study reach.

One of the purposes for the fluvial analysis, which has been approved by LACDPW, was to provide a level of understanding of the Santa Clara River Newhall Ranch reach fluvial mechanics related to existing conditions and proposed NRSP development conditions to identify any potential project impacts. The fluvial analysis showed very little change between the pre- and post-development conditions and therefore concluded that there is no potential adverse impact to the fluvial mechanics of the river.

Conclusion

As discussed above, the NRSP projects will include a number of hydrologic source control PDFs that will substantially lessen any potential contribution to cumulative hydromodification impacts to the Santa Clara River. In addition, it is presumed that all future development within the watershed will implement hydromodification controls to meet flow criteria that will be adopted by the LACDPW under Part 4, § D.1 of the MS4 Permit. These measures are designed to mitigate and prevent direct and cumulative hydromodification impacts.

Within the Santa Clara River watershed, major perturbations (urbanization, dam construction, levee construction, decadal changes in climate, and increases in woody vegetation) do not appear to have had a significant impact on the geomorphic expression of the Santa Clara River. Large "re-set" events (those which are typically not as affected by increases in impervious area) have episodically completely altered the form of the Santa Clara River channel. These events, occurring on average once every ten years, are a dominant force in defining channel characteristics. The geomorphic dominance of "re-set" events determines the geomorphic character of the Santa Clara River and the Santa Clara River's response to anthropogenic perturbations, including hydromodification impacts associated with development, is expected to be minimal in light of the "re-set" driven nature of the Santa Clara River channel. Due to these episodic "re-sets," "unraveling" of the Santa Clara River mainstem due to hydromodification associated with cumulative urban development within the watershed, as is seen in many smaller southern California watersheds, is not expected to occur. The "re-set" events appear to adequately buffer changes that may occur in short-term sediment transport, between re-set events.

Based upon the above discussion, that the NRSP projects include hydromodification controls as Project Design Features, that the NRSP projects will be conditioned to include Project Design Features to meet the performance standard established in this Report to protect the Tributaries from hydromodification impacts, that future development projects within the watershed will control flow in compliance with the regional program, and that large-scale changes naturally occur in the Santa Clara River in response to major episodic events, the NRSP projects' contribution to cumulative hydromodification impacts to the Santa Clara River and the Tributaries will be less than significant and consistent with the requirements of the MS4 permit.

7.9.2. Dry Weather Runoff

7.9.2.1. Direct Impacts

In order to quantitatively address dry weather impacts, a dry weather water balance was performed. The quantity of dry weather flows from urban sources is variable and not easily quantified. Information available from the Irvine Ranch Water District suggests an average dry weather flow from urban areas of 2.9×10^{-4} cfs per urbanized acre (IRWD, 2003). Dry weather flow estimates in Santa Monica, used to design a dry weather flow recycling facility, indicate a range of dry weather flows between 8.3×10^{-5} to 1.8×10^{-4} cfs per urbanized acre (Antich *et. al.*, 2003). For purposes of conservatively estimating the impacts of dry weather flows, a dry weather discharge of 3.0×10^{-4} cfs per urbanized acre was used in this report. Table 7-20 presents a monthly dry weather flow balance for the NRSP area. The treatment control BMPs were conservatively assumed to infiltrate at 0.05 inches per hour, which is representative of compacted Hydrologic Group Type C soils (e.g., clay loams, shallow sandy loams, soils low in organic matter, and soils usually high in clay). Infiltration volume was calculated as the BMP bottom area times the infiltration rate. Evapotranspiration rates were conservatively assumed to be 60% of reference rates from the California Irrigation Management Information System (CIMIS) Zone 14, in which the NRSP area is located. It was assumed that open space in the NRSP area would result in no dry weather runoff.

It is predicted that all dry weather flows will be infiltrated or removed by evapotranspiration in the treatment control PDFs, which also provide hydrologic source control. As a result, no appreciable change in seasonality of flows is anticipated to result from development.

Based on comprehensive site planning, source control, and treatment control strategy and the water balance analysis, the impact of the NRSP projects on dry weather water quality and seasonality of flow in the Tributaries and the River is considered less than significant.

Table 7-20: Predicted Dry Weather Water Balance

Month	Dry Weather Flow (af)[1]	ETo Capacity (af)[2]	Infiltration Capacity (af)[3]	Excess Capacity (af)[4]
January	65.1	2.1	85.4	22.4
February	58.8	3.1	77.1	21.4
March	65.1	5.1	85.4	25.4
April	63.0	7.0	82.6	26.6
May	65.1	9.4	85.4	29.7
June	63.0	10.7	82.6	30.4
July	65.1	12.0	85.4	32.2
August	65.1	10.7	85.4	30.9
September	63.0	7.8	82.6	27.5
October	65.1	5.6	85.4	25.8
November	63.0	2.9	82.6	22.5
December	65.1	2.1	85.4	22.4

[1] Based on dry weather flow of 0.0003 cfs/acre from a range of researched values.
[2] 60% of reference evapotranspiration rate (ETo) from CIMIS Zone 14.
[3] Equal to 0.05 in/hr over BMP bottom area.
[4] Equal to (ETo + Infiltration Capacity) – Dry Weather Flow.

8. CONCLUSIONS

This section summarizes the potential effects, if any, of the NRSP projects on water quality and hydromodification in Santa Clara River Reach 5.

8.1. Water Quality Impacts

The following are the conclusions regarding the significance of impacts for the pollutants of concern under wet and dry weather conditions:

- ***Sediments*:** MS4 Permit, Construction General Permit, Dewatering General Permit, and SUSMP-compliant BMPs will be incorporated into the NRSP projects to address sediment in both the construction phase and post-development. Mean total suspended solids concentration and load are predicted to be less in the post-development condition than in the existing condition. Turbidity in stormwater runoff will be controlled through implementation of a Construction SWPPP and will be permanently reduced through the stabilization of erodible soils with development. On this basis, the impact of the NRSP projects on sediments is considered less than significant.

- ***Nutrients (Phosphorus and Nitrogen (Nitrate-N + Nitrite-N and Ammonia-N))***: MS4 Permit, Construction General Permit, Dewatering General Permit, and SUSMP-compliant BMPs will be incorporated into the NRSP projects to address nutrients in both the construction phase and post-development. Although total ammonia loads are predicted to increase, total nitrogen and nitrate-nitrogen plus nitrite-nitrogen concentrations and loads are predicted to decrease in the post-developed condition. Total phosphorus loads and concentration are predicted to decrease in post-development conditions and concentrations are predicted to be below the minimum observed value in the Santa Clara River. Nitrate-N plus nitrite-N and ammonia-N concentrations are predicted to decrease with development to a point well below LA Basin Plan objectives and below or in the low range of observed values in the Santa Clara River Reach 5. The predicted nutrient concentrations are not expected to cause increased algal growth. On this basis, the impact of the NRSP projects on nutrients is considered less than significant.

- ***Trace Metals*:** MS4 Permit, Construction General Permit, General Dewatering Permit, and SUSMP-compliant BMPs will be incorporated into the NRSP projects to address trace metals in both the construction phase and post-development. The trace metals mean loads and dissolved zinc concentration are predicted to increase with NRSP project development, while total aluminum, dissolved copper, and total lead concentrations are predicted to decrease. Mean concentrations of dissolved copper, total lead, dissolved zinc, and total aluminum are below benchmark Basin Plan objectives, CTR criteria, and the NAWQC criterion for aluminum. Cadmium is not expected to be present in runoff discharges from the NRSP projects. On this basis, the impact of the NRSP projects on trace metals is considered less than significant.

- ***Chloride*:** MS4 Permit, Construction General Permit, Dewatering General Permit, and SUSMP-compliant BMPs will be incorporated into the NRSP projects to address chloride in both the construction phase and post-development. Although the chloride load is predicted to increase, the mean concentration of chloride is predicted to decrease with development and the predicted concentration is well below the LA Basin Plan objective and is near the low range of observed values in the Santa Clara River Reach 5. On this basis, the impact of the NRSP projects on chloride is considered less than significant.

- ***Pesticides*:** Pesticides in runoff may or may not increase in the post-development phase as a result of landscape applications. Proposed pesticide management practices, including source control, removal with sediments in treatment control PDFs, and advanced irrigation controls, in compliance with the requirements of the MS4 Permit and the SUSMP will minimize the presence of pesticides in runoff. During the Construction phase of the NRSP projects, erosion and sediment control BMPs implemented per General Permit and General De-Watering Permit requirements will prevent pesticides associated with sediment from being discharged. Final site stabilization will limit mobility of legacy pesticides that may be present in pre-development conditions. On this basis, the impact of the NRSP projects on pesticides is considered less than significant.

- ***Pathogens*:** Post-development pathogen sources include both natural and anthropogenic sources. The natural sources include bird and mammal excrement. Anthropogenic sources include leaking septic and sewer systems and pet wastes. The NRSP projects will not include septic systems and the sewer system will be designed to current standards which minimizes the potential for leaks. Thus pet wastes are the primary source of concern. The PDFs will include source controls and treatment controls which in combination should help to reduce pathogen indicator levels in post-construction stormwater runoff. Pathogens are not expected to occur at elevated levels during the construction-phase of the NRSP projects. On this basis, the NRSP projects' impact on pathogen and pathogen indicators is considered less than significant.

- ***Hydrocarbons*:** Hydrocarbon concentrations will likely increase in post-development because of vehicular emissions and leaks. In stormwater runoff, hydrocarbons are often associated with soot particles that can combine with other solids in the runoff. Such materials are subject to treatment in the proposed extended detention basins, bioretention areas, and vegetated swales. Source control BMPs incorporated in compliance with the MS4 Permit and the SUSMP requirements will also minimize the presence of hydrocarbons in runoff. During the construction phase of the NRSP projects, pursuant to the Construction General Permit, the Construction Stormwater Pollution Prevention Plan must include BMPs that address proper handling of petroleum products on the construction site, such as proper petroleum product storage and spill response practices, and those BMPs must effectively prevent the release of hydrocarbons to runoff per the Best Available Technology Economically Achievable and Best Conventional Pollutant

Control Technology standards. On this basis, the impact of the NRSP projects on hydrocarbons is considered less than significant.

- ***Trash and debris*:** Trash and debris in runoff are likely to increase in post-development if left unchecked. However, the PDFs, including source control and treatment BMPs incorporated in compliance with the MS4 Permit and the SUSMP requirements, will minimize the adverse impacts of trash and debris. Source controls such as street sweeping, public education, fines for littering, covered trash receptacles, and storm drain stenciling are effective in reducing the amount of trash and debris that is available for mobilization during wet weather. Trash and debris will be captured in catch basin inserts in the commercial area parking lots and in the treatment control PDFs. During the construction phase of the NRSP projects, PDFs implemented per General Permit and General De-Watering Permit requirements will remove trash and debris through the use of BMPs such as catch basin inserts and by general good housekeeping practices. Trash and debris are not expected to significantly impact receiving waters due to the implementation of the NRSP project PDFs.

- ***Methylene Blue Activated Substances (MBAS):*** In the post-development phase, the presence of soap in runoff from the project will be controlled through the source control PDFs, including a public education program on residential and charity car washing and the provision of a centralized car wash area directed to sanitary sewer in the multi-family residential areas. Other sources of MBAS, such as cross connections between sanitary and storm sewers, are unlikely given modern sanitary sewer installation methods and inspection and maintenance practices. During the construction phase of the NRSP projects, equipment and vehicle washing will not use soaps or any other MBAS sources. Therefore, MBAS are not expected to significantly impact the receiving waters of the NRSP projects.

- ***Cyanide:*** In addition to the expected relatively low level of cyanide in untreated stormwater, cyanide in runoff from the NRSP projects would be readily removed by biological uptake, degradation by microorganisms, and by volatilization in the treatment PDFs, especially the dry extended detention basins. Therefore cyanide is not expected to significantly impact the receiving waters of the NRSP projects.

- ***Bioaccumulation***: In the literature, the primary pollutants that are of concern with regard to bioaccumulation are mercury and selenium. However, selenium and mercury are not of concern in this watershed, so bioaccumulation of selenium and mercury is also not expected to result either during the construction or post-development project phases. On this basis, the potential for bioaccumulation (in the NRSP projects' PDFs or in the receiving waters) to cause adverse effects on waterfowl and other species is considered less than significant.

- ***Construction Impacts***: Construction impacts on water quality are generally caused by soil disturbance and subsequent suspended solids discharge. These impacts will be

minimized through implementation of construction BMPs that will meet or exceed measures required by the Construction General Permit, as well as BMPs that control the other potential construction-related pollutants (i.e., PAHs, metals). A SWPPP will be developed as required by, and in compliance with, the Construction General Permit and Los Angeles County Standard Conditions. Erosion control BMPs, including but not limited to hydro-mulch, erosion control blankets, and energy dissipaters will be implemented to prevent erosion, whereas sediment controls, including but not limited to silt fence, sedimentation ponds, and secondary containment on stockpiles, will be implemented to trap sediment once it has been mobilized. On this basis, the construction-related impact of the NRSP projects on water quality is considered less than significant.

- ***Regulatory Requirements***: The NRSP projects satisfy MS4 Permit requirements for new development, including SUSMP requirements and SQMP requirements, and satisfy construction-related requirements of the Construction General Permit and General Dewatering Permit, and therefore comply with water quality regulatory requirements applicable to stormwater runoff.

8.2. Groundwater Impacts

- ***Groundwater Quality Impacts (Nitrate-N+Nitrite-N)***: MS4 Permit, Construction General Permit, Dewatering General Permit, and SUSMP-compliant BMPs will be incorporated into the NRSP projects to address nutrients in both the construction phase and post-development. Nitrate-nitrogen plus nitrite-nitrogen concentrations are predicted to decrease in the post-developed condition. The predicted nitrate-nitrogen plus nitrite-nitrogen concentration in stormwater runoff after treatment in the projects' PDFs and in irrigation water is well below the groundwater quality objective. On this basis, the potential for adversely affecting groundwater quality is considered less than significant.

- ***Groundwater Recharge Impacts***: Project stormwater runoff will be discharged directly or indirectly to the Santa Clara River after treatment, whose channel is predominantly natural and consists of vegetation and coarse-grained sediments (rather than concrete). The porous nature of the sands and gravels forming the streambed will allow for significant infiltration to occur to the underlying groundwater. Also, irrigation water is predicted to be fully infiltrated during dry weather, which will increase groundwater recharge from the NRSP projects. On this basis, the NRSP projects' impact on groundwater recharge is considered less than significant.

8.3. Hydromodification Impacts

The following are the conclusions regarding the significance of impacts for hydromodification impacts under wet- and dry weather conditions:

- ***Wet Weather Project Impacts****:* Although NRSP projects' runoff volumes, flow rates, and durations will increase, potential impacts of hydromodification (i.e., the potential to

cause erosion, siltation, or channel instability) will be avoided, minimized, and mitigated by the Project PDFs in the following ways:

- Project low impact/site design and on-site treatment and flow duration control PDFs, especially open space retention, routing of impervious area runoff to vegetated areas, efficient irrigation, bioretention areas, and flow duration control basins will avoid and/or minimize increases in runoff volume from the development area, the preferred method for controlling hydromodification impacts from new development (SCCWRP, 2005a).

- Concentrated flows will be mitigated with energy dissipaters at the discharge points to the Santa Clara River and to the Tributaries. The Santa Clara River and Tributary banks will be protected primarily with vegetated buried bank stabilization in non-jurisdictional upland areas adjacent to the river. This type of biostabilization technique is the preferred approach for bank stabilization (SCCWRP, 2005a). In the Tributaries, geomorphic principles will be used in combination with on-site controls to design stable stream channels given the expected hydrologic and sediment regimes of each tributary. A minimum of hard, engineered structural elements will be used within the stream channel so that a natural appearance will be preserved while the new stream channel form can remain stable.

- Hydromodification control PDFs, including a combination of on-site controls and/or in-stream controls designed to meet the performance standard set forth in this Report and by reference to the framework set forth in Appendix G, will protect the Santa Clara River and Tributaries from excessive erosion and degradation by discharges from the NSRP projects.

For these reasons, direct hydromodification impacts of the NRSP projects on the Santa Clara River and Tributaries are considered less than significant.

- ***Cumulative Wet Weather Impacts:*** The NRSP projects contribute only five percent of total potential impervious surface at build out within the watershed, the NRSP projects include hydromodification controls as Project Design Features, the NRSP projects will be conditioned to include Project Design Features to meet the performance standard established in this Report to protect the Tributaries from hydromodification impacts, future development projects within the watershed will control flow in compliance with the regional program, and large-scale changes naturally occur in the Santa Clara River in response to major episodic events, therefore, the NRSP projects' contribution to cumulative hydromodification impacts to the Santa Clara River and the Tributaries will be less than significant and consistent with the requirements of the MS4 permit.

- ***Dry Weather Hydromodification Impacts:*** It is predicted that all dry weather flows will be removed in the treatment control PDFs, which also provide hydrologic source control.

As a result, no appreciable change in seasonality of flows is anticipated to result from development. Based on the comprehensive site planning, source control, and treatment control strategy and that no dry weather flows are predicted to be discharges to the Santa Clara River or Tributaries, the impact of the NRSP projects on dry weather water quality and seasonality of flow in the River and Tributaries is considered less than significant.

9. REFERENCES

Antich, Anthony, Harvey R. Gobas, and Jag Salgaonkar. The Santa Monica Urban Runoff Recycling Facility and the Sustainable Environment. Stormwater Journal. Available at: http://www.forester.net/sw_0207_santa.html.

American Society of Civil Engineers (ASCE), 2001. User's Guide National Stormwater Best Management Practices (BMP) Database Version 1.2. Prepared by Urban Water Resources Research Council (UWRRC) of ASCE and Wright Water Engineers, Inc., Urban Drainage and Flood Control District, URS Greiner Woodward Clyde, in cooperation with Office of Water US Environmental Protection Agency, Washington, DC. March 2001

American Society of Civil Engineers Urban Water Resources Research Council and United States Environmental Protection Agency (ASCE/EPA), 2003, International Stormwater Best Management Practices Database. http://www.bmpdatabase.org/index.htm.

Balance Hydrologics, 2005. Assessment of Potential Impacts Resulting from Cumulative Hydromodification Effects, Selected Reaches of the Santa Clara River, Los Angeles County, California. Prepared by Balance Hydrologics Inc. for Newhall Land. October 2005.

Barber, T.R., Lutes, C.C., Doorn, M.R.J., Fuchsman, P.C., Timmenga, H.J., and R.L. Crouch, 2003. Aquatic Ecological Risks Due to Cyanide Releases from Biomass Burning. Chemosphere 50:33, 343-348, January 2003.

Bledsoe, Brian P. and Chester C. Watson. 2001. Effects of Urbanization on Channel Instability. Journal of the American Water Resources Association, vol. 37 (2). 255-270.

Booth, Derek, B. 1990. Stream-channel incision following drainage-basin urbanization. Water Resources Bulletin, vol 26, pg 407-417.

Booth, D.B. and Jackson C.R. 1997 Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detection, and the Limits of Mitigation. Journal of the American Water Resources Association, vol 33 (5), pg 1077-1090.

Brown & Caldwell, 1984. Fresno Nationwide Urban Runoff Program Project. Report for the Fresno Metropolitan Flood Control Board, May 1984.

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practices Handbook: New Development and Redevelopment and Construction.

Center for Watershed Protection (CWP), 1996. Design of Stormwater Filtering Systems, Prepared for the Chesapeake Research Consortium, December.

Center for Watershed Protection (CWP), 2000. National Pollutant Removal Performance Database.

CH2M HILL, 2005. Analysis of Groundwater Basin Yield – Upper Santa Clara River Groundwater Basin, East Subbasin, Los Angeles County, California. Presented in Support of the August 2001 Memorandum of Understanding between the Upper Basin Water Purveyors and the United Water Conservation District. Prepared for the Upper Basin Water Purveyors (Castaic Lake Water Agency [CLWA], Newhall County Water District, Santa Clarita Water Division of CLWA, and Valencia Water Company). Prepared in cooperation with Luhdorff & Scalmanini Consulting Engineers. August 2005.

CH2M Hill, 2007. Newhall Ranch Water Reclamation Plant: Conceptual Design Report, April 2007.

City of Austin. 1990. Removal Efficiencies of Stormwater Control Structures. Environmental Resources Management Division, Environmental and Conservation Services Department, City of Austin, Austin, TX.

Cole, R.H., R.E. Frederick, and R.P. Healy, 1984. Preliminary Findings of the Priority Pollutant Monitoring Project of the Nationwide Urban Runoff Program. Journal of the Water Pollution Control Federation. 56:898-908.

Colman, John A., Karen C. Rice, and Timothy C. Willoughby, 2001. Methodology and Significance of Studies of Atmospheric Deposition in Highway Runoff. USGS Open-File Report 01-259. A Contribution to the National Highway Runoff Data and Methodology Synthesis. Prepared in cooperation with the Federal Highway Administration. U.S. Department of the Interior, U.S. Geological Survey. Northborough, Massachusetts. 2001.

DeClerk, F. and M. J. Singer. 2003. Looking back 60 years, California soils maintain overall chemical quality. California Agriculture 57(2), 38-41.

Department of Land and Water Conservation (DLWC), 1996. DRAFT: Department of Land and Water Conservation "The Manager's Guide to: Sediment, Nutrients, and Gross Pollutant Control," lst ed., Resource Management Division, Sydney, Australia.

Gaffney, J.S., G.E. Streit, and W.D. Spall, 1987. Beyond Acid Rain: Do Soluble Oxidants and Organic Toxins Interact with SO2 and NOX to Increase Ecosystem Effects? Environmental Science and Technology. 21:519-523.

Geosyntec Consultants, 2002. Hydromodification Management Plan Literature Review, Santa Clara Valley Urban Runoff Pollution Prevention Program.

Geosyntec Consultants, 2004. Hydromodification Management Plan, Santa Clara Valley Urban Runoff Pollution Prevention Program.

Hammer, Thomas R. 1972. Stream and channel enlargement due to urbanization. Water Resources Research, vol. 8, pg 1530-1540

Hollis, G.E. 1975. The Effect of Urbanization on Floods of Different Recurrence Intervals. Water Resources Research, vol. 11 (3), pg 431-435.

Impact Sciences, 1999. Newhall Ranch Specific Plan and Water Reclamation Plant Draft Environmental Impact Report. Prepared for Los Angeles County Department of Regional Planning by Impact Sciences Inc. March 1999.

Impact Sciences, 2003. Revised Additional Analysis to the Newhall Ranch Specific Plan and Water Reclamation Plant Final Environmental Impact Report, Volume VIII. Prepared for Los Angeles County Department of Regional Planning by Impact Sciences Inc. May 2003.

Irvine Ranch Water District (IRWD), 2003. The Residential Runoff Reduction Study Municipal Water District of Orange County. July 2004.

Katznelson, R. and T. Mumley, 1997. Diazinon in Surface Waters in the San Francisco Bay Area: Occurrence and Potential Impact. Prepared for California State Water Resources Control Board, and Alameda County Clean Water Program.

Kobayashi, J. and Kizu, R. 2001. Evaluation of Metal Contents in River Water Using a Simple Fractionation Method. J. Health Sci., 47(5), 460-463.

Kurz, 1999. Removal of Microbial Indicators from Stormwater Using Sand Filtration, Wet Detention, and Alum Treatment Best Management Practices. Sixth Biennial Stormwater Research & Watershed Management Conference. September 1999.

Luhdorff & Scalmanini Consulting Engineers, 2005. Santa Clarita Valley Water Report 2004

Luhdorff & Scalmanini Consulting Engineers, 2006. Santa Clarita Valley Water Report 2005.

Los Angeles County Department of Public Works (LACDPW), 2001. Comment Letter from the County of Los Angeles Dept. of Pub. Works to the Los Angeles Regional Water Quality Control Board (Sept. 18, 2001))

Los Angeles County Department of Public Works (LACDPW), 2000. Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report. Available at: http://ladpw.org/wmd/NPDES/IntTC.cfm.

Los Angeles County Department of Public Works (LACDPW), 2003. Los Angeles County 2002-2003 Stormwater Monitoring Report. August 15, 2003.

Los Angeles County Department of Public Works (LACDPW), 2004. Los Angeles County 2003-2004 Stormwater Monitoring Report. August 15, 2004

Los Angeles County Department of Public Works (LACDPW), 2005. Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report Final Report - August 2005. Available at: http://ladpw.org/wmd/NPDES/1994-05_report/contents.html.

Los Angeles County Department of Public Works (LACDPW), 2006. Los Angeles County 2005-2006 Stormwater Monitoring Report. August 22, 2006.

Los Angeles County Department of Public Works (LACDPW), 2007. Los Angeles County 2006-2007 Stormwater Monitoring Report. September 4, 2007.

Los Angeles Regional Water Quality Control Board (LARWQCB), 1994. Water Quality Control Plan Los Angeles Region (as amended).

Los Angeles Regional Water Quality Control Board (LARWQCB), 2003. Santa Clara River Total Maximum Daily Loads for Nitrogen Compounds Staff Report. California Regional Water Quality Control Board Los Angeles Region. June 16, 2003.

Los Angeles Regional Water Quality Control Board (LARWQCB), 2004. Total Maximum Daily Loads for Bacteria Malibu Creek Watershed. January 29, 2004. (http://www.waterboards.ca.gov/losangeles/html/meetings/tmdl/santa_monica/04_0129/Final_Staff_Report.pdf)

Los Angeles Regional Water Quality Control Board (LARWQCB), 2006. Letter to Mark Pastrella, Assistant Deputy Director, Department of Public Works, County of Los Angeles, from Jonathan Biship, P.E., Executive Officer, California Regional Water Quality Control Board, Los Angeles Region. December 15, 2006.

Los Angeles Regional Water Quality Control Board (LARWQCB), 2007. Order No. R4-2007-0046, NPDES Permit No. CA0064556, Waste Discharge Requirements for the Newhall Ranch Sanitation District (Newhall Ranch Water Reclamation Plan) Discharge to the Santa Clara River. October 27, 2007.

MacRae, C.R. 1992. The Role of Moderate Flow Events and Bank Structure in the Determination of Channel Response to Urbanization. Resolving conflicts and uncertainty in water management: Proceedings of the 45th Annual Conference of the Canadian Water Resources Association. Shrubsole, Dan, ed. 1992, pg 12.1-12.21.

Marsalek, J., Watt, W.E., Anderson, B.C., and Jaskot, C., 1997. "Physical and Chemical Characteristics of Sediments from a Stormwater Management Pond." Water Quality Research Journal of Canada, 32(1), 89-100.

Marshack, 2003. A Compilation of Water Quality Goals. Prepared by Jon B. Marshack, California Regional Water Quality Control Board, Central Valley Region. August 2003 with tables updated August 2007.

Newhall, 2006. Newhall Ranch Water Reclamation Plant National Pollutant Discharge Elimination System Permit Baseline Receiving Water Monitoring Data, May 2004 – April 2006. Available via public information request at the Los Angeles Regional Water Quality Control Board.

Novotny, V., D.W. Smith, D.A. Kuemmel, J. Mastriano, and A. Bartosova, 1999. Urban and Highway Snowmelt: Minimizing the Impact on Receiving Water. Project 94-IRM-2. Report for Water Environment Research Foundation.

PACE, 2006. Newhall Ranch River Fluvial Study Phase I Final Draft. Prepared for Newhall Land by Pacific Advanced Civil Engineering, Inc. Fountain Valley, CA.

Paulsen, Susan and J. List, 2005. Review of Bacteria Data from Southern California Watersheds. Prepared by Flow Science for The Irvine Company. April 2005.

PBS&J, 1999. Evaluation of Bacteriological Impacts to Runoff and Coastal Waters from the Crystal Cove Development.

Pitt et al, 1994. Pitt, R., S. Clark, and K. Parmer. "Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration." Journal of Alabama's Water Environment Association. Vol. 15, No. 1. pp. 8-11. Summer 1994.

Pitt, R., A. Maestre, and R. Morguecho, 2003. "The National Stormwater Quality Database (NSWQ, Version 1.0)," Prepared by University of Alabama and Center for Watershed Protection.

Ribes, Sandra, B. Van Drooge, J. Dachs, O. Gustafsson, and J.O. Grimalt, 2003. Influence of Soot Carbon on the Soil-Air Partitioning of Polycyclic Aromatic Hydrocarbons, Environmental Science & Technology 37, 2675-2680.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), 2003. Insecticide Market Trends and Potential Water Quality Implications, prepared by K. Moran, TDC Environmental, April, pp. 1-105.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), 2005. Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks. Water Quality Attainment Stratefy and

Total Maximum Daily Load (TMDL) Proposed Basin Plan Amendment and Staff Report. California Regional Water Quality Control Board San Francisco Bay Region. November 9, 2005.

San Francisco Estuary Project (SFEP) 2005a. Pesticides in Urban Surface Water, Urban Pesticide Use Trends Annual Report 2005, prepared by TDC Environmental, March.

Sawyer et al, 1994. Chemistry for Environmental Engineering, Fourth Edition. Clair Sawyer, Perry McCarty, and Gene Parkin. McGraw-Hill, Inc., 1994.

SCCWRP, 2005a. Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams. Technical Report 450. April 2005.

SCCRWP, 2005b. Managing Runoff to Protect Natural Streams: The Latest Developments on Investigation and Management of Hydromodification in California. Technical Report 475. December 2005.

Schroeder, E.D., W.M. Stallard, D.E. Thompson, F.J. Loge, M.A. Deshusses, H.J. Cox, 2002. Management of Pathogens Associated with Storm Drain Discharge, Center for Environmental and Water Resources Engineering, Dept. of Civil and Environmental Engineering, University of California, Davis prepared for Division of Environmental Analysis, California Department of Transportation, May.

Schueler, Thomas R. and Heather K. Holland, 2000. The Practice of Watershed Protection, Article 1, "The Importance of Imperviousness", pp. 7 – 18.

Stormwater Quality Task Force (SWQTF), 1993. California Stormwater Best Management Practices Handbook – Industrial/Commercial.

Strecker, E. *et. al.*, 2004. Analyses of the Expanded EPA/ASCE International BMP Database and Potential Implications for BMP Design, World Water and Envt. Cong. Proc. (June 27-July 1, 2004).

Suter, G.W, II, and C.L.Tsao., 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, ES/ER/TM-96/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

URS, 2003. Jurisdiction Delineation Package. Prepared for Newhall Land by URS Corporation, December 2003.

URS, 2006. Hybrid Functional Assessment of Wetland and Riparian Habitats for the Newhall Ranch Habitat Management Plan. Prepared for Newhall Land by URS Corporation, June 2006.

USEPA, 1981. Exposure and Risk Assessment for Cyanide. Washington, DC: U.S. Environmental Protection Agency. Office of Water. EPA440485008. PB85220572.

USEPA 1983. Nationwide Urban Runoff program. Final Report. Water Planning Division, USEPA, Washington DC.

USEPA, 1988. Ambient Water Quality Criteria for Aluminum – 1988. EPA 440/5-86-008. August 1988.

US EPA, 1993. Office of Water. Guidance to Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA-840-B-92-002. Washington, DC.

US EPA, 2001. Organophosphate Pesticide; Availability of Revised Risk Assessments. Federal Register: January 31, 2001 (Volume 66, Number 21), Page 8400-8401.

USEPA, 2002. Total Maximum Daily Loads for Toxic Pollutants – San Diego Creek and Newport Bay, California, June 14, 2002.

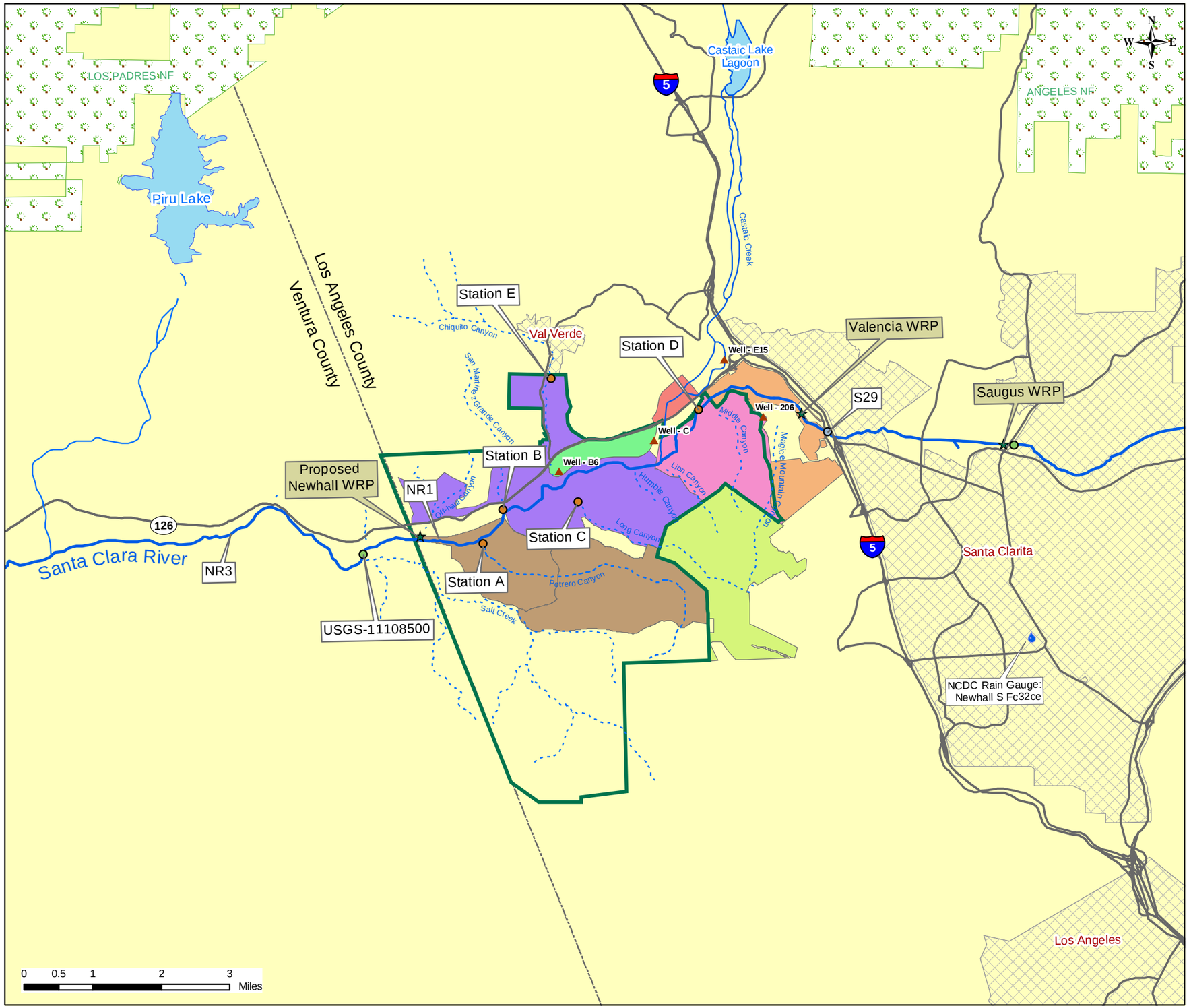
USEPA, 2003. Ecological Soil Screening Level for Aluminum. EPA OSWER directive 9285.7-60, November 2003.

USEPA, 2007. Aquatic Life Ambient Freshwater Quality Criteria – Copper 2007 Revision. United States Environmental Protection Agency Office of Water. EPA-822-R-07-001. February 2007.

Ventura County, 2005. Ventura County stormwater quality monitoring data, from various annual reports (http://www.vcstormwater.org/publications.htm)

Water Environment Federation (WEF), 1998. WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, Urban Runoff Quality Management.

Water Environment Research Foundation (WERF), 2007. Development of a Protocol for Risk Assessment of Microorganisms in Separate Stormwater Systems. 03-SW-2. 2007.



Legend

- Rain Gage
- Water Reclamation Plant

Monitoring Stations

- LACDPW Mass Emissions Station
- Newhall Ranch Sampling Site
- USGS Station
- Groundwater Monitoring Wells
- Rivers and Streams
- Roads
- Major Basin Tributaries
- Newhall Ranch Specific Plan
- Water Bodies
- Legacy Village
- Portrero
- Entrada
- Landmark Village
- Homestead
- Mission Village
- Commerce Center
- National Forest
- City Boundaries
- County Boundaries

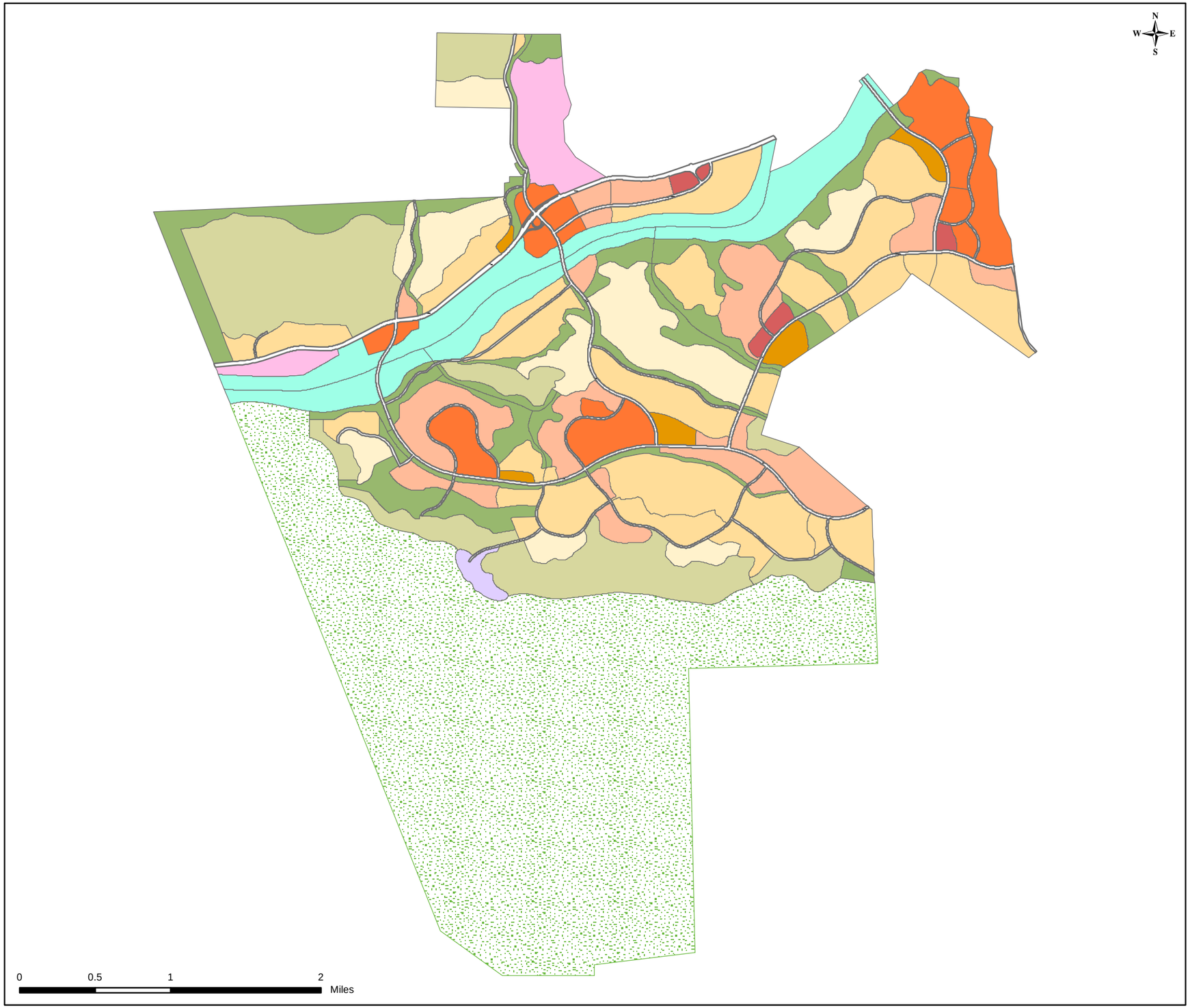
Figure 2-1
Newhall Ranch Specific Plan Location Map

December 2007

Geosyntec consultants

P:\GIS\Projects\Newhall\Base GIS\Maps\Dec2007\Fig2-1_NRSP_LocationMap.mxd

Prepared By: A. Poresky



Legend

- Roads

Land Use

- Estate
- Low Density Residential
- Low-Medium Residential
- Medium Residential
- High Density Residential
- Mixed-Use
- Commercial
- Business Park
- Vistor Serving
- Open Area
- River Corridor
- High Country

Figure 2-2
NRSP Land Uses

December 2007

Geosyntec consultants

P:\GIS\Projects\Newhall\Base GIS\Maps\Dec2007\Fig2-2_LandUsePlan.mxd

Prepared By: A. Poresky

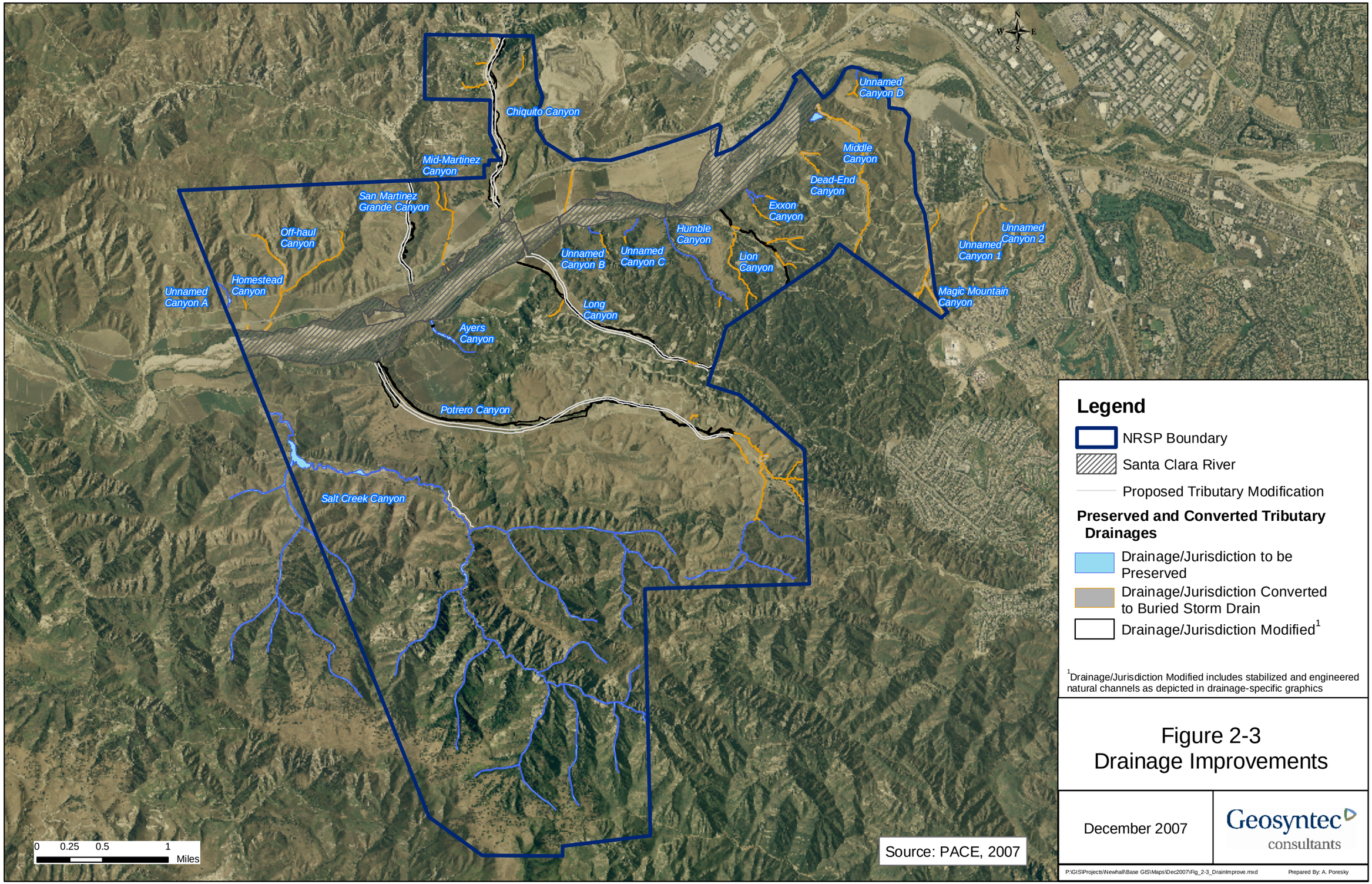
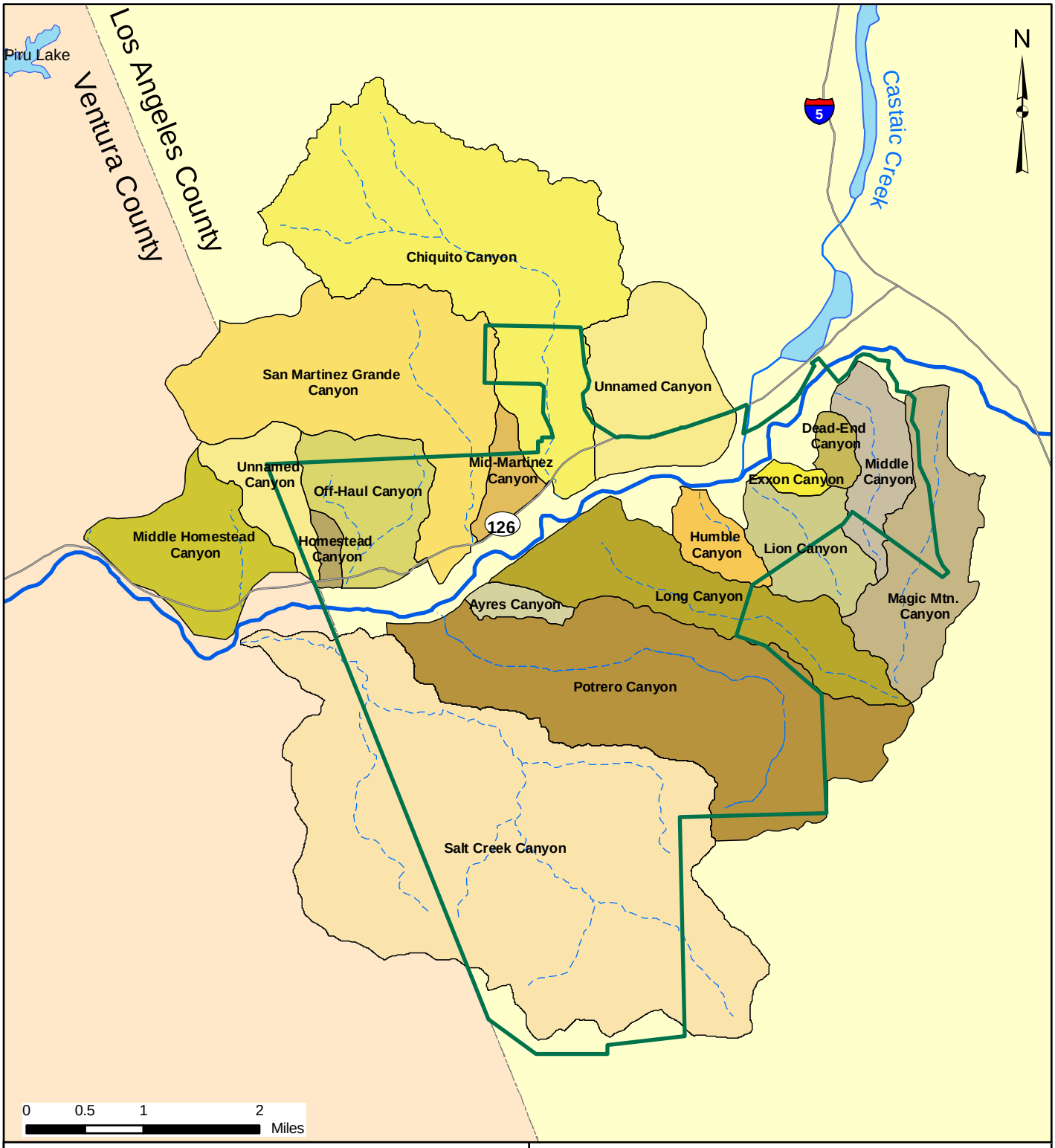


Figure 2-3
Drainage Improvements

December 2007

Geosyntec consultants

P:\GIS\Projects\Newhall\Base GIS\Maps\Dec2007\Fig_2-3_DrainImprove.mxd Prepared By: A. Poresky



Legend

- Highway
- Canyon Tributary
- Santa Clara River
- Water Bodies
- Subwatersheds
- Los Angeles County
- Ventura County
- NRSP Boundary

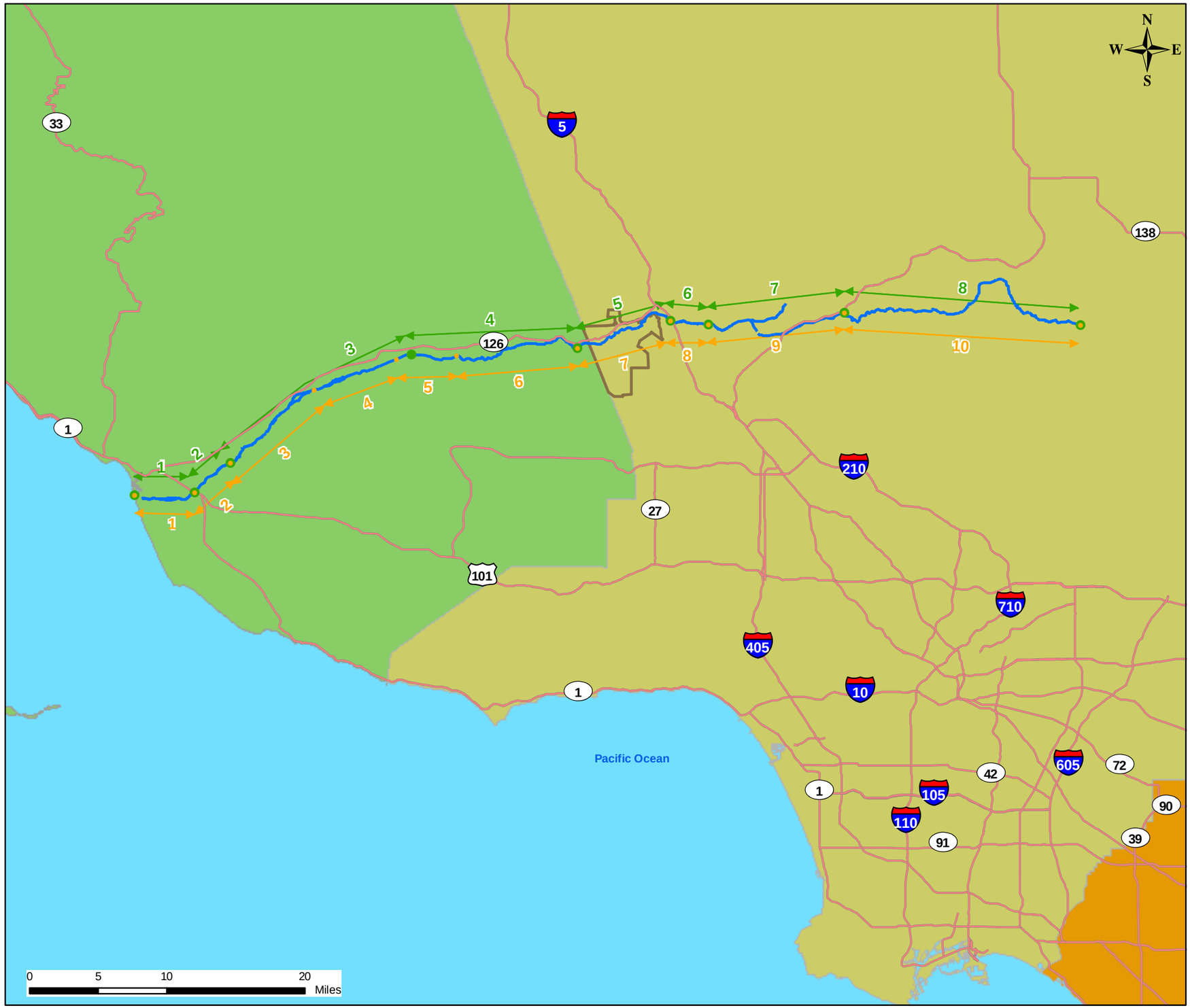
Figure 2-4
Newhall Ranch Specific Plan
Subwatershed Boundaries

December 2007

Geosyntec consultants

P:\GIS\Projects\Newhall\Base GIS\Maps\Dec2007\Fig2-4TribDrainageBounds.mxd

Prepared By: A. Poresky



Legend

- LA RWQCB Reach Boundary
- EPA Reach Boundary
- Project Boundary
- Highways
- Santa Clara River
- Ventura County
- Los Angeles County
- Orange County

Figure 2-5
Santa Clara River
Reach Boundaries

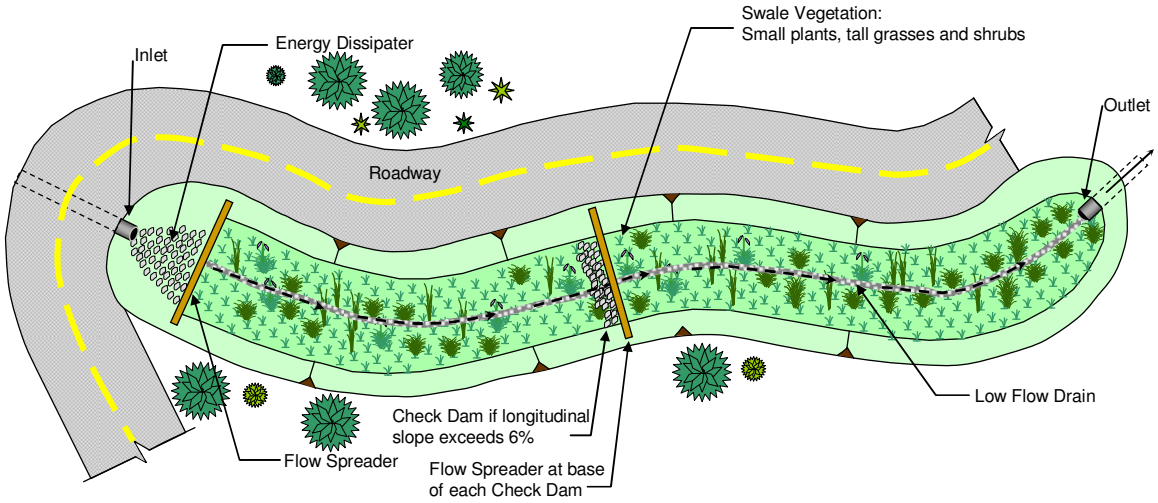
December 2007

Geosyntec consultants

P:\GIS\Projects\Newhall\BaseGIS\Maps\Dec2007\Fig5-2_SCRiverReaches

Prepared By: A. Poresky

Plan View



Profile

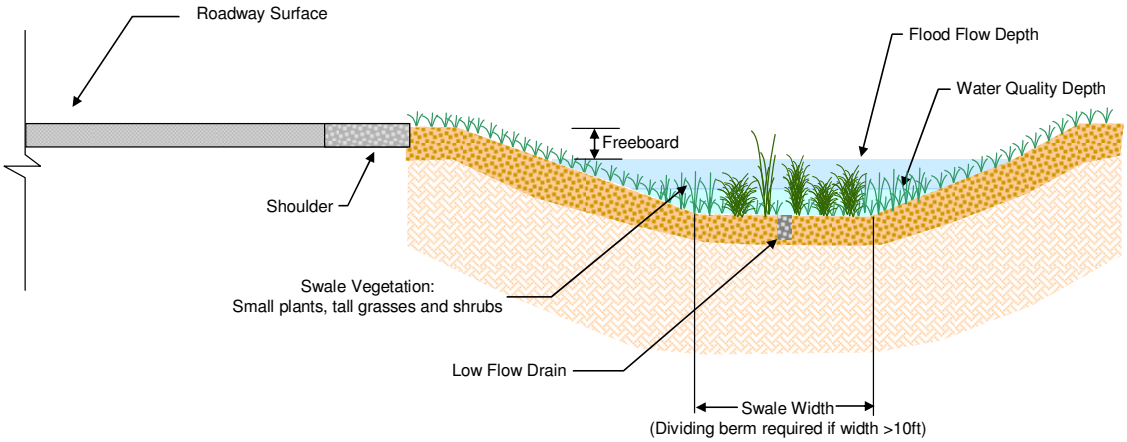


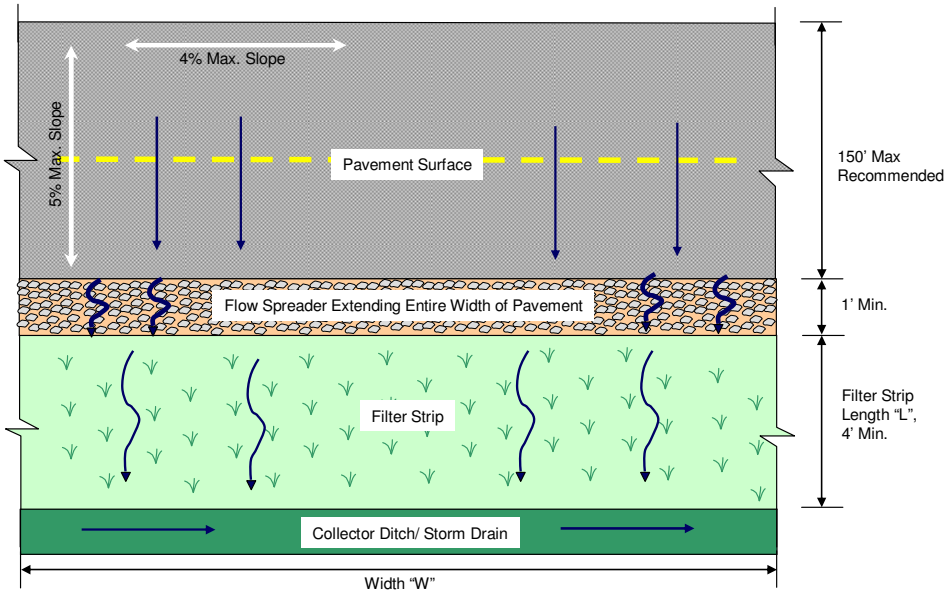
Figure 5-1
Conceptual Illustration of a Vegetated Swale

December 2007	**Newhall Ranch Specific Plan Subregional Stormwater Mitigation Plan**	Geosyntec consultants

Figure 5-2
Examples of Vegetated Swales

December 2007	**Newhall Ranch Specific Plan Subregional Stormwater Mitigation Plan**	Geosyntec consultants

Plan View



Profile

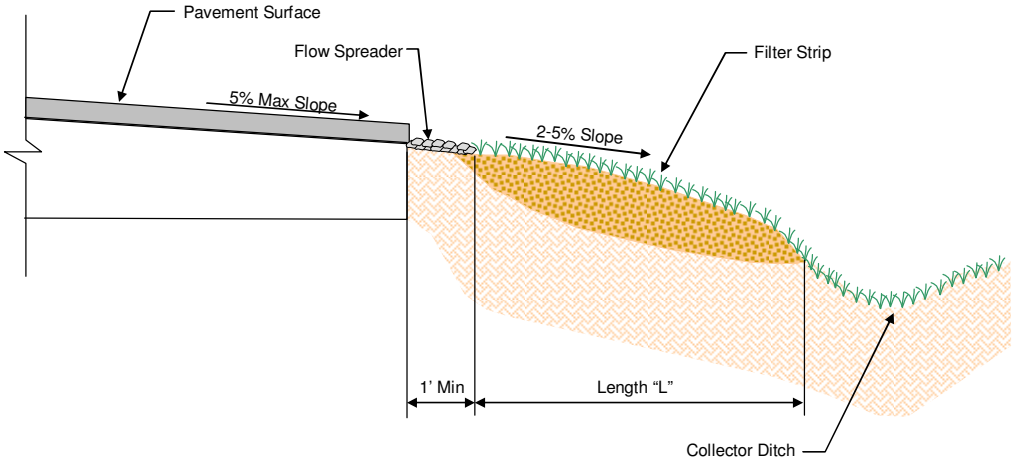
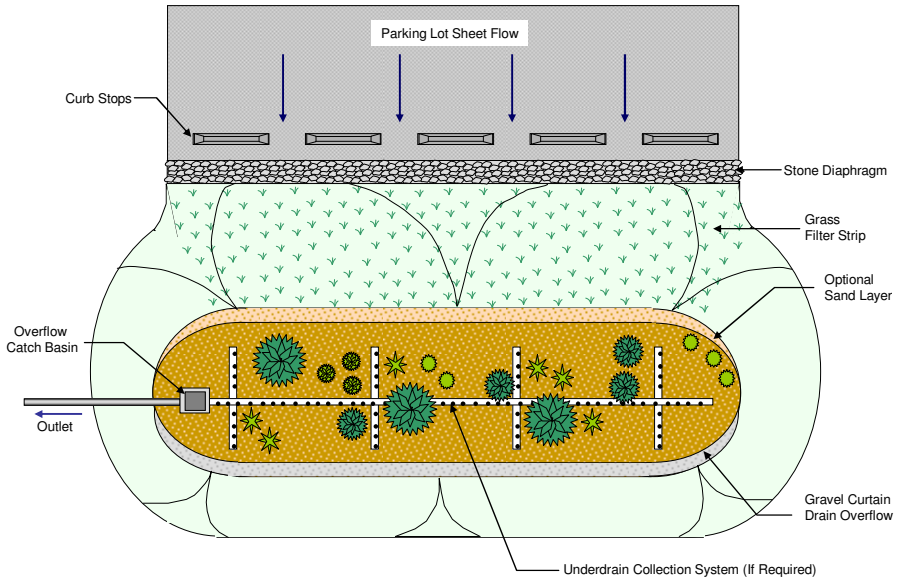


Figure 5-3
Conceptual Illustration of a Filter Strip

Plan View



Profile

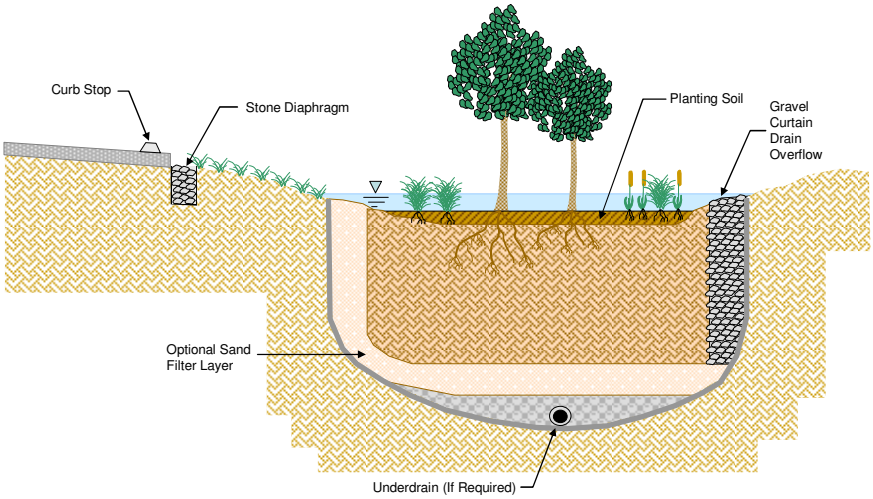
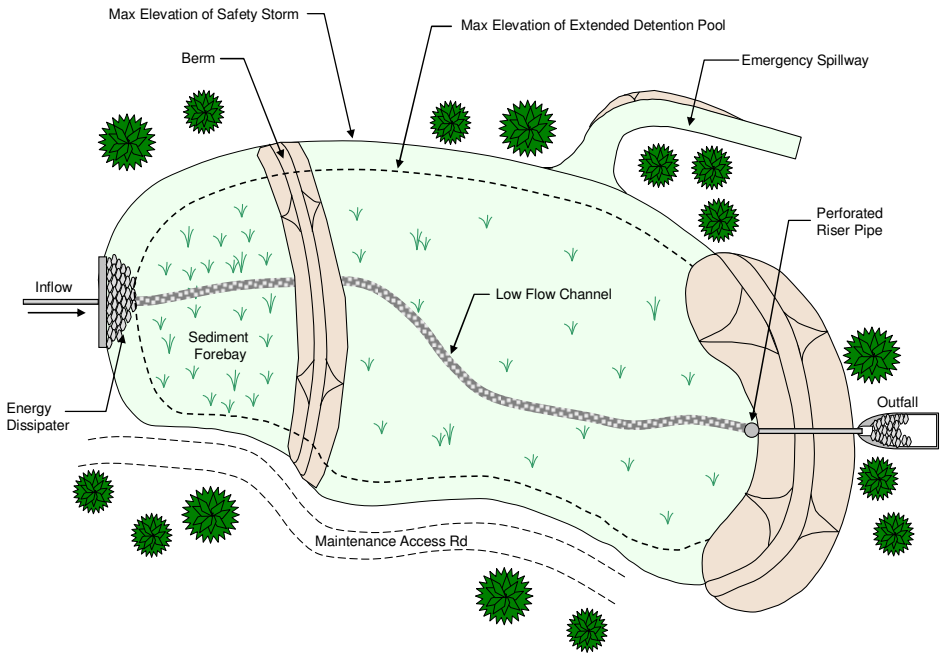


Figure 5-4
Conceptual Illustration of a Bioretention Facility

Figure 5-5
Examples of Bioretention Facilities

December 2007	**Newhall Ranch Specific Plan Subregional Stormwater Mitigation Plan**	Geosyntec consultants

Plan View



Profile

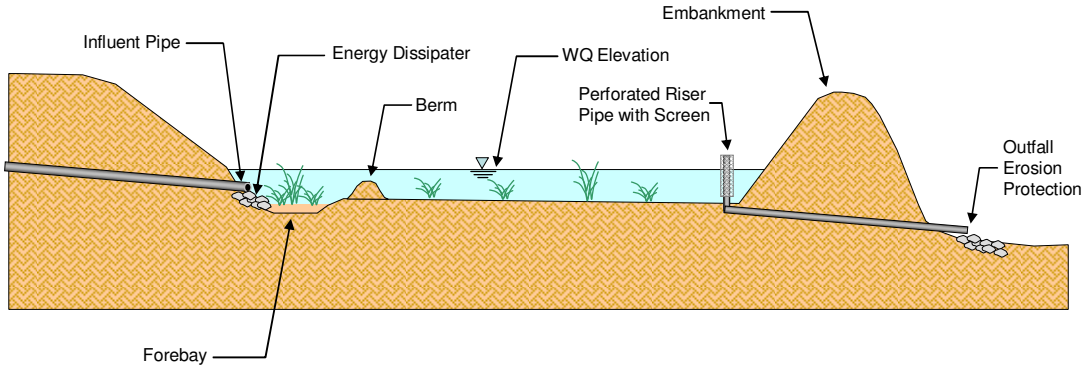
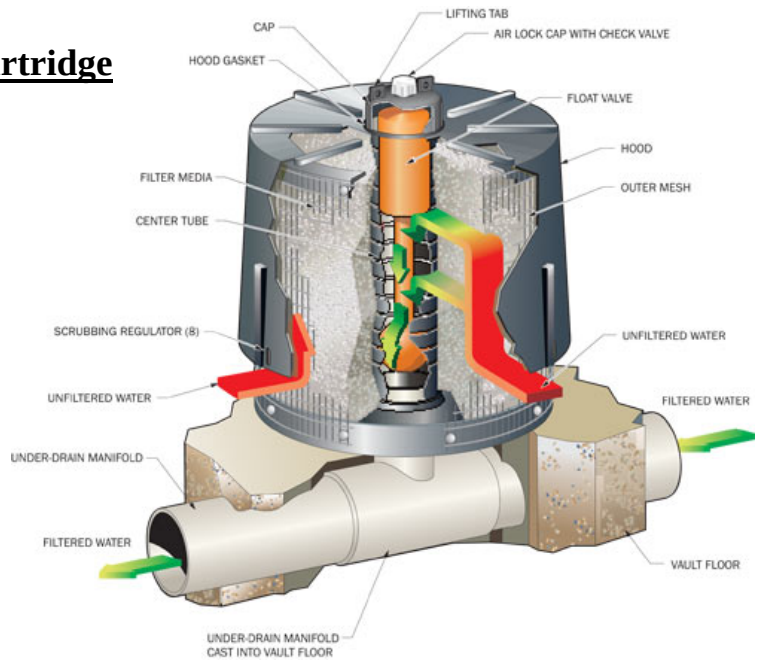


Figure 5-6
Conceptual Illustration of a Dry Extended Detention Basin

December 2007	**Newhall Ranch Specific Plan Subregional Stormwater Mitigation Plan**	Geosyntec consultants

Figure 5-7
Examples of Extended Detention Basins

StormFilter Media Cartridge



Example configuration of Catch Basin Storm Filter

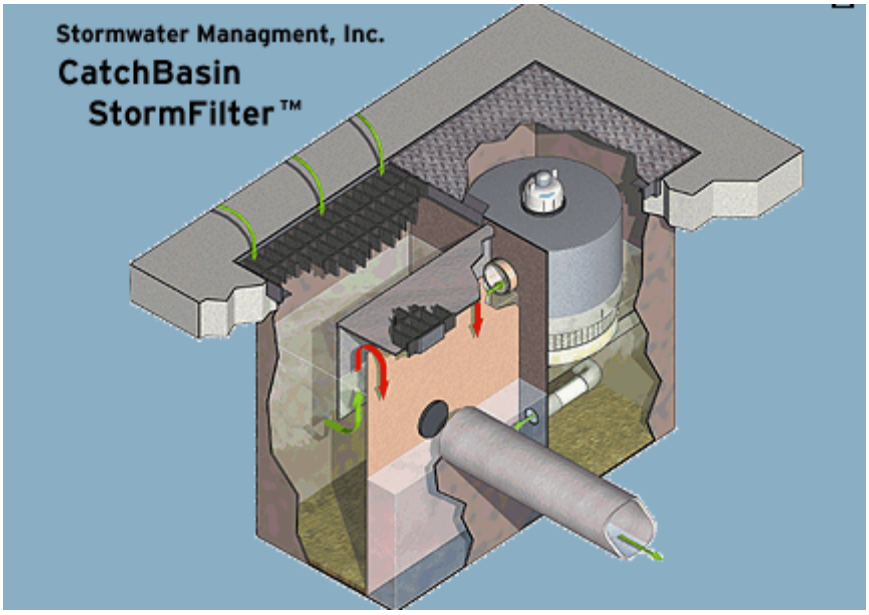


Figure 5-8
Conceptual Illustration of a StormFilter™ Media Filter

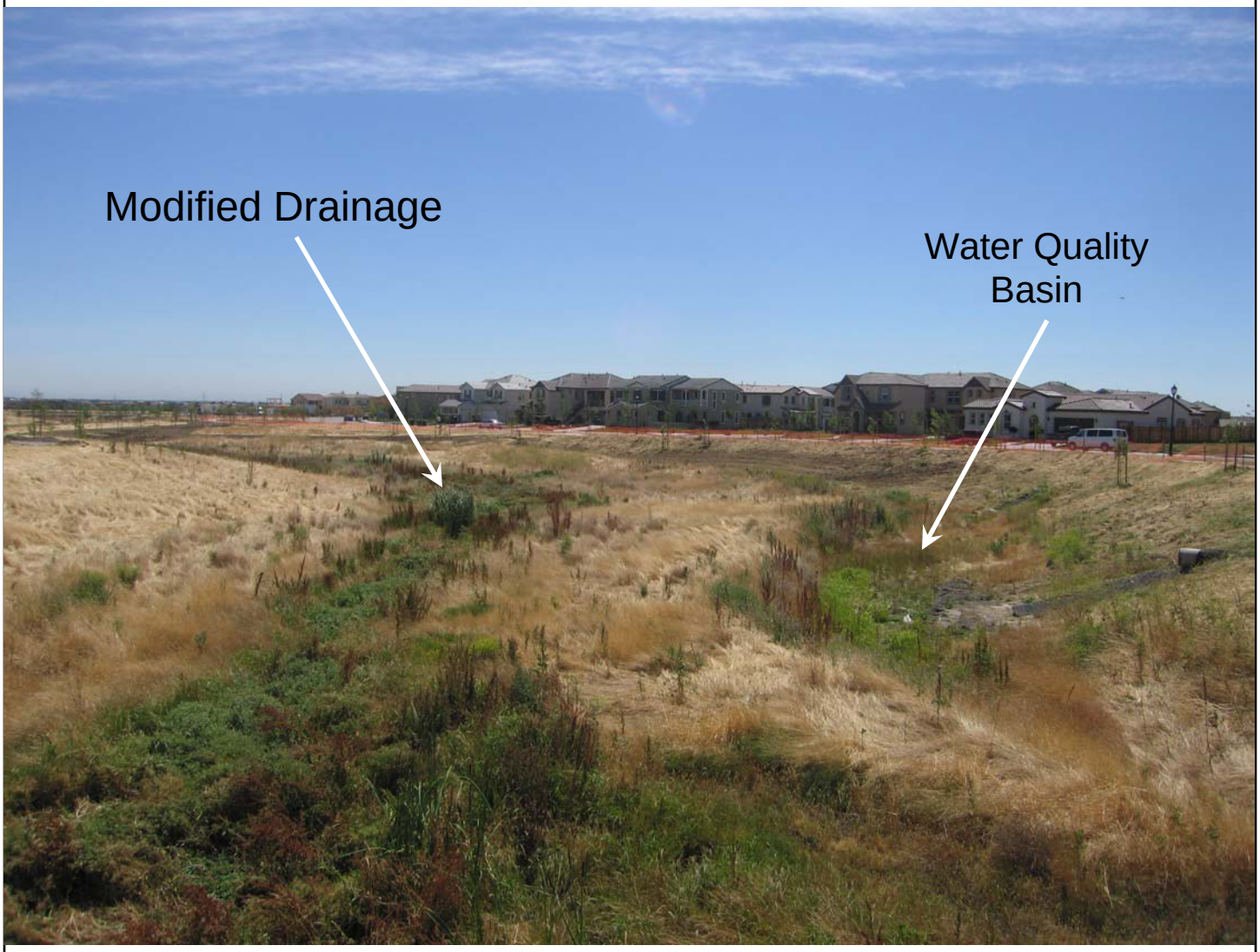


Figure 5-9
Example of Modified Channel/Engineered Natural Channel

Newhall Ranch Specific Plan
Sub-Regional Stormwater Mitigation Plan
Technical Appendices

(A) Pollutants of Concern

(B) Modeling Parameters & Methodology

(C) Newhall Ranch Stormwater Monitoring Data

(D) Review of Bacteria Data from Southern California Watersheds

(E) Effect of Urbanization on Groundwater Recharge in the Santa Clarita Valley

(F) Assessment of Potential Impacts Resulting from Cumulative Hydromodification Effects, Selected Reaches of the Santa Clara River, Los Angeles County, California

(G) Newhall Ranch Hydromodification Control

POLLUTANTS OF CONCERN

A.1. Pollutants of Concern

Pollutant of Concern [1]	Rationale for Selection / Exclusion	Significance Criteria
Sediment: Total Suspended Solids (TSS) & Turbidity	1. Sediment is a common component of stormwater, and can be a pollutant. Sediment can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, reproduction, and oxygen exchange in water bodies. Sediment can transport other pollutants that are attached to it including nutrients, trace metals, and hydrocarbons. Sediment is the primary component of total suspended solids (TSS), a common water quality analytical parameter (CASQA, 2003). 2. Turbidity is a measure of suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. Turbidity may be caused by a wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. In lakes or other waters existing under relatively quiescent conditions, most of the turbidity will be due to colloidal and extremely fine dispersions. In rivers under flood conditions, most of the turbidity will be due to relatively coarse dispersions. Erosion of clay and silt soils may contribute to in-stream turbidity. Organic materials reaching rivers serve as food for bacteria, and the resulting bacterial growth and other microorganisms that feed upon the bacteria produce additional turbidity. Nutrients in runoff may stimulate the growth of algae, which may also contribute to turbidity. Discharges of turbid runoff are primarily of concern during the construction phase of development.	1. Narrative objective in the Basin Plan: "Water shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses." 2. Basin Plan objective for turbidity: "Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in natural turbidity attributable to controllable water quality factors shall not exceed the following limits: Natural Turbidity — Max Increase 0-50 NTU — 20% > 50 NTU — 10% Allowable zones of dilution within which higher concentrations may be tolerated may be defined for each discharge in specific Water Discharge Requirements."

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Nutrients: Ammonia, Nitrite, Nitrate, Total Nitrogen, and Total Phosphorus	1. Nutrients including nitrogen and phosphorus are the major plant nutrients used for fertilizing landscapes, and are often found in stormwater. These nutrients can result in excessive or accelerated growth of vegetation, such as algae, resulting in impaired use of water in lakes and other sources of water supply. For example, nutrients have led to a loss of water clarity in Lake Tahoe. In addition, un-ionized ammonia (one of the nitrogen forms) can be toxic to fish (CASQA, 2003).	1. Basin Plan standards for ammonia: "In order to protect aquatic life, ammonia concentrations in receiving waters shall not exceed the values listed for the corresponding in-stream conditions in Tables 3-1 to 3-4." The criterion for ammonia in Tables 3-1 to 3-4 varies with pH and temperature; the criterion is lower for lower pH and temperature. The basin plan amendment for updated ammonia standards (dated 04/02, effective July 15, 2003) will be used. 2. Basin Plan surface water standards for nitrogen: "Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO_3-N + NO_2-N), 45 mg/L as nitrate (NO_3), 10 mg/L as nitrate-nitrogen (NO_3-N), or 1 mg/L as nitrite-nitrogen (NO_2-N) or as otherwise designated in Table 3-8." Table 3-8 lists Santa Clara River Reach 5 with a water quality objective of 5 mg/L nitrate-N + nitrite-N. 3. Basin Plan groundwater standards for nitrogen: "Ground waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO_3-N + NO_2-N), 45 mg/L as nitrate (NO_3), 10 mg/L as nitrate-nitrogen (NO_3-N), or 1 mg/L as nitrite-nitrogen (NO_2-N)." 4. Resolution 03-011 (LARWQCB, 08/2003) promulgates Nitrogen Compounds TMDLs for Santa Clara River Reach 5. The numeric target for NO3-N + NO2-N in the Nitrogen Compounds TMDL was based on achieving the existing water quality objective of 5 mg/L NO3-N + NO2-N. The numeric target that was used to calculate the wasteload allocations included a 10% margin of safety; thus the numeric target is 4.5 mg/L NO3-N + NO2-N (30-day average). The water quality objectives for ammonia in Reach 5 used in the

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
		Nitrogen Compounds TMDL are: TMDL Ammonia Water Quality Objective (mg/L as N) 1-hr average / 30-day average Reach 5 at County Line 3.4 / 1.2 Reach 5 below Valencia 5.5 / 2.0 Reach 5 above Valencia 4.8 / 2.0 5. Narrative objective for biostimulatory substances in the Basin Plan: "Waters shall not contain biostimulatory substances in concentrations that promote algal growth to the extent that such growth causes nuisance or adversely affects beneficial uses."
Trace metals: Aluminum, Copper, Lead, and Zinc	1. Trace metals are commonly found in stormwater. Many of the artificial surfaces of the urban environment (e.g., galvanized metal, paint, automobiles, or preserved wood) contain metals, which enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. Over half the trace metal load carried in stormwater is associated with sediments. Metals are of concern because they can be toxic to aquatic organisms, can bioaccumulate (accumulate to toxic levels in aquatic animals such as fish), and have the potential to contaminate drinking water supplies (CASQA, 2003). 2. Aluminum has been identified by the DPW as a constituent of concern for the Santa Clara River based on monitoring conducted at mass emission station S29 (LACDPW, 2005).	1. Narrative objective in the Basin Plan: "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. …" 2. The CTR criteria are the applicable water quality objectives for protection of aquatic life (40 CFR §131.38). The CTR criteria are expressed for acute and chronic (4-day average) conditions; however, only acute conditions are applicable for stormwater discharges because the duration of stormwater discharge is typically less than 4 days in the NRSP subregion. 3. CTR criteria are determined on the basis of hardness in the receiving water. In application of criteria to the NRSP sub-regional projects, a hardness value of 250 mg/L based on the minimum observed value at USGS monitoring station will be used.

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
		4. CTR criteria at 250 mg/L hardness are as follows: a. Dissolved copper – 32 µg/L. b. Total lead – 260 µg/L. c. Dissolved zinc – 250 µg/L. 5. The CTR does not include aluminum. The NAWQC contains an acute criterion for acid soluble aluminum (750 µg/L for a pH range of 6.5 to 9.0).
Chloride	1. Resolution No. R03-008, Amendment to the Water Quality Control Plan (Basin Plan) for the Los Angeles Region to Incorporate a Total Maximum Daily Load for Chloride in the Upper Santa Clara River (07/03) states: Elevated chloride concentrations are causing impairments of the water quality objective in Reach 5 and Reach 6 of the Santa Clara River. This objective was set to protect all beneficial uses; agricultural beneficial uses have been determined to be most sensitive, and not currently attained at the downstream end of Reach 5 and Reach 6 in the Upper Santa Clara River. Irrigation of salt sensitive crops such as avocados and strawberries with water containing elevated levels of chloride results in reduced crop yields. Chloride levels in groundwater are also rising.	1. The Basin Plan chloride objective for Reach 5 of the Santa Clara River is 100 mg/L. 2. The TMDL wasteload allocation for MS4 discharges into Santa Clara River Reach 5 is 100 mg/L.

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Pathogens (Bacteria, Viruses, and Protozoa)	1. Bacteria and viruses are common contaminants of stormwater. For separate storm drain systems, sources of these contaminants include animal excrement and sanitary sewer overflow. High levels of indicator bacteria in stormwater have led to the closure of beaches, lakes, and rivers to contact recreation such as swimming (CASQA, 2003). 2. Fecal and total coliform are frequently monitored indicator organisms of pathogens. 3. Human-related activities can increase coliform concentrations. 4. Concentrations of coliform in stormwater also can be elevated due to the presence of coliform bacteria from natural sources.	1. Basin Plan objectives are based on the designated uses of the water body. Santa Clara River Reach 5 is listed with a REC1 beneficial use. Resolution No. 01-018 (LARWQCB, 2001) amended the Basin Plan objectives for bacteria in waters with a contact recreation beneficial use. These standards for freshwaters are Geometric Mean / Single Sample E. coli ≤ 126/100 mL / ≤ 235/100 mL fecal coliform ≤ 200/100 mL / ≤ 400/100 mL
Petroleum Hydrocarbons: Oil & Grease and Polycyclic Aromatic Hydrocarbons (PAHs)	1. Oil and grease includes a wide array of hydrocarbon compounds, some of which are toxic to aquatic organisms at low concentrations. Sources of oil and grease include leakage, spills, cleaning and sloughing associated with vehicle and equipment engines and suspensions, leaking and breaks in hydraulic systems, restaurants, and waste oil disposal (CASQA, 2003). 2. Hydrocarbons are hydrophobic (low solubility in water), have the potential to volatilize, and most forms are biodegradable. A subset of hydrocarbons, Polynuclear Aromatic Hydrocarbons (PAHs) can be toxic depending on the concentration levels, exposure history, and sensitivity of the receptor organisms. Of particular concern are those PAH compounds associated with transportation-related sources. 3. Petroleum hydrocarbons are ubiquitous, and used in a wide variety of applications. Potential sources are generally expected to increase with urban development and potentially during construction of the Project.	1. Narrative objective in the Basin Plan for oil & grease: "Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance or that otherwise adversely affect beneficial uses." 2. PAHs are a class of compounds. CTR values for individual PAHs are available for protection of human health only. There are no regulatory standards for PAHs for the protection of aquatic health.

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Pesticides	1. Pesticides (including herbicides, fungicides, rodenticides, and insecticides) have been repeatedly detected in stormwater at toxic levels, even when pesticides have been applied in accordance with label instructions. As pesticide use has increased, so too have concerns about adverse effects of pesticides on the environment and human health. Accumulation of these compounds in simple aquatic organisms, such as plankton, provides an avenue for biomagnification through the food web, potentially resulting in elevated levels of toxins in organisms that feed on them, such as fish and birds (CASQA, 2003). 2. Pesticides loads may be present in runoff from developed areas due to pesticide use for urban landscaping.	1. Narrative objective in the Basin Plan: "Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of pesticides in excess of the limiting concentrations specified in … Title 22 of the California Code of Regulations …." Title 22 contains maximum contaminant levels for a range of pesticides. 2. CTR lists numeric objectives for some, but not all pesticides. There are no CTR criteria for diazinon and chlorpyrifos, but these pesticides, along with other toxic legacy pesticides such as Chlordane, Dieldrin, DDT, and Toxaphene, are now banned from most residential uses.

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Trash and Debris	1. Gross Pollutants (trash, debris, and floatables) may include heavy metals, pesticides, and bacteria in stormwater. Typically resulting from an urban environment, industrial sites and construction sites, trash and floatables may create an aesthetic "eye sore" in waterways. Gross pollutants also include plant debris (such as leaves and lawn-clippings from landscape maintenance), animal excrement, street litter, and other organic matter. Such substances may harbor bacteria, viruses, vectors, and depress the dissolved oxygen levels in streams, lakes, and estuaries sometimes causing fish kills (CASQA, 2003). 2. During the construction phase, there is potential for an increase in trash and debris loads due to lack of proper contractor good housekeeping practices at the construction site.	1. Basin Plan narrative floating material objective: "Waters shall not contain floating materials, including solids, liquids, foams, and scum, in concentrations that cause a nuisance or adversely affect beneficial uses." 2. Basin Plan narrative settleable materials objective: "Waters shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses." 3. Basin Plan narrative Biochemical Oxygen Demand (BOD5) objective: "Waters shall be free of substances that result in increases in the BOD which adversely affect beneficial uses." 4. Basin Plan objectives for dissolved oxygen (DO): "At a minimum (see specifics below), the mean annual dissolved oxygen concentration of all waters shall be greater than 7 mg/L, and no single determination shall be less than 5.0 mg/L, except when natural conditions cause lesser concentrations. The dissolved oxygen concentration of all surface waters designated as WARM shall not be depressed below 5 mg/L as a result of waste discharges."
MBAS (Methylene blue activated substances)	1. MBAS are related to the presence of detergents in water. Positive results may indicate the presence of wastewater or be associated with urban runoff due to commercial and/or residential vehicle washing or other outdoor washing activities. Surfactants disturb the surface tension which affects insects and can affect gills in aquatic life.	1. Basin Plan objective for MBAS: "Waters shall not have MBAS concentrations greater than 0.5 mg/L in water designated (MUN)."
Cyanide	1. Cyanide has been identified by the Los Angeles County Department of Public Works as a constituent of concern for the Santa Clara River based on monitoring conducted at mass emission Station S29	1. The CTR criteria are the applicable water quality objectives for protection of aquatic life (40 CFR 131.38). The CTR criteria are expressed for acute and chronic (4-day average)

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
	(LACDPW, 2005). Cyanide is used in electroplating, metallurgy, and gold mining. It is also used to make synthetic fibers, plastics, dyes, pharmaceuticals, and pesticides, including fumigants. In addition, cyanide serves as a chemical intermediate in various production processes. Natural cyanides are produced by certain bacteria, fungi, and algae, and they are present in a number of plants and foods as cyanogenic glycosides. Man-made cyanides typically enter the environment from metal finishing and organic chemical industries. Other sources include iron and steel works, municipal waste burning, cyanide-containing pesticides, road deicers, and vehicle exhaust.	conditions; however, only acute conditions are applicable for stormwater discharges because the duration of stormwater discharge is typically less than 4 days in the Project area. CTR freshwater aquatic life protection acute criteria is 22 µg/L.
Bioaccumulation	1. Some pollutants of concern in stormwater runoff, such as metals or pesticides, have the potential to bioaccumulate in aquatic organisms potentially affecting the health of those organism or other species higher up the food chain.	1. Although bioaccumulation is not a pollutant, it is a condition of concern. The Basin Plan objective for bioaccumulation is: "Toxic pollutants shall not be present at levels that would bioaccumulate in aquatic life to levels which are harmful to aquatic life or human health."
Oxygen, Dissolved & BOD (Biochemical oxygen demand)	1. Adequate DO levels are required to support aquatic life. Depressed levels may lead to anaerobic conditions. 2. BOD can result in decreased dissolved oxygen levels affecting beneficial uses such as habitat designations. 3. DO & BOD are correlated to nutrients and other organic compounds and are subsumed by those categories.	1. Basin Plan objective for dissolved oxygen: "The dissolved oxygen content of all surface waters designated as WARM shall not be depressed below 5 mg/L as a result of waste discharges." 2. Basin Plan objective for BOD: "Waters shall be free of substances that result in increases in the BOD which adversely affect beneficial uses."

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Biostimulatory substances	1. Biostimulatory substances include excess nutrients and other compounds that stimulate aquatic growth resulting in impaired aesthetics and water quality impairments such as lowered dissolved oxygen values. 2. Biostimulatory substances are correlated to nutrients and other organic compounds and are subsumed by those categories.	1. Basin Plan objectives for biostimulatory substances: "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance of adversely affects beneficial uses."
Chemical Pollutants	3. Chemical pollutants in excessive amounts in drinking water are harmful to human health. 4. The chemical pollutants referenced under this water quality objective, such as trace metals and nitrate, are either subsumed by the categories above, or are not found in urban runoff (e.g., fluoride).	2. Basin Plan objectives for chemical Pollutants: "Surface waters shall not contain concentrations of chemical Pollutants in amounts that adversely affect any designated beneficial use."
Temperature	1. Elevated temperatures are typically associated with discharges of process wastewaters or non-contact cooling waters. Increase in temperature can result in lower dissolved oxygen levels impairing habitat and other beneficial uses of receiving waters. Stormwater runoff from the Project site is expected to cool somewhat during treatment in structural BMPs and will be diluted in the receiving water. As the beneficial uses in the receiving waters for the Project include warm freshwater habitat to support warm water ecosystems, any increase in temperature resulting from stormwater runoff from the project is expected to be less than significant.	1. Basin Plan objectives for temperature: "For waters designated WARM, water temperature shall not be altered by more than 5 ºF above the natural temperature. At no time shall these WARM-designated waters be raised above 80 ºF as a result of waste discharges".

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Total Residual Chlorine	1. Municipal pools and private pools in areas served by a municipal sanitary system are required to be discharged into the sanitary system. Chlorine disinfection will not take place on the project site and there will not be any sources of elemental chlorine. Chloride sources (e.g. fertilizers or other compounds with salts) are evaluated separately. Therefore, total residual chlorine will not be present in runoff from the project.	1. Basin Plan objectives for total residual chlorine: "Chlorine residual shall not be present in surface water discharges at concentrations that exceed 0.1 mg/L and shall not persist in receiving waters at any concentration that causes impairment for beneficial uses".
Color, Taste, and Odor	1. Undesirable tastes and odors in water may be a nuisance and may indicate the presence of a pollutant(s). Odor associated with water can result from decomposition of organic matter or the reduction of inorganic compounds, such as sulfate. Other potential sources of odor causing substances, such as industrial processes, will not occur as part of the project. Color in water may arise naturally, such as from minerals, plant matter, or algae, or may be caused by industrial pollutants. 2. The Project will contain no heavy industrial uses. Commercial areas of the project are not expected to be a significant source of pollutants that might impart color or odor to stormwater flows from the Project area. Source controls are expected to reduce the amount of plant material and BMPs will reduce sediment which could contribute to color or odor nuisances. Therefore, color-, taste-, or odor-producing substances are not pollutants of concern for the project.	1. Basin Plan objective for color: "Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses". 2. Basin Plan objectives for taste and odor: "Ground waters shall not contain taste or odor-producing substances in concentration that cause nuisance or adversely affect beneficial uses".

Pollutant of Concern [(1)]	**Rationale for Selection / Exclusion**	**Significance Criteria**
Exotic Vegetation	1. Exotic vegetation typically provides little habitat value and can out compete native vegetation that is more suitable habitat for aquatic and terrestrial organisms. 2. The landscape management plan will not use exotic vegetation, and undesirable invasive vegetation will be eradicated to the extent possible. Therefore, exotic vegetation is not a pollutant of concern for the Project.	1. Basin Plan objective for exotic vegetation: "Exotic vegetation shall not be introduced around stream courses to the extent that such growth causes nuisance or adversely affects designated beneficial uses."
Mineral Quality (TDS, Boron, Sulfate, Sodium Absorption Ratio - SAR)	1. LADPW stormwater monitoring data arithmetic mean concentrations for TDS, sulfate, and boron for urban land uses are below the water quality objectives for minerals. Calculated SAR values are 0.6 for SF residential and 1.9 for commercial based on LADPW data. The minerals listed in the Basin Plan, except chloride and nitrogen, are not believed to be pollutants of concern due to the absence of river impairments and /or anticipated runoff concentrations below the Basin Plan objectives	1. Basin Plan objectives for minerals: Reach 5 TDS (mg/L) 1000 Sulfate (mg/L) 400 Boron (mg/L) 1.5 SAR (mg/L) 10
pH	1. Mean runoff concentrations in the Los Angeles County stormwater monitoring data ranged from 6.5 for mixed- and single-family residential land uses to 7.0 for commercial land use. Therefore, pH in the Santa Clara River is not expected to be affected by runoff discharges from the project.	1. Basin Plan objective for pH: "the pH of inland waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge."

Pollutant of Concern [(1)]	Rationale for Selection / Exclusion	Significance Criteria
PCBs	1. PCBs are highly toxic persistent chemicals that have been historically released into the environment from industrial uses, such as transformers. Due to their persistence, PCBs can still be detected in urban runoff due to historic industrial sources of these chemicals. 2. The project area did not historically include PCB-producing land uses and industrial land uses are not included in the proposed project. Therefore, PCBs are not a pollutant of concern for the project.	1. Basin Plan narrative regarding PCBs: "The purposeful discharge of PCBs to waters of the Region, or at locations where the waste can subsequently reach waters of the Region, is prohibited. Pass-through or uncontrollable discharges to waters of the Region, or at locations where the waste can subsequently reach waters of the Region, are limited to 70 pg/L (30 day average) for protection of human health and 14 ng/L and 30 ng/L (daily average) to protect aquatic life in inland fresh waters and estuarine waters respectively".
Radioactive Substances	1. Some activities such as mining or industrial activities can increase the amount of radioactive substances impairing beneficial uses. 2. The project will not have industrial or other activities that would be a source of any radioactive substances, and development will stabilize any naturally radioactive soils, though unlikely to be present in the project area. Therefore, radioactive substances are not a pollutant of concern for the project.	1. Basin Plan narrative objective for radioactive substances: "Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life or that result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life".

1. The pollutants of concern for the water quality analysis are those that are anticipated or potentially could be generated by the project at concentrations, based on water quality data collected in Los Angeles County from land uses that are the same as those included in the NRSP, that current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at concentrations or loads considered potentially toxic to humans and/or flora and fauna.

A.2. References

California Association of Stormwater Quality Agencies (CASQA), 2003. *Stormwater Best Management Practices Handbook New Development & Redevelopment*.

Los Angeles Regional Water Quality Control Board, 1995. Water Quality Control Plan Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties.

Los Angeles Regional Water Quality Control Board, October, 25th, 2001. Resolution 01-018: Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Bacteria Objectives for Water Bodies Designated for Water Contact Recreation

Los Angeles Regional Water Quality Control Board, July, 10th, 2003. Resolution R03-008 Revision of interim waste load allocations for chloride in the Amendment to the Water Quality Control Plan for the Los Angeles Region to include a TMDL for Chloride in the Upper Santa Clara River.

Los Angeles Regional Water Quality Control Board, August, 7th, 2003. Resolution R03-011 Amendment to the Water Quality Control Plan for the Los Angeles Region to include a TMDL for Nitrogen Compounds in the Santa Clara River.

US Environmental Protection Agency California Toxics Rule (CTR), 40 C.F.R. §131.38.

APPENDIX B

WATER QUALITY MODEL METHODOLOGY

APPENDIX B TABLE OF CONTENTS

B. Water Quality Model Methodology 1
B.1. Model Description 1
B.1.1. Model Overview 1
B.1.2. Model Assumptions 3
B.2. Model Input Parameters 3
B.2.1. Storm Events 3
B.2.2. Runoff Coefficients 6
B.2.2.1. SWMM Runoff Coefficient Modeling Parameters 7
B.2.2.2. SWMM Runoff Coefficient Results 11
B.2.3. Land Use & Treatment BMPs 13
B.2.4. Stormwater Runoff Pollutant Concentrations 17
B.2.4.1. Los Angeles County Monitoring Data 17
B.2.4.2. Ventura County Monitoring Data 18
B.2.4.3. Data Analysis for Derivation of Land Use EMCs 19
B.2.5. Estimate of BMP Performance Parameters 27
B.2.5.1. BMP Capture Efficiency 27
B.2.5.1.1. Volume-based BMP Capture Efficiency 27
B.2.5.1.2. Flow Based BMP Capture Efficiency 29
B.2.5.1.3. BMP Volume Reductions 29
B.2.5.2. BMP Pollutant Removal 30
B.2.6. Model Parameter Reliability & Assumptions 32
B.3. Model Methodology 34
B.3.1. Storms & Stormwater Runoff (steps 1 & 2) 36
B.3.2. Pollutant Loads & Concentrations (step 3 & 4) 37
B.3.3. Annual Pollutant Loads, Concentrations, and Distributions (steps 5, 6, & 7) 40
B.3.4. Model Methodology Assumptions 40
B.4. Model Reliability 43
B.5. References 43

1. WATER QUALITY MODEL METHODOLOGY

1.1. Model Description

1.1.1. Model Overview

The model used to assess stormwater quality impacts associated with the proposed Newhall Ranch Specific Plan is an empirical, volume-based pollutant loads model. This type of loadings model is generally applicable in the planning and evaluation stages of a project. The model was developed to assess the potential impact of development on water quality and to evaluate the effectiveness of the structural Best Management Practices (BMPs) that will treat storm water runoff as part of the project storm water treatment system. Two project conditions were evaluated with the water quality model:

1. Pre-development
2. Post-development with treatment BMPs

Measured runoff volumes and water quality characteristics of storm water are highly variable. To account for this variability, a statistical modeling approach was used to estimate the volume of storm water, the concentration of pollutants in storm water, and the overall pollutant load (total mass of pollutants) in storm water runoff. A statistical description of storm water provides an indication of the average characteristics and variability of the water quality parameters of storm water. It does not forecast runoff characteristics for specific storms or monitoring periods.

The statistical model is based on relatively simple rainfall/runoff relationships and estimated concentrations in storm water runoff. The volume of storm water runoff is estimated using a modification to the Rational Formula, an empirical expression that relates runoff volume to the rainfall depth and the basin characteristics such as imperviousness, and soils infiltration characteristics. The pollutant concentration in storm water runoff is represented by an expected average pollutant concentration, called the event mean concentrations (EMC). The EMCs are estimated from available monitoring data and are strongly dependent on the land-use type.

The flow chart in Figure 1-1 provides an overview of the modeling methodology.

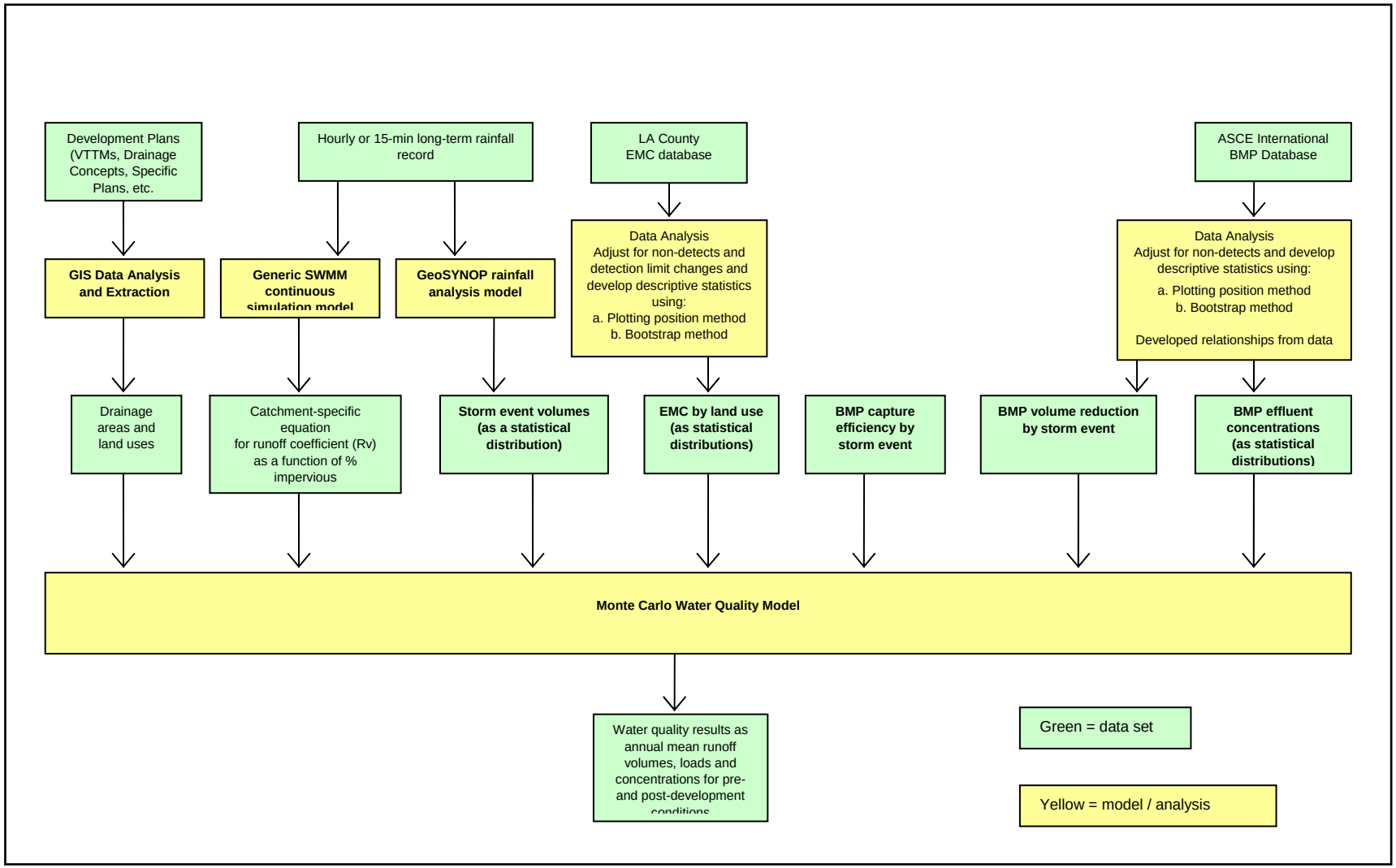


Figure 1-1: Overview of Water Quality Analysis Methodology

The model does not incorporate the detailed hydraulics or hydrology of the site, which would be more appropriate for design stages and requires additional data and more sophisticated modeling. The model includes water quality benefits achieved by structural BMPs but not source control BMPs because data is generally not available or conclusive for the latter. Model results are presented for average annual runoff volumes, pollutant loads, and pollutant concentrations.

As with all environmental modeling, the precision of results is heavily dependent on how well the hydrologic, water quality and BMP effectiveness data describe the actual site characteristics. Local and regional data are used to the fullest extent possible to help minimize errors in predictions, but such data are limited and traditional calibration and verification of the model is not feasible. It is important to note that the predictions of relative differences should be more accurate than absolute values.

1.1.2. Model Assumptions

The water quality modeling methodology requires that some assumptions are made for both the model input parameters and the way the modeling calculations are carried out. Section 1.2.6 discusses the assumptions that were made in specifying the model parameters and Section 1.3.4 discusses the assumptions regarding the modeling approach. Section 1.4 discusses model accuracy.

1.2. Model Input Parameters

Many parameters that can affect pollutant loads and concentrations vary spatially and may not be adequately represented by stormwater monitoring data collected at discrete locations. Examples include source concentrations, topography, soil type, and rainfall characteristics all of which can influence the buildup and mobilization of pollutants. The following model parameters represent the best data currently available for representation of existing and developed site conditions in the water quality model.

1.2.1. Storm Events

Rainfall analysis was conducted with data from the National Climatic Data Center (NCDC) Newhall rain gauge (station number 046162), located in the town of Newhall, California. Figure 1-2 shows the location of the Newhall gauge in relation to the Newhall Ranch Project area. This gauge is located approximately 7 miles from the project. The gauge elevation of 1,243 ft above mean sea level (AMSL) is comparable to the Project area elevation of approximately 1,000-1,500 ft AMSL.

While the period of record rainfall data collected at the Newhall rain gauge is quite long (35 years), there are still some gaps in the record. In order to improve the characterization of rainfall at the project site, estimates of the missing rainfall data were made through correlation of the Newhall rain gauge with the San Fernando rain gauge (NCDC station number 047762) which is located approximately 5 miles away (south and slightly east).

The Castaic Junction gauge monitored by LADPW is located closer to the Project; however the usable period of record at this gauge is limited to approximately 12 years which is considered too short to produce significant results in long-term simulation.

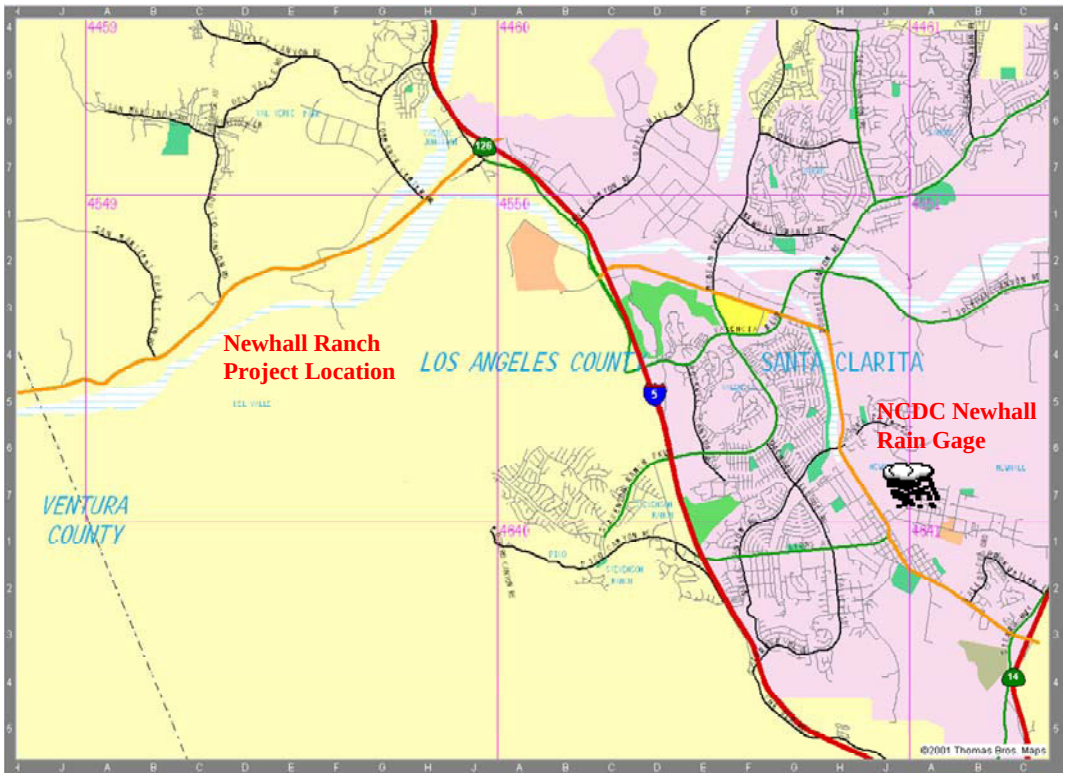


Figure 1-2: Location of Newhall Rain Gauge in the Vicinity of the Project Area

First a comparison of daily rainfall totals was made from the available data to assess the similarity in rainfall amounts between the two stations. Daily data from 1969 to 2003 was screened to keep only the 24-hour totals with measured rainfall at both stations, which eliminated missing data at either station. Correlation of the 24-hour rainfall totals is shown in Figure 1-3.

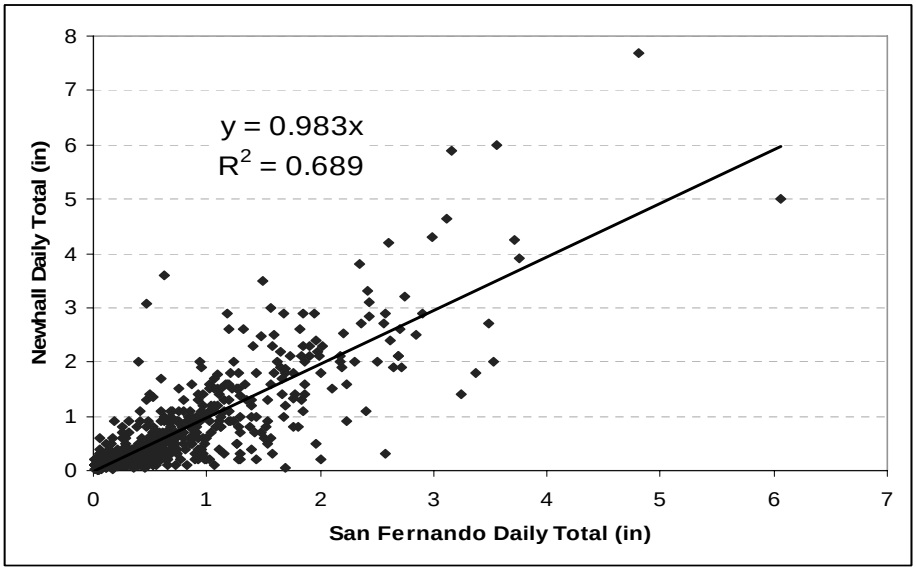


Figure 1-3: Correlation of 24-hour Totals between Newhall & San Fernando Gauges

The correlation is reasonably strong considering that the comparison is between the daily accumulations, i.e. a storm could result in appreciable rainfall at one gauge and little rainfall at the other. This comparison indicates that daily precipitation depths are similar between the two gauges. Another comparison was made using only months with a complete rainfall record and measured rainfall at both stations (Figure 1-4). This monthly correlation was much stronger due to the longer comparison period, and indicated slightly higher rainfall amounts at the Newhall gauge compared to the San Fernando gauge.

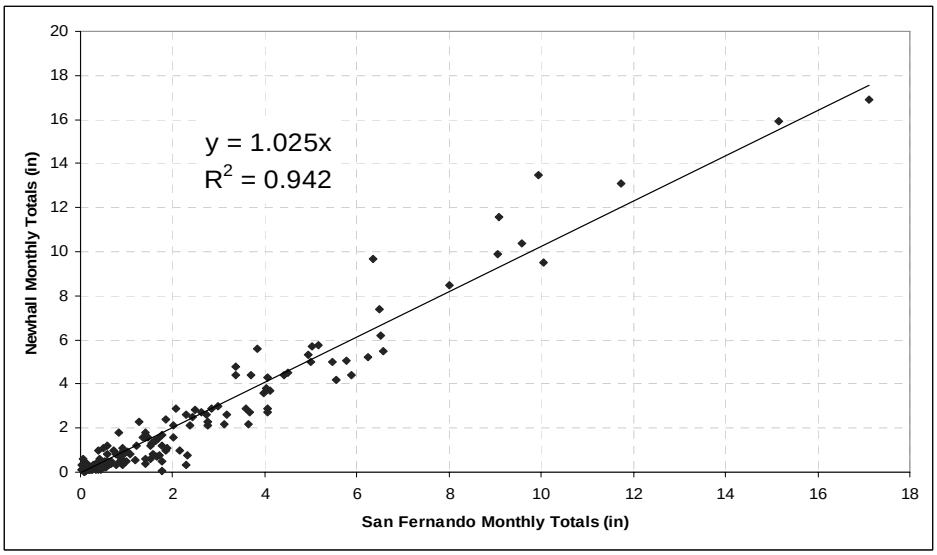


Figure 1-4: Correlation of Monthly Totals Newhall & San Fernando Gauges

Based on the relationship developed through the monthly comparison, a multiplier of 1.025 was applied to the hourly rainfall data from the San Fernando gauge to fill in the missing periods of rainfall data at the Newhall gauge. Values were rounded to the nearest 1/100 inch after the adjustment.

Rainfall analysis was conducted for all storm events and for the storms that are expected to contribute to stormwater runoff (storms >0.1 inches). The rainfall data were analyzed using a code similar in performance to EPA's Synoptic Rainfall Analysis Program (SYNOP). The customized code (GeoSYNOP) was used as it facilitates filling in missing periods of data and is more robust when handling the date and time of storms. GeoSYNOP subdivides the rainfall record into discrete events separated by a dry inter-event period, which in this case was set to a minimum of 6 hours. Small rainfall events whose depth was less than or equal to 0.10 inches were deleted from the record as such events tend to produce little if any runoff (USEPA, 1989; Schueler, 1987). For the Newhall gauge, a total of 538 storm events (>0.1 inches) were segregated from the continuous data. Storm statistics for the full (all the storms) and the trimmed (storms > 0.1 inch) data sets are shown in Table 1-1.

Table 1-1: Analysis Results for the Actual and Filled Newhall Rainfall Data

Storms	Newhall Gauge 1969 – 2003	Original Record	Augmented Record[1]
	Total Missing Records (days):	427	52
All Storms	Average annual rainfall (in):	17.4	18.8
	Total number of storms:	840	890
	Average number of storms per year:	24.0	25.4
	Average storm volume (in):	0.72	0.74
	Average storm duration (hrs):	6.87	7.35
	Average storm intensity (in/hr):	0.103	0.101
Storms >0.1 inch	Average annual rainfall (in):	16.2	17.9
	Total number of storms:	493	538
	Average number of storms per year:	14.1	15.4
	Average storm volume (in):	1.15	1.16
	Average storm duration (hrs):	11.0	11.5
	Average storm intensity (in/hr):	0.107	0.105

[1] Augmented record includes adjusted data from San Fernando gauge to fill gaps in Newhall gauge record.

1.2.2. Runoff Coefficients

One of the most variable parameters is the runoff coefficient, which is a function of the percent impervious and many other catchment parameters to lesser degrees. Novotny and Olem (1994), when discussing the Rational Formula, state "...the runoff coefficient is the most important task of the entire calculation." The following describes how the runoff coefficients were estimated in the model.

1.2.2.1. SWMM Runoff Coefficient Modeling Parameters

The Water Quality model uses a linear equation to estimate a runoff coefficient for sub-basins as a function of the percent impervious. The format of this equation is described as:

Runoff Coefficient = Slope × % Impervious + Intercept

The appropriate slope and intercept to define the runoff coefficient equation may be taken from region-specific data, regulatory guidance or developed using hydrologic models. The Los Angeles County Standard Urban Stormwater Mitigation Plan (SUSMP) Manual and the LA County Hydrology Manual use the following equation to calculate developed runoff coefficient:

$$C_D = (0.9 \times I) + (1.0 - I) \times C_U$$

Where: C_D = Developed Runoff Coefficient
I = Proportion Impervious (0 to 1)
C_U = Undeveloped Runoff Coefficient

The undeveloped runoff coefficient (C_U) in this equation is a function of soil type and rainfall intensity. For most soils found in LA County area and the range of intensities associated with water quality storms, C_U may be assumed to equal 0.1. Substituting this value into the equation above yields:

Runoff Coefficient = 0.008 × % Impervious + 0.1

Note: This equation was <u>not</u> used in water quality modeling. It was only used as a basis for comparison with project-specific runoff coefficient equations developed as described below.

As the Newhall Ranch Project area contains a variety of soil conditions, continuous simulation modeling using the Storm Water Management Model (SWMM) was conducted to determine the appropriate slope and intercept parameters to use in the linear runoff coefficient equation. Key parameters for the SWMM model are shown in Table 1-2.

Table 1-2: SWMM Runoff Module Parameters

SWMM Runoff Parameters	Units	Values
Wet time step	seconds	600
Wet/dry time step	seconds	600
Dry time step	seconds	14,400
Impervious Manning's n		0.012

SWMM Runoff Parameters	Units	Values
Pervious Manning's n		0.25
Drainage area modeled for Rv determination	acres	10
Shape		Rectangular, 500 ft flow path length for pervious areas, 250 ft flow path length for impervious area
Impervious Fractions Modeled		0%, 33.3%, and 100%. See Table 1-3 for specific runoff block dimensions.
Slope	ft/ft	0.10 for pre-development project conditions and 0.05 for post-development project conditions.
Evaporation	inches / month	60% of reference ET values contained in Table 1-5 were used for the existing site conditions to reflect existing uses and the post-development project condition.
Soil properties / infiltration		Green-Ampt soil parameters per Maidment (1993).
Depression storage, impervious	inches	0.02, based on Table 5-14 in SWMM manual (James and James, 2000)
Depression storage, pervious	inches	0.06, based on Table 5-14 in SWMM manual (James and James, 2000)

Runoff path lengths will affect ET and runoff volumes. As the path length increases, ET and infiltration increase and runoff decreases. For consistency in model runs three scenarios were modeled as shown in Table 1-3 with consistent runoff path lengths for pervious surfaces and impervious surfaces. Rectangular catchments were assumed, thus the catchment width for input to SWMM was calculated as the catchment area divided by the total path length. As only one width may be assigned for each catchment, modeled impervious fractions were chosen specifically to result in consistent runoff path lengths for pervious and impervious surfaces. Maintaining consistent path lengths ensures that the results of SWMM can be well-approximated by a linear trendline.

Table 1-3: SWMM Runoff Block Modeled Percent Impervious Values

Area (ac)	% Impervious	SWMM Width (ft)	Pervious Flow Length (ft)	Pervious Flow Length (ft)
10	0	871	500	0
10	33.3	581	500	250
10	100	1742	0	250

The Newhall Ranch Project contains a variety of soil conditions including 34% group B soils comprised mostly of loams and sandy loams, 59% group C soils comprised mostly of silty clay loams, and the remainder group A sandy soils and rock outcropping. For the general level of

analysis being conducted, it was considered appropriate to use a soil type that represents average conditions for all of Newhall Ranch. The soil type used was a moderately permeable soil representative of a silt loam which results in little surface runoff for the existing condition and a conservative estimate for the developed condition when further reducing the hydraulic conductivity by 25 percent to account for compaction. The Green-Ampt soils properties used for the SWMM modeling are shown in Table 1-4.

Table 1-4: Green-Ampt Soil Parameters

Soil Texture Class	Suction Head (in)	Ks (in/hr)	Initial Moisture Deficit (in/in)
Silt Loam – Existing Condition	6.57	0.27	0.32
Silt Loam – Developed Condition	6.57	0.20	0.32

Soil properties estimated from information contained in Table 5.5.5 of the Handbook of Hydrology (Maidment, ed. 2003)

Reference ET values for estimating actual ET rates was taken from Figure 1-5 produced by the California Department of Water Resources. The Newhall Ranch Project site is located in zone 14. Reference ET values for zone 14 are reproduced in Table 1-5.

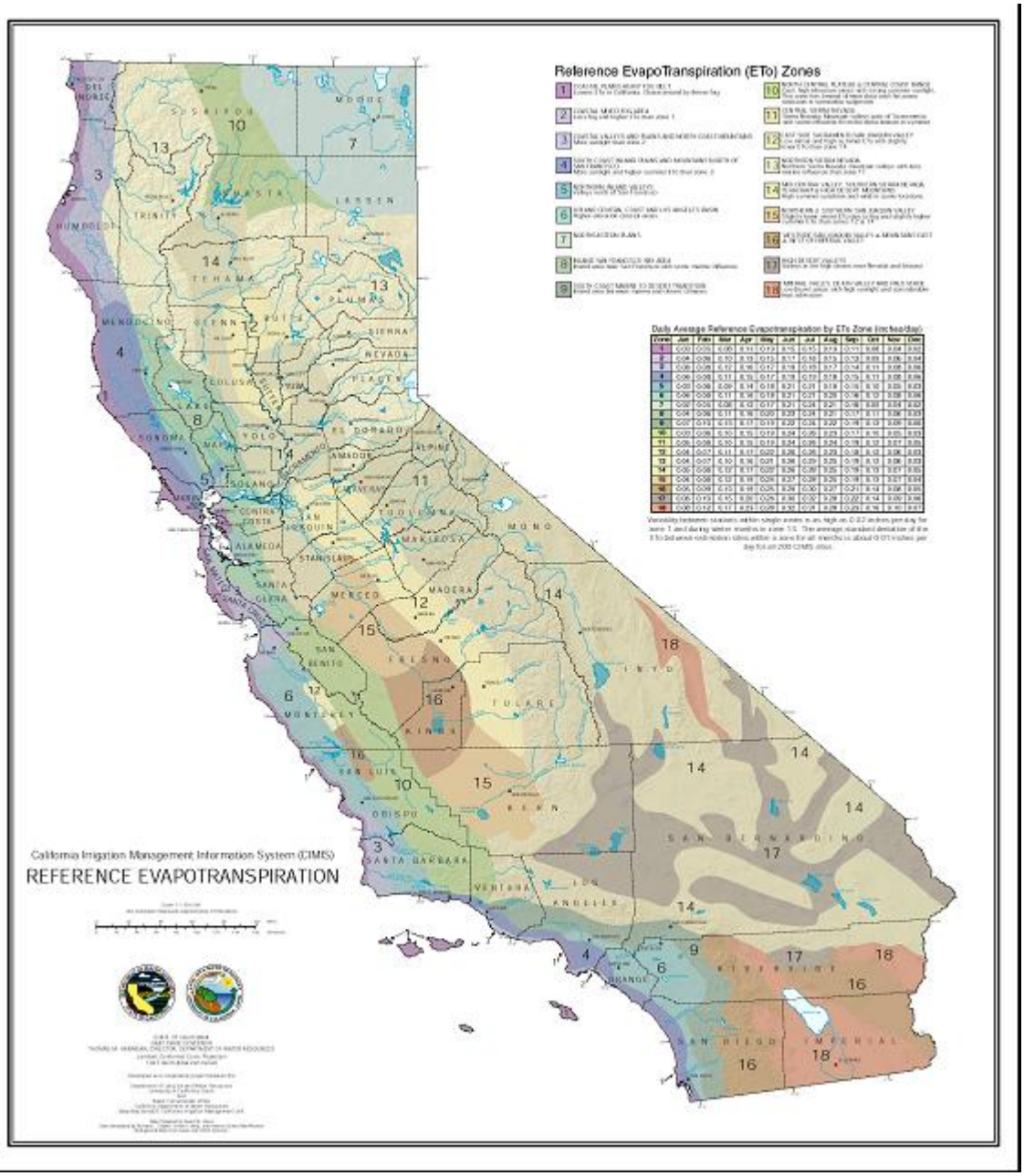


Figure 1-5: Reference ET for CA Zones

Existing site conditions consist of natural grasses, shrubs, and small trees; agricultural row crops, both irrigated and dry farming; and mineral extraction areas including gravel/dirt roads, and unvegetated clearings. To represent average existing site conditions, 60% of the reference ET values were used to reflect partially shaded conditions, semi-arid vegetation, dry crops and bare soil. Sixty percent of the reference ET values were also used to simulate the landscaped areas in the post-development condition.

Table 1-5: Evaporation Parameters for Hydrology Model (from CA ET map)

Month	Evapotranspiration Rates			60%
	Inch / day	Days / month	Inch / Month	Inch / Month
January	0.05	31	1.55	0.93
February	0.08	28	2.24	1.34
March	0.12	31	3.72	2.23
April	0.17	30	5.1	3.06
May	0.22	31	6.82	4.09
June	0.26	30	7.8	4.68
July	0.28	31	8.68	5.21
August	0.25	31	7.75	4.65
September	0.19	30	5.7	3.42
October	0.13	31	4.03	2.42
November	0.07	30	2.1	1.26
December	0.05	31	1.55	0.93
	Total	365	57.04	34.22

1.2.2.2. SWMM Runoff Coefficient Results

Using the model input parameters described above, runoff coefficient equations have been developed for the Newhall Ranch Specific Plan area. Figure 1-6 and Figure 1-7 display the SWMM results (as diamonds) and the best fit line for existing and developed conditions, respectively, for the entire Project site.

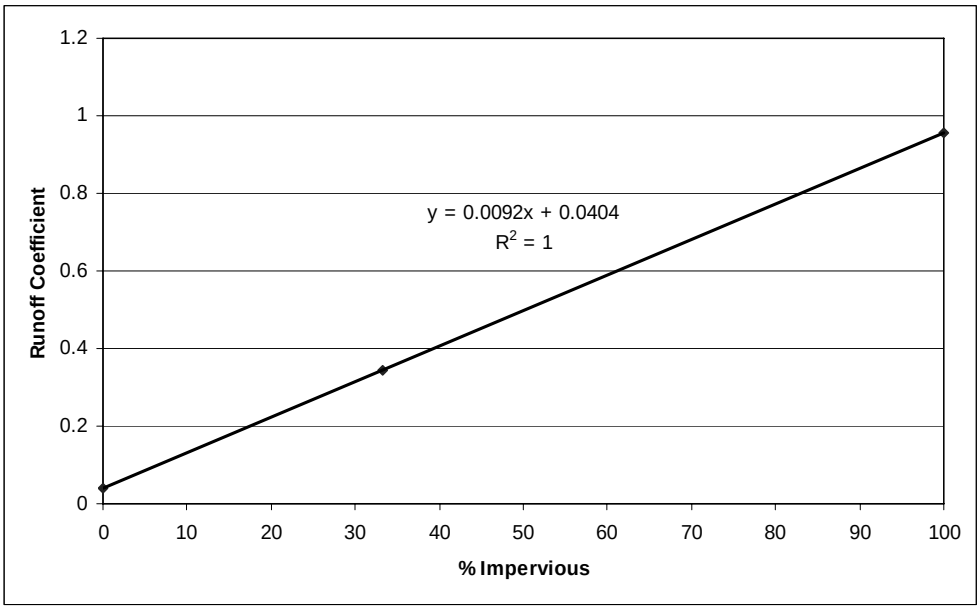


Figure 1-6: Existing Conditions Runoff Coefficient Equation

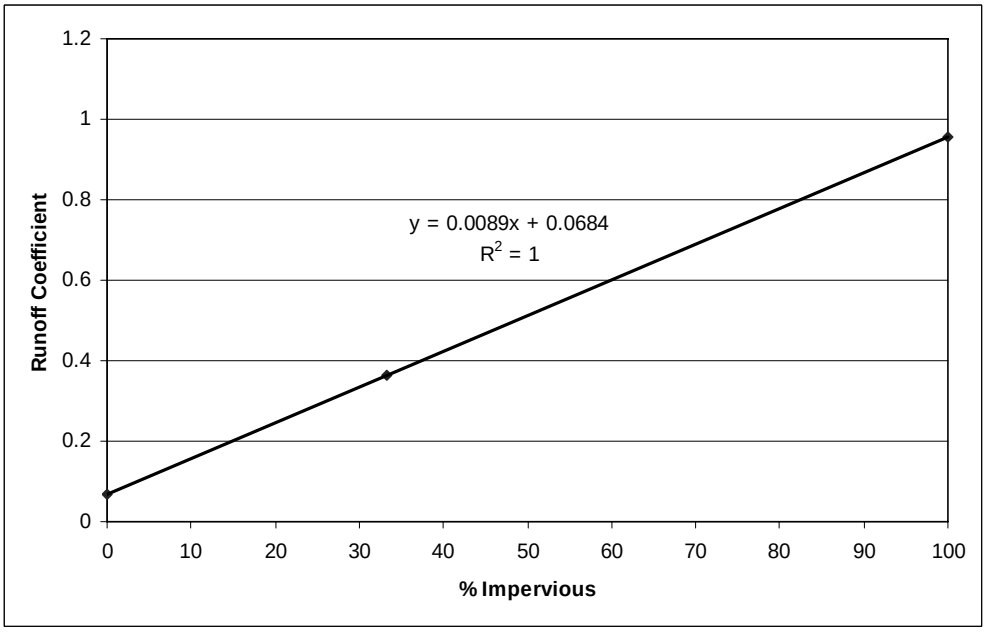


Figure 1-7: Developed Conditions Runoff Coefficient Equation

The SWMM continuous simulation results for the Project model as a whole agree relatively closely with the LA County runoff coefficient equation discussed above. The intercept was rounded to three decimal places resulting in the following equations used to estimate runoff coefficients in the water quality model as a function of imperviousness:

Existing Conditions:

- Total Project Runoff Coefficient = 0.0092 × % Impervious + 0.0404

Developed Conditions:

- Total Project Runoff Coefficient = 0.0089 × % Impervious + 0.0684

1.2.3. Land Use & Treatment BMPs

The delineation of existing land uses and areas within Newhall Ranch were determined from the Los Angeles County Department of Public Works (LADPW) existing land use coverage and Newhall Land records of existing agriculture areas. Based on an inspection of recent aerial photography, project areas designated with the existing land use "Mineral Extraction- Oil and Gas" were divided into open space land use (85%) and light industrial land use (15%) to better define the origin of stormwater runoff and pollutants. High country areas discharge to the Santa Clara River near the project boundary therefore, these areas and the Santa Clara River Corridor were not included in the water quality modeling. The modeled project area was 7,003 acres. Table 1-6 provides the existing condition land uses and areas for Newhall Ranch as well as the land use category for water quality modeling, percent impervious value, and runoff coefficient used for the land uses. The modeled land uses were based on the most representative land use within the available data sets (see Section 1.2.4).

Table 1-6: Modeled Existing Conditions

Land Use	Area (acres)	Land Use Category for Modeling	% Impervious[1]	Runoff Equation Type
Open Space	3,825.8	Open	1	Undeveloped
Oil and Gas Extraction	1309.6	Light Industrial/ Open Space[2]	10	Undeveloped[3]
Agriculture – Dry	1,016.3	Agriculture	2	Developed
Agriculture - Irrigated	810.9	Agriculture	2	Developed
SR-126	40.4	Transportation	100	Developed
High Country	4234.3	Not Modeled		
River Corridor	761.9	Not Modeled		

Land Use	Area (acres)	Land Use Category for Modeling	% Impervious[1]	Runoff Equation Type
Total Modeled	7,003.0			
Total	11,999.2			

[1] Percent impervious values are based on the LA County Hydrology Manual.
[2] Areas zoned Oil and Gas Extraction were assumed to be 85% vacant land use with 1% imperviousness and 15% light industrial land use with 60% imperviousness, equivalent to 10% composite imperviousness.
[3] Areas zoned Oil and Gas Extraction were modeled using the undeveloped runoff coefficient since the oil and gas pads (modeled as light industrial) are well distributed and are a small portion (15%) of the total land use area. Overall, it was assumed that the total land use area is best represented by the undeveloped runoff coefficient.

The delineation of developed land uses and areas within Newhall Ranch were determined from the Newhall Ranch Specific Plan land use data provided by PSOMAS Engineering. As with the existing condition, high country areas discharge to the Santa Clara River near the project boundary therefore, these areas and the Santa Clara River Corridor were not included in the water quality modeling. The modeled project area was 7,003 acres.

The BMPs included in the water quality modeling were swales for the majority of the Landmark Village Project and dry extended detention water quality basins for the remaining developed areas within the Newhall Ranch Project area. Although bioretention areas will be incorporated into the Newhall Ranch Project area to reduce stormwater runoff volumes in order to protect receiving waters, these BMPs were not modeled.

Table 1-7 provides developed condition land uses and areas for Newhall Ranch as well as the land use category for water quality modeling, percent impervious value, runoff coefficient used for the land uses. Table 1-7 also divides the total area for each land use between areas treated by swales and water quality basins and areas not treated by a BMP. In addition, area weighted percent impervious values for areas treated by swales and water quality basins and areas not treated by a BMP are provided. Percent imperviousness values for each BMP are required for the water quality model.

Detention basins have been incorporated into the water quality model as it has not yet been determined where and to what extent it will be possible to incorporate bioretention areas into the stormwater (and dry weather flows) treatment systems for the Newhall Ranch. Detention basins have been modeled as the water quality BMP for the majority of the Newhall Ranch area, as this is representative of the minimum level of treatment that will be provided for stormwater runoff. Treatment in bioretention facilities will provide for greater volume and pollutant load reduction than detention basins. Therefore, the water quality model results based on dry extended detention basin treatment are conservative and represent the maximum stormwater runoff volumes and pollutant loads anticipated for the developed project condition. Stormwater runoff volumes and pollutant loads will be reduced in areas treated with bioretention.

Table 1-7: Modeled Developed Conditions

Land Use	Area (acres)	Land Use Category for Modeling	% Impervious[1]	Runoff Eqn Type	Area (acres) by BMP			Area Weighted % Impervious by BMP		
					No Treatment	Swales	WQ Basins	No Treatment	Swales	WQ Basins
Commercial	463.2	Commercial	91	Developed		34.2	429.0		8.80	11.8
Estate Residential	352.6	Single Family Residential	30	Developed			352.6			3.2
Low Density SF Residential	419.3	Single Family Residential	42	Developed			419.3			5.3
Low-Med Density SF Residential	978.4	Single Family Residential	42	Developed			978.4			12.4
Medium Density SF Residential	610.9	Single Family Residential	55	Developed		49.0	561.9		7.6	9.3
High Density MF Residential	151.2	Multi-Family Residential	68	Developed		76.5	74.7		14.7	1.5
Education	100.5	Education	68	Developed		9.0	91.5		1.7	1.9
Road	340.0	Roadways[2]	100	Developed		130.3	209.7		36.8	6.3
Open Space	3,337.9	Open Space	1	Undeveloped	3,303.3	34.6		1.0	0.1	
Park	52.3	Open Space	15	Developed		20.0	32.3		0.8	0.1
Golf Course	172.5	Open Space	10	Developed			172.5			0.5
Water	24.2	Water[3]	100	Undeveloped	24.2			0.7		
High Country	4234.3	Not modeled	-	-						
River Corridor	761.9	Not modeled	-	-						
Total Modeled	7,003.0				3327.5	353.6	3,321.9	1.7	70.7	52.3
Total	11,999.2									

[1] Percent impervious values are based on the LA County Hydrology Manual.

[2] Of the 340 acres of roadways, 193 acres are high use roads (>30,000 vehicles per day) and were modeled as transportation land use. The remaining 147 acres of roads are lower use (<30,000 vehicles per day) and were modeled as 100% impervious residential areas. The residential stormwater monitoring data used to represent pollutant concentrations includes residential roadways.

[3] All rainfall on water surfaces is modeled as 100% impervious because rainfall is equal to runoff. It is assumed that 100% of the rainfall that falls on the water surface is captured in the waterbody. Since the runoff is immediately captured in the waterbody and does not travel across impervious surfaces, it is assumed that the runoff does not generate any pollutant loads.

1.2.4. Stormwater Runoff Pollutant Concentrations

Stormwater monitoring data collected by the Los Angeles Department of Public Works (LADPW) was used to derive estimates of pollutant concentrations in runoff from urban land uses. The existing conditions of the Newhall Ranch Project site contain agricultural uses. Stormwater monitoring data collected by Ventura County was used to estimate stormwater pollutant concentrations for agricultural land use.

1.2.4.1. Los Angeles County Monitoring Data

Recent and regional land-use based stormwater quality monitoring data was collected through the LA County Stormwater Monitoring Program. This program was initiated with the goal of providing technical data and information to support effective watershed stormwater quality management programs in Los Angeles County. Specific objectives of this project included monitoring and assessing pollutant concentrations from specific land uses and watershed areas. In order to achieve this objective, the County undertook an extensive stormwater sampling project that included 8 land use stations and 5 mass emission stations (located at the mouths of major streams and rivers), which were tested for 82 water quality constituents. These data are presented in *Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report, 2000* and *Los Angeles County 2000-2001 Stormwater Monitoring Report, 2001*.

Stormwater quality for the Newhall Ranch Project was estimated based on the recent EMC data collected by LA County (LA County, 2000). These data were used because of the relatively close location to the project site and because the monitored land uses were representative of the proposed land uses for the Newhall Ranch Project. The monitored land uses stations are listed in Table B-8 with a brief description of the site and when the monitoring data were collected.

Table 1-8: LA County Land Use Monitoring Stations Available for Water Quality Modeling

Station Name	#	Modeled Land Use	Site Description[1]	Years Monitoring Conducted
Santa Monica Pier	S08	Commercial	The monitoring site is located near intersection of Appian Way and Moss Avenue in Santa Monica. The storm drain discharges below the Santa Monica Pier. Drainage area is approximately 81 acres. The Santa Monica Mall and Third St. Promenade dominate the watershed with remaining land uses consisting of office buildings, small shops, restaurants, hotels and high-density apartments.	1995-1999

Station Name	#	Modeled Land Use	Site Description[1]	Years Monitoring Conducted
Sawpit Creek	S11	Open Space (& Parks)	Located in Los Angeles River watershed in City of Monrovia. The monitoring station is Sawpit Creek, downstream of Monrovia Creek. Sawpit Creek is a natural watercourse at this location. Drainage area is approximately 3300 acres.	1995-2001
Project 620	S18	Single Family Residential	Located in the Los Angeles River watershed in the City of Glendale. The monitoring station is at the intersection of Glenwood Road and Cleveland Avenue. Land use is predominantly high-density, single-family residential. Drainage area is approximately 120 acres.	1995-2001
Project 1202	S24	Light Industrial	Located in the Dominguez Channel/Los Angeles Harbor Watershed in the City of Carson. The monitoring station is near the intersection of Wilmington Avenue and 220th Street. The overall watershed land use is predominantly industrial.	1995-2001
Dominguez Channel	S23	Freeway (Roadways)	Located within the Dominguez Channel/Los Angeles Harbor watershed in Lennox, near LAX. The monitoring station is near the intersection of 116th Street and Isis Avenue. Land use is predominantly transportation and includes areas of LAX and Interstate 105.	1995-2001
Project 474	S25	Education (Schools)	Located in Los Angeles River watershed in the Northridge section of the City of Los Angeles. The monitoring station is located along Lindley Avenue, one block south of Nordoff Street. The station monitors runoff from the California State University of Northridge. Drainage area is approximately 262 acres.	1997-2001
Project 404	S26	Multi-Family Residential	Located in Los Angeles River watershed in City of Arcadia. The monitoring station is located along Duarte Road, between Holly Ave and La Cadena Ave. Drainage area is approximately 214 acres.	1997-2001

[1] Los Angeles County 1999-2000 Draft Stormwater Monitoring Report (Los Angeles County, 2000)

1.2.4.2. Ventura County Monitoring Data

As part of its NPDES permit, the Ventura County Flood Control District conducts monitoring to determine the water quality of stormwater runoff from areas with specific land uses. One monitoring station, Wood Road at Revolon Slough (site A-1), drains the approximately 350 acre Oxnard Agricultural Plain, which is comprised almost entirely of agricultural land (primarily row crops), including a small number of farm residences and ancillary farm facilities for equipment

maintenance and storage. Data from the Wood Road station was used to estimate pollutant concentrations in stormwater runoff for agricultural land use.

Land use runoff sampling for the Ventura County stormwater monitoring program originally began during the 1992/93 monitoring season, with up to several samples collected at each site during each storm season. For the A-1 site, the period of record begins during the 1996/97 storm season, and continues through the 2003/04 season. All land use monitoring sites are equipped with automated monitoring equipment, including flowmeters (with area-velocity probes and level sensors) and refrigerated auto-samplers which enable the collection of flow-weighted composite samples. Stormwater quality monitoring data for the agricultural land use site was provided by Mark Davis of the Ventura County Watershed Protection District. This information was extracted from their newly-constructed water quality database, which contains monitoring data for their land use, mass emission, and receiving water monitoring sites.

1.2.4.3. Data Analysis for Derivation of Land Use EMCs

The County of Los Angeles Department of Public Works (LADPW) has monitored stormwater runoff quality from various land uses throughout the County on an annual basis beginning in 1995 through 2001. For each year of monitoring several storm event mean concentrations (EMCs) are reported and included in the County's annual water quality report to the Los Angeles Regional Water Quality Control Board. The convention for dealing with the censored data (e.g., data only known to be below the analytical detection limit) is to substitute ½ of the detection limit for all non-detects. L.A. County has followed this convention when providing summary arithmetic statistics of the stormwater monitoring data. This method tends to introduce bias into the estimate of the mean and standard deviation and the summary statistics are not believed to be robust or adequately account for non-detects. To further complicate matters, the detection limit for dissolved copper and total lead has changed during the period stormwater monitoring was conducted by LADPW.

In an effort to provide more reliable and accurate estimates of land use EMCs for the Newhall Ranch Specific Plan water quality modeling, a robust method of estimating descriptive statistics for censored data with multiple detection limits was employed. The plotting position method described in Helsel and Cohn (1988) was used to estimate censored values using the distribution of uncensored values. Descriptive statistics were then estimated using the parametric bootstrap method suggested by Singh, Singh, and Engelhardt (1997).

Example Data Set

To illustrate the statistical methods used to obtain land use EMCs, the LADPW stormwater monitoring data collected for total lead from the transportation land use station is used. The data were collected from 01/1996 to 04/2001. At the beginning of March 1997 the detection limit for total lead changed from 10 to 5 μg/L. Table 1-9 describes the data according to the number of censored and uncensored values in the example data set.

Table 1-9. Number of Censored and Uncensored Data Points in the Total Lead Transportation Land Use Data Set

Total Lead EMC Data for Transportation Land Use	
Uncensored	37
Censored < 10 µg/L	2
Censored < 5 µg/L	38
Total Data Count	77

Prior to applying the plotting position method, it is necessary to check the normality of the data. Figure 1-8 shows histograms and probability plots of the transportation land use total lead data above detection limits in normal and lognormal space. As indicated in the figure, the data tends to follow a lognormal distribution, a finding that is common with many pollutants in stormwater.

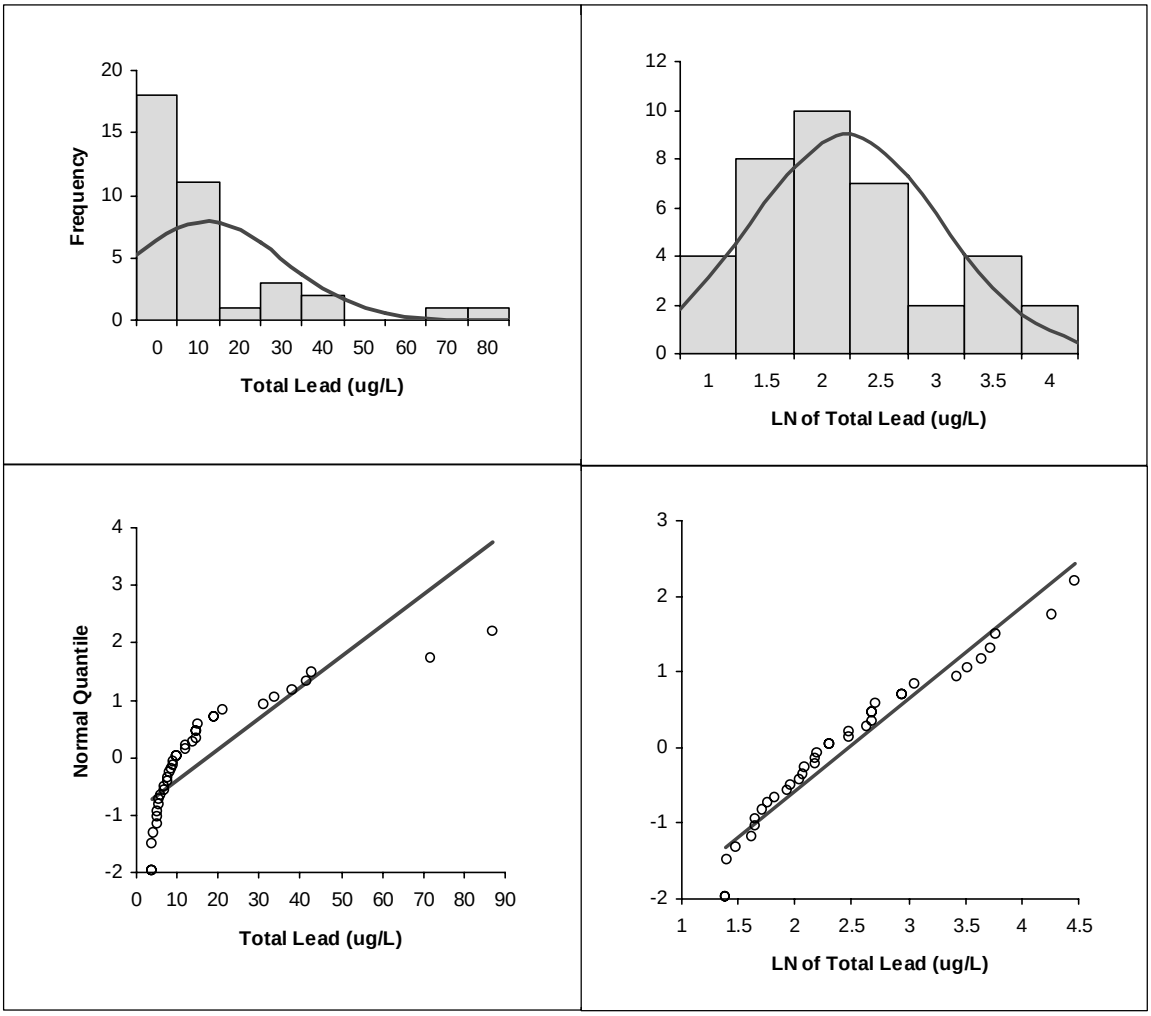


Figure 1-8: Histograms and Probability Plots of Transportation Total Lead Data in Arithmetic and Lognormal Space

To verify the visual check that the data are lognormally distributed, the Shapiro-Wilk goodness-of-fit test was used (Royston, 1992). In this test, if $p > 0.1$, the null hypothesis that the log data follow a normal distribution cannot be rejected. For this example data set, the p-value of the log-transformed uncensored data is 0.293, which indicates that lognormal distribution is a good approximation of the distribution of the data set.

Method for Dealing with Multiple Detection Limits

To account for the multiple detection limits in the censored data sets, a regression on order statistics (ROS) method was employed. ROS is a category of robust methods for estimating descriptive statistics of censored data sets that utilize the normal scores for the order statistics (Shumway et al. 2002). The plotting position method by Hirsch and Stendinger (1987) (summarized by Helsel and Cohn, 1988) was the ROS method used. In this method, plotting positions are based on conditional probabilities and ranks, where the ranks of the censored (below detection) and uncensored data (above detection) related to each detection limit are ranked independently. The method is summarized in the equations below.

After plotting positions for the censored and uncensored values have been calculated, the uncensored values are plotted against the z-statistic corresponding to the plotting position and the best-fit line of the known data points is derived. Using this line and the plotting positions for the uncensored data, the values for the uncensored data are extrapolated. Figure 1-9 illustrates the plotting position method results on the total lead data for transportation land use.

$$pe_j = pe_{j+1} + \frac{A_j}{(A_j + B_j)} \times (1 - pe_{j+1}) \qquad (1)$$

Where:

A_j = the number of uncensored observations above the j detection limit and below the j +1 detection limit.

B_j = the number of censored and uncensored observations less than or equal to the j detection limit.

pe_j = the probability of exceeding the j threshold for j = m, m -1, … 2, 1 where m is the number of thresholds; by convention $pe_{m+1} = 0$.

Equation 2 was used for plotting the uncensored data and equation 3 was used for plotting the censored data; the plotting positions of the data were calculated using the Weibull plotting position formula.

$$p(i) = (1 - pe_j) + \frac{(pe_j - pe_{j+1}) \times r}{(A_j + 1)} \qquad (2)$$

Where:

p(i) = the plotting position of the uncensored i data point.

r = the rank of the ith observation of the A_j observations above the j detection limit.

$$pc(i) = \frac{(1 - pe_j) \times r}{(n_j + 1)} \qquad (3)$$

Where:

pc(i) = the plotting position of the censored i data point.

r = the rank of the ith observation of the n_j censored values below the j detection limit.

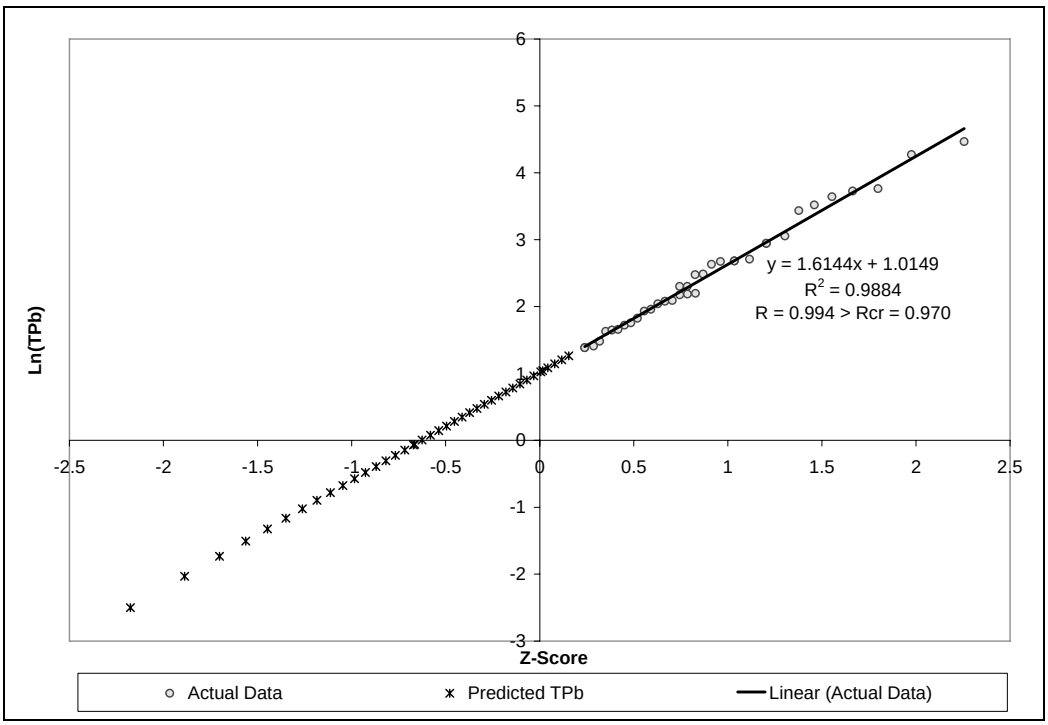


Figure 1-9: Probability Plot of the Uncensored and Predicted (Censored) Total Lead Transportation EMCs

Method for Calculating Descriptive Statistics

After the censored data are estimated (or for datasets without non-detects), descriptive statistics were computed using the bootstrap method (Singh et al. 1997). The bootstrap method samples from the data set with replacement several thousand times and calculates the desired descriptive statistics from the sampled data. The steps of the bootstrap estimation method are described below.

1. Take a sample of size *n* with replacement (the sampled data point remains in the data set for subsequent sampling) from the existing data set (Singh et al. recommends n be the same size as the original data set, this recommendation was followed for the analysis) and compute the descriptive statistic, θ_i, from the sampled data.
2. Repeat Step 1 independently N times (10,000 for this analysis) each time calculating a new estimate for θ_i.
3. Calculate the bootstrap estimate θ_B by averaging the θ_i's for i=1 to N

Fundamentally, the bootstrap procedure is based on the Central Limit Theorem (CLT), which suggests that even when the underlying population distribution is non-normal, averaging produces a distribution more closely approximated with normal distribution than the sampled distribution (Devore 1995). Figure 1-10 compares the total lead data after estimating censored values using the ROS method described prior to applying the bootstrap method with bootstrapped means of the ROS data. Note the bootstrap means are more normally distributed than the original data and the central tendency of the data is centered near 8 ug/L.

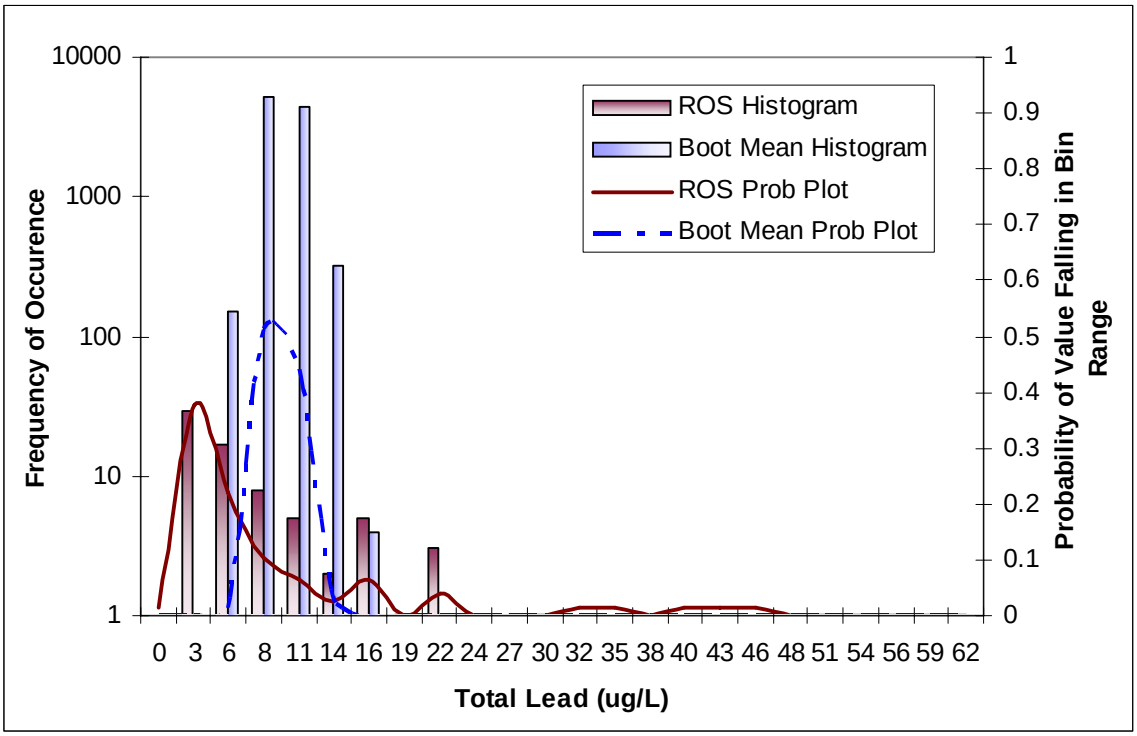


Figure 1-10: Comparison of the Distribution of ROS Method Total Lead Data and the Bootstrap Means of the ROS Data.

The majority of the LADPW stormwater monitoring for the pollutant land use combinations analyzed fit a lognormal distribution. The data that did not statistically fit the lognormal distribution were more closely approximated with a lognormal distribution than a normal distribution. The bootstrap method was applied differently depending on the distributional fit of

the data. If the pollutant EMC data for a particular land use fit a lognormal distribution according to the Shapiro-Wilk goodness-of-fit test, the log-transformed data were bootstrapped and an estimate of the mean and standard deviation were obtained in log space and then converted to arithmetic space. The assumption of lognormality was more stringently applied than normal by using an alpha significance value of 0.1. This was done to improve the estimate of the standard deviation when the hypothesis of lognormality is rejected. When analyzing data in log space there is a tendency to overestimate the standard deviation for relatively symmetric data and underestimate the standard deviation for severely skewed data. For datasets that did not fit the lognormal distribution, the raw data were bootstrapped to obtain the mean and standard deviation statistics. Bootstrapping the data in arithmetic space assumes no distribution in those instances when a distribution could not be confirmed through goodness-of-fit testing.

Conclusions

The plotting position method for multiple detection limits has been used in conjunction with the bootstrap procedure for calculating the descriptive statistics used to represent pollutant EMC distributions in the water quality model. If the uncensored data were determined to be lognormally distributed with less than 50% of the data below the detection limit (censored), the bootstrap procedure was coupled with lognormal theory (i.e., data were log transformed prior to the bootstrap analysis). Otherwise, the original data plus the estimates of the censored data were analyzed in arithmetic space to calculate the arithmetic mean and standard deviation. Table 1-10 summarizes the lognormal descriptive statistics, and Table 1-11 summarizes the resulting arithmetic means. The latter data represent the land use specific pollutant EMCs in the Monte Carlo water quality model.

Table 1-10: Lognormal Statistics for Modeling Pollutants Concentrations from Land Uses.

Land Use		TSS	TP	NH3	NO3	NO2	TKN	Diss Cu	Tot Pb	Diss Zn	Cl
	Arithmetic Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L
Commercial	Mean	3.966	-1.242	-0.832	-0.884	-2.721	0.711	2.210	1.292	4.778	3.043
	St. Dev	0.609	0.680	1.218	0.635	1.060	0.804	0.685	1.389	0.703	1.226
Education	Mean	4.097	-1.375	-1.838	-0.750	-3.127	0.296	2.163	0.777	4.121	2.380
	St. Dev	0.923	0.515	1.111	0.626	1.177	0.604	0.733	0.891	0.531	1.264
Light Industrial	Mean	5.019	-1.328	-1.065	-0.574	-2.650	0.783	2.344	1.994	5.591	2.238
	St. Dev	0.741	0.828	0.957	0.828	0.667	0.694	0.764	1.041	0.769	0.590
Transportation	Mean	3.935	-1.229	-1.271	-0.687	-3.011	0.345	2.806	1.902	4.783	1.261
	St. Dev	0.834	0.992	0.608	0.749	1.056	0.654	1.116	0.631	1.040	0.998
Multi-Family Residential	Mean	3.144	-1.788	-1.208	-0.180	-2.932	0.346	1.768	0.812	3.965	2.124
	St. Dev	0.920	0.728	0.886	0.930	1.102	0.556	0.576	0.985	0.707	1.119
Single Family Residential	Mean	4.178	-1.170	-1.248	-1.219	-3.198	0.734	1.869	1.762	2.392	1.440
	St. Dev	1.026	0.640	0.964	1.274	1.191	0.747	0.783	0.997	1.085	0.570
Agriculture (Ventura County)	Mean	6.754	0.990	0.338	2.519	-2.120	1.948	2.839	3.015	3.252	3.666
	St. Dev	0.551	0.469	0.712	0.460	0.000	0.380	0.536	0.763	0.847	0.689
Vacant / Open Space	Mean	3.342	-3.060	-3.075	-0.033	-3.976	-0.458	-2.573	-1.246	1.293[1]	1.864
	St. Dev	1.859	1.064	0.811	0.548	0.459	0.784	1.505	1.616	1.312	0.226
Golf Course	Mean	4.649*	-0.705*	-1.031*	-0.397*	-3.976+	1.058	-2.573+	-1.246+	1.293+	1.864+
	St. Dev	0	0	0	0	0.459+	0	1.505+	1.616+	1.312+	0.226+

[1] Dissolved zinc for open space was estimated from the total zinc analysis of LADPW monitoring data. Four data points for dissolved and total zinc from the National Stormwater Quality Database gave an average ratio of dissolved to total zinc of 50 percent. For the open space land uses the variation of dissolved zinc was assumed to equal that of total zinc (i.e. same standard deviation) and the lognormal mean was set to give an average concentration of 8.6 ug/L for the open space land use, half of the average total zinc concentration of 17.2 ug/L.

* Developed through literature review of golf course runoff quality.

+ Used same EMC as vacant/open space to represent golf course runoff quality

Table 1-11: Resulting Arithmetic Means from Lognormal Statistics for Modeling Pollutant Concentrations[1]

Land Use	TSS	TP	NH3	NO3	NO2	TKN	Diss Cu	Tot Pb	Diss Zn	Cl
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L
Commercial	63.5	0.364	0.913	0.505	0.115	2.81	11.5	9.55	152	44.5
Education	92.1	0.289	0.295	0.575	0.088	1.61	11.4	3.23	70.9	24.0
Light Industrial	151	0.265	0.345	0.563	0.071	2.19	10.4	7.34	268	9.38
Transportation	72.4	0.478	0.338	0.666	0.086	1.75	30.8	8.17	205	5.80
Multi-Family Residential	35.4	0.218	0.442	1.29	0.098	1.65	6.92	3.66	67.7	15.6
Single Family Residential	110	0.381	0.457	0.665	0.083	2.75	8.81	9.57	19.7	4.97
Agriculture (Ventura County)	998	3.00	1.81	13.8	0.120	7.54	19.7	27.3	37.0	49.6
Vacant / Open Space	159	0.083	0.064	1.12	0.021	0.860	0.237	1.06	8.61	6.62
Golf Course	104	0.494	0.357	0.672	0.021	2.88	0.237	1.06	8.61	6.62

[1] Calculated from values provided in Table 1-10: Lognormal Statistics for Modeling Pollutants Concentrations from Land Uses. - all footnote comments from Table 1-10 apply.

1.2.5. Estimate of BMP Performance Parameters

BMP performance is a function of three factors: (1) the fraction of stormwater runoff receiving treatment (often referred to as percent of runoff captured, or simply percent capture); (2) the pollutant removal achieved in the unit by virtue of infiltration and/or evapotranspiration (generically referred to as volume reduction); and (3) the pollutant removal achieved in the treatment unit by virtue of improved water quality. Newhall Ranch has committed to designing stormwater BMPs to capture and treat at least 80 percent of the stormwater runoff volume on an average annual basis.

Capture efficiency calculations used to estimate results for the individual storms and volume reduction estimates are discussed in Section 1.2.5.1. Pollutant removal estimates are described in Section 1.2.5.2.

1.2.5.1. BMP Capture Efficiency

The modeled structural BMPs were analyzed as flow or volume-based. Different methods were used to calculate the capture efficiency of each type of BMP as discussed below.

1.2.5.1.1. Volume-based BMP Capture Efficiency

The volume-based BMP that is included in the Newhall Ranch Project is the extended detention water quality basin. The capture efficiency is calculated by first running the GeoSYNOP program that provides descriptive statistics of storm events based upon analysis of hourly rainfall records. Included in these statistics is the dry time between storms. This information, along with the storm depths and drainage rates of the volume based BMPs, was used to estimate the percent capture of the volume-based BMPs for each storm in the period of record. The percent capture calculations for volume-based BMPs required the following steps.

Step 1 – Estimate Runoff Volumes for Each Storm in the Period of Record Modeled
The runoff volume for each storm in the period of record (538 storms) was calculated for the tributary area draining to each BMP.

Step 2 – Determine the BMP Storage Capacity
Next, the available storage capacity of the BMP was calculated for each storm. If the time from the preceding storm was equal to or larger than the drawdown time of the BMP (48 hours for DEDBs), then the BMP was considered empty at the time of the storm.

If the time between storms was less than the drawdown time, then the capture volume was calculated to account for the size of the previous storm, the drawdown that occurred during the previous storm, and the drawdown during the dry period between storms. This is done in order

to account for insufficient time for the BMPs to completely empty before the next storm arrived. If the volume of stormwater runoff to the BMP from the previous storm minus the drawdown that occurred during the previous storm was larger than the BMP volume, then the BMP was assumed to be filled completely at the end of the previous storm and the initial storage capacity (*ISC*) in equation 4 is equal to the volume of drawdown that occurred during the dry period between storms.

If the runoff volume (for a storm occurring less than the drawdown time prior to the storm of interest) was less than the storage capacity of the BMP, then the difference between the storage capacity of the BMP and the volume remaining in the BMP after the previous storm plus the volume of drawdown that occurred during the dry period between storms was considered available to capture runoff from the next storm. This volume is then added to the storage capacity created from outflow from the basin during the time of the storms as shown in equation 4.

$$TC = ISC + [BV \times DD \times T] \qquad (4)$$

Where:

- TC = the treatment capacity (ft^3) of a volume-based BMP available to capture runoff over the duration of a storm
- ISC = the initial storage capacity for storm of interest (ft^3)
- BV = the BMP volume (ft^3)
- DD = the draw down rate of a volume-based BMP in percent per hour (hr^{-1}) [2.08% per hour for a 48 hour draw down time]
- T = the storm duration (hr)

The above equation accounts for storage capacity that is created during emptying of the BMP while a storm occurs. That is, during long duration storms more runoff can be processed through the BMP than for a short storm of comparable rainfall intensities and runoff rates. This method has produced percent capture results that consistently are in close agreement with the overall results from EPA's Stormwater Management Model (SWMM), which are used to verify the results from this method.

Step 3 – Determine BMP Percent Captures for Storms

The storage capacity estimated from step 2 is compared to the runoff volume estimate from step 1. If the storage capacity exceeds the storm runoff volume then the storm is considered to be completely (100%) captured. If the storage capacity is less than the runoff volume, a volume of runoff equal to the storage capacity is considered treated by the BMP. The excess volume is assumed to bypass the BMP and enter the receiving water untreated.

1.2.5.1.2. Flow Based BMP Capture Efficiency

The flow based BMPs (swales) are sized to treat a flow capacity exceeding the LA County SUSMP sizing requirements in order to achieve treatment of approximately 80% of the stormwater runoff. Off-line swales (swales with a diversion structure for flows up to the swale treatment capacity) that provide treatment even when a fraction of the runoff is bypassed achieve higher capture efficiency than in-line swales. The following steps were followed in estimating the percent capture for flow based BMPs.

Step 1 – Estimate the Depth of Runoff Captured on an Hourly Basis

The percent capture estimate for each storm is made through comparison of the hourly rainfall data comprising the storm event to the design rainfall intensity of the flow-based BMP. For off-line BMPs, if the depth of rainfall for a given hour exceeds the design rainfall intensity, then no treatment is credited for the rainfall above the design intensity (0.3 inches per hour). If the design capacity (in inches per hour) of the BMP meets or exceeds the depth of rainfall occurring in a given hour, then all of the resulting runoff during that hour is considered captured by the BMP.

Step 2 – Sum the Depth of Rainfall Capture for Each Storm Event

The depth of rainfall captured for each hour of rainfall during the storm event is then summed to give the total depth of rainfall considered captured by the BMP for the storm of interest.

Step 3 – Calculate the Percent Capture for Each Storm Event

The depth of rainfall captured during a given storm event is divided by the total depth of the storm to give the percent capture for the storm event that is used in the water quality model input.

Note that because flow-based BMPs are designed based on rainfall intensity and because a non-variable runoff coefficient method is used to convert rainfall to runoff over each catchment, the runoff characteristics of the catchment do not need to be known to calculate capture efficiency at the design stage. Rather, capture efficiency is based on a comparison of design rainfall intensity to measured rainfall intensity.

1.2.5.1.3. BMP Volume Reductions

The volume reduction achieved by a BMP is a function of the capture efficiency and the fraction of captured stormwater runoff that is infiltrated, evaporated, or transpired by vegetation.

Data in the International BMP Database have shown that as much as 30 percent of stormwater volume captured by dry extended detention basins and 35 percent captured by swales can be lost to infiltration (Strecker et al., 2004) which indicates that this may be an important mechanism that should be included in the water quality analysis. Evapotranspiration is expected to occur in vegetated basins and swales but is anticipated to be much less significant than infiltration and was not included in the volume reduction estimates.

BMPs specifically designed to infiltrate stormwater runoff (e.g. bioretention) were not included in the modeled stormwater management system for the Newhall Ranch Specific Plan water quality assessment, although bioretention will be included on the project level. Bioretention areas are expected to reduce captured stormwater runoff volumes by 90 percent or more, primarily through infiltration with smaller volume reductions occurring due to evapotranspiration. The large reduction in captured stormwater runoff volumes will not only achieve greater reductions in pollutant loads than water quality basins and swales, but will also provide significant benefits for minimizing potential receiving water impacts due to hydrologic changes (i.e. increased runoff volumes). As mentioned previously, the bioretention BMPs were not simulated in the water quality model as the planning level detail required for incorporating these BMPs into the project areas is largely unavailable at this time. The Newhall Ranch Specific Plan results are therefore conservatively based by modeling DEDBs and swales which have lower volume reductions.

1.2.5.2. BMP Pollutant Removal

Various data sources were examined to estimate the anticipated performance of the treatment BMPs. A comprehensive source of BMP performance information is the American Society of Civil Engineers (ASCE) International Stormwater BMP Database (ASCE, 2001, Strecker et al., 2001). The ASCE BMP database is comprised of carefully examined data from a peer-reviewed collection of studies that have monitored the effectiveness of a variety of BMPs in treating water quality pollutants for a variety of land use types. The mean effluent water quality for treatment BMPs used for modeling purposes was based on values found in the International Stormwater BMP Database (ASCE/EPA, 2004). Recent work in characterizing BMP performance suggests that effluent quality rather than percent removal is more reliable in modeling stormwater treatment (Strecker et al. 2001).

To match site conditions, the BMP database studies were screened to exclude studies where BMP design or function was believed to result in significantly lower performance than the BMP design criteria that will be met for the Newhall Ranch Project BMPs. For example some of the detention basin studies had significantly lower maximum detention times than the 48 hour criteria for the water quality basins. The water quality data for detention basins with a drawdown time of less than 9 hours were excluded from the data set used to predict detention basin performance. Certain studies in the detention basins category were not considered comparable in function to the dry-extended detention basin that will be incorporated into the Newhall Ranch Project treatment system. Detention basins that were listed as either underground vaults or settling chambers were also excluded.

As with the estimation of land use EMCs, final effluent values to be used in modeling analysis were determined using a combination of regression-on-order statistics and the “bootstrap” method (see Section 1.2.4.3).

Once the BMP sites had been screened for design criteria, the normality and lognormality of all BMP effluent sample data sets were tested using the Shapiro-Wilk goodness-of-fit test (Royston 1992). The majority of the pollutant data fit a lognormal distribution. The data that did not statistically fit the lognormal distribution were more closely approximated with a lognormal distribution than a normal distribution. The bootstrap method was applied differently depending on the distributional fit of the data. If the data fit a lognormal distribution, the log-transformed data were bootstrapped and an estimate of the mean and standard deviation were obtained in log space and then converted to arithmetic space. The assumption of lognormality was more stringently applied than normal by using an alpha significance value of 0.1. This was done to improve the estimate of the standard deviation when the assumption of lognormality fails. When analyzing data in log space there is a tendency to overestimate the standard deviation for relatively symmetric data and underestimate the standard deviation for severely skewed data. For datasets that did not fit the lognormal distribution, the raw data were bootstrapped to obtain mean and standard deviation values. Bootstrapping the data in arithmetic space assumes no distribution in those instances when a distribution could not be confirmed through goodness-of-fit testing.

Table 1-12 shows the lognormal effluent quality descriptive statistics and corresponding arithmetic means for detention basins and swales. These values were estimated using the above procedure on the ASCE/USEPA International BMP Database data (ASCE, 2003). Note that sufficient data were not available for nitrite-N or ammonia for detention basins, and removal of these pollutants was not simulated. Chloride removal was not simulated in either of the treatment BMPs.

Table 1-12: Summary of Lognormal Effluent Quality Statistics & Arithmetic Mean Effluent Quality for Modeled BMPs.

	Lognormal Modeling Parameters				**Arithmetic Means**	
	Detention Basins		**Swales**		**Detention Basins**	**Swales**
Pollutant	Mean	St Dev	Mean	St. Dev		
TSS	3.503	0.709	3.089	0.821	42.7	30.7
Total P	-1.262	0.553	NA	NA	0.330	NA
NH3	NA	NA	NA	NA	NA	NA
NO3	-0.346	0.671	-1.394	1.108	0.886	0.459
NO2	NA	NA	NA	NA	NA	NA
TKN	0.460	0.522	0.336	0.593	1.81	1.67
Dissolved Cu	NA	NA	1.756	0.776	NA	7.82
Total Pb	3.000	0.931	1.402	1.314	31.0	9.64
Dissolved Zn	3.786	0.705	3.231	0.714	56.5	32.6

NA - not available

BMP effectiveness studies in the International BMP database infrequently monitor aluminum therefore insufficient effluent data were available to model the removal effectiveness of treatment control BMPs for this water quality constituent. In order to estimate the reduction in total aluminum load and concentration (dissolved aluminum was assumed to pass through BMPs without removal), TSS removal was used as a surrogate.

Due to lack of aluminum monitoring data, it was necessary to simulate treatment for total aluminum using percent removal rather than the preferred BMP effluent concentration. TSS removal was modeled using BMP effluent concentrations for detention basins and swales and stormwater runoff concentrations for commercial, residential, and transportation land use; the most prevalent land uses in the Newhall Ranch Project. Detention basins and swales were found to remove, on average, 54% and 61% of the total TSS, respectively. The average fraction of total aluminum in dissolved form was 23% when averaging the available stormwater monitoring data from LADPW. The particulate fraction of total aluminum (77%) was multiplied by the percent removal for TSS to derive the reduction in total aluminum for detention basins (42%) and swales (47%).

It is possible that particulate aluminum is not uniformly distributed among the range of particle sizes and that the smaller particles with a higher ratio of surface area have a higher fraction of aluminum sorbed to these particles. However, it is also possible that dissolved aluminum could be sorbed to particulates within the treatment BMP affecting some removal of the dissolved fraction of aluminum. To best account for the variability in particulate and dissolved aluminum, the removal efficiency of total aluminum was modeled assuming no removal of dissolved aluminum and a uniform distribution of particulates for removal of particulate aluminum. The overall effectiveness for total aluminum was about 35% when taking into account the average annual 80% capture efficiency of the treatment BMPs.

1.2.6. Model Parameter Reliability & Assumptions

The input parameters for the water quality model fall into the following five main categories:

- Rainfall data;
- Runoff Coefficients;
- Land Use data;
- Stormwater pollutant EMCs; and
- BMP performance estimates.

Each of the categories of input data is evaluated for accuracy in reflecting the project site conditions:

<u>Rainfall Data:</u> A limited period of record (about 12 years of hourly data) is available from the Castaic Junction gauge monitored by the LADPW. The Castaic Junction gauge is nearer to the project site and consistently measures precipitation amounts lower than recorded at the Newhall

gauge. However, the limited period of hourly data collected at the Castaic Gauge is insufficient for water quality modeling and the rainfall data collected at the Newhall gauge was used. The rainfall data from the Newhall gauge are believed to overestimate the average annual rainfall by about 3 inches per year resulting in a conservative estimate of stormwater runoff volumes and changes in average annual volumes resulting from development. The San Fernando gauge which was used to fill in missing periods in the Newhall gauge measures only slightly lower average rainfall depths than the Newhall gauge and the data used from this gauge were corrected to account for this small difference. Thus the use of San Fernando gauge data to fill gaps in the Newhall record results in a more accurate representation of actual rainfall and does not significantly bias estimates of runoff volume or concentration.

Runoff Coefficients: The estimation of runoff coefficients, described in Section B.2.2, is highly dependant on soil properties (i.e. infiltration potential) and less dependent on parameters such as ET rates, slopes, and surface roughness. Soil properties are estimated as accurately as possible from available data such as soil surveys and site specific geomorphology studies. The result is estimates for runoff coefficients that may somewhat overestimate or underestimate stormwater runoff. The net result on the water quality model is that this parameter is not conservatively estimated; however, it is estimated as accurately as the available information permits. When combined with the overestimate of average annual rainfall and land use percent impervious values (discussed below), stormwater runoff volumes are somewhat conservatively predicted.

Land Use Data: Land use data is generally considered a relatively accurately quantified input parameter. The land use data for the developed conditions can be use to classify land use type and compute area. The percent impervious values used in the water quality model for the urban land uses in the developed project condition are based upon the values listed in the LA County Hydrology Manual (2006). The percent impervious values assigned to types of urban land uses may slightly overestimate imperviousness for some land uses because the Manual is intended for drainage and flood control analysis of large storm events. However on a whole the Hydrology Manual values are generally considered to be a fairly accurate quantification of impervious where detailed site designs are not available. The emphasis of modeling efforts described herein is to quantify imperviousness as accurately as possible without intentionally incorporating conservatism.

Stormwater Pollutant EMCs: Stormwater pollutant EMCs are estimated from monitoring data collected by the LADPW from land use characterization stations and generally do not have site design and source control BMPs that will be implemented for the Newhall Ranch Project. Therefore the stormwater pollutant EMCs estimated from the LADPW data are probably slightly conservative compared to the pollutant concentrations in stormwater runoff that will occur from the developed conditions of the project site.

BMP Capture Efficiency & Effluent Concentrations: Stormwater capture efficiency estimates were calculated in Excel spreadsheets and calibrated with continuous simulation to provide

results on a storm-by-storm basis for input into the water quality model, to accurately reflect the anticipated performance of the structural stormwater BMPs.

BMP effluent concentrations are based on studies contained in the International BMP database. These studies are screened to remove data for undersized (i.e., inadequate design criteria) BMPs that are likely to have pollutant removal performance substantially less than the BMPs to be constructed for the Newhall Ranch Project. This screening is believed to improve the accuracy of BMP performance estimates; however it is only intended to remove BMPs that are clearly unrepresentative in terms of sizing. The screening process is intended to include BMPs with adequate performance that may not be as well designed or maintained as the structural BMPs that will be part of Newhall Ranch Project. It is anticipated that the BMPs for the Newhall Ranch Project will perform as well, if not slightly better than, the projected performance based on the database. A major issue in the use of the International Database is representativeness for semi-arid climates. In this respect the database contains sites from different climates, but does include a number of sites from semi-arid climates, including data for over 40 sites studied by Caltrans.

Conclusions: The runoff coefficient, land use type and area, land use percent imperviousness and BMP performance model input parameters are thought to be reasonably accurate representations of the site conditions and do not increase the conservativeness of the water quality model. The rainfall data and stormwater pollutant EMC estimates are believed to result in conservative estimates of stormwater runoff volumes, pollutant concentrations and therefore pollutant loads. Overall the predevelopment model input parameters likely result in a slight underestimation of estimated loads and concentrations in the existing condition. The water quality estimates for the developed project condition are also believed to be conservative (i.e., tend to overestimate loads and concentrations) due to pollutant concentration estimates, and BMP performance estimates that in general do not include the benefits of site design or source control BMPs that are planned to be implemented in the Newhall Ranch Project.

1.3. Model Methodology

A Monte Carlo simulation method was used to develop the statistical description for storm water quality. In this approach, the storm water characteristics from a single rainfall event are first estimated. The rainfall depth was determined by randomly sampling from the historical rainfall depth frequency distribution. Similarly, an EMC was determined by randomly sampling from the frequency distribution of EMCs. The rainfall volume and EMC were used to determine runoff volume, pollutant concentration, and pollutant load of the single storm event. BMP volume reduction and performance (effluent quality), determined by randomly sampling from the developed frequency distributions, were used to calculate the pollutant removal resulting from treatment in the BMP system. This procedure was then repeated thousands of times (20,000), recording the volume, EMC and load from each randomly selected storm event, including treatment for the developed project condition. The statistics of these recorded results provide a

description of the average characteristics and variability of the volume and water quality of storm water runoff.

- Total Suspended Solids (sediment)
- Total Phosphorus
- Ammonia
- Nitrate
- Nitrite
- Total Nitrogen[1]
- Dissolved Copper
- Total Lead
- Dissolved Zinc
- Chloride

The steps in the Monte Carlo Water Quality Model are as follows:

1. Develop a statistical description of the number of storm events per year, and randomly select a number N_{storms}.
2. Estimate the volume of storm runoff for each land use area from a randomly selected storm event.
3. Randomly select a pollutant concentration in storm runoff for each land-use area and each pollutant.
4. Calculate the total runoff volume, pollutant load, and concentration in runoff from the modeled portion of the project, for both existing and developed conditions.
5. Calculate a total annual pollutant load by repeating steps 2-4 N_{storms} times, where N_{storms} is the number of storms per year, randomly selected in step 1.
6. Repeat steps 1 - 6 a total of 20,000 times for each pollutant modeled, recording the estimated pollutant concentration and annual load for each iteration.
7. Develop a statistical representation (mean annual value) of the recorded storm water pollutant loads and concentrations.

Each of the seven steps is described below.

[1] TKN is modeled, but the results are not reported. Total Nitrogen results are reported from the sum of nitrate, nitrite, and TKN.

1.3.1. Storms & Stormwater Runoff (steps 1 & 2)

Step 1 – Statistical Representation of Number of Storm Events per Year

Number of Storms per Year
The number of storm events per year was calculated for the 35 complete years in the available period of record from 1969 – 2003. The modeled average number of storm events per year (> 0.1 inches) was 15.4, with a standard deviation of 6.2. Figure 1-11 illustrates a frequency histogram of the number of storm events per year at the Newhall gauge. The number of storm events per year was modeled with a normal distribution. In the simulation, the number of storms per year was determined by randomly sampling from the normal distribution and rounding to the nearest whole number, using the equation:

$$N_{storms} = 15.4 + 6.2\ R_N$$

where:
R_N = a standard normal variant with a mean of 0 and a standard deviation of 1.

If the arbitrary number of storms per year was zero or negative, then the normal distribution was re-sampled until a positive number was obtained.

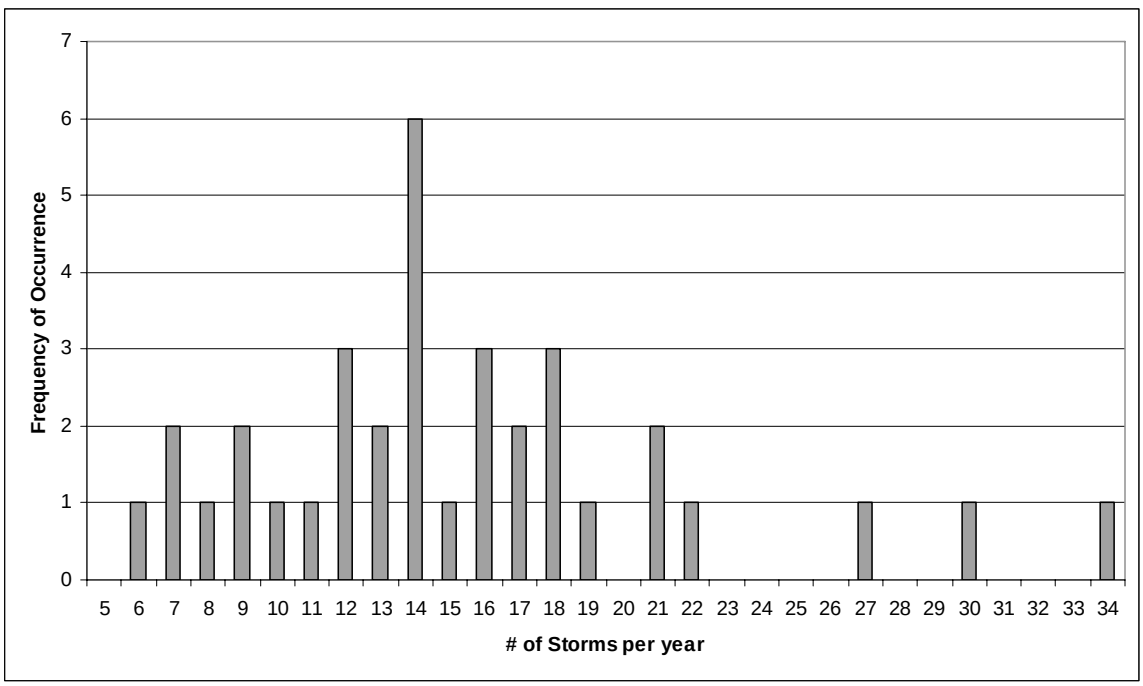


Figure 1-11: Distribution of Storms per Year at the Newhall Gauge

Step 2 – Estimate the Volume of Storm Runoff from a Storm Event.
The runoff volume from each storm was estimated using the following equation:

$$V = R_v P A \qquad (5)$$

where:

V = the stormwater runoff volume (ft^3)

P = the rainfall depth of the storm (ft)

A = the drainage area (ft^2)

R_v = the mean volumetric runoff coefficient, a unit-less value that is a function of the imperviousness of the drainage.

For sub-basins that contain multiple land-use types, the total stormwater runoff volume is determined as the sum of runoff from each land-use type:

$$V_{wshed} = \Sigma_{lu} V_{lu} = \Sigma_{lu} (R_{v\,lu} PA_{lu)} \qquad (6)$$

where *lu* designates the land-use type. It is assumed that rain falls uniformly over all land-uses in the sub-basin.

The steps used to calculate the volume of runoff from a randomly selected storm event were:

Step 2a Obtain a rainfall depth by randomly sampling from the 538 storm events.

Step 2b For each land-use area calculate a runoff volume using equation (5). The same rainfall depth is applied to each land-use area.

Step 2c Sum the runoff volumes from each land-use area to obtain the total runoff from the watershed for a particular storm event with equation (6).

1.3.2. Pollutant Loads & Concentrations (step 3 & 4)

Step 3 – Estimate a Pollutant Concentration in Storm Runoff from Each Land Use Area

Runoff Concentration

The distribution of land use-based pollutant concentration in storm runoff was developed based on the process described in Section B.2.4.3. For each storm event, stormwater EMCs were sampled randomly for each modeled land use and water quality parameter. The runoff concentration from each land-use area was evaluated with the expression:

$$C_{land-use} = \exp\left(\mu_{\ln x} + \sigma_{\ln x} R_N\right) \qquad (7)$$

where:

$\mu_{\ln x}$ = the log-normal mean

$\sigma_{\ln x}$ = the log-normal standard deviation

R_N = a standard normal random variable

Step 4 – Calculate the Total Runoff Volume, Pollutant Load, and Pollutant Concentration in a Storm Event

Step 4A - The total runoff volume in the watershed was calculated with equation (6) as discussed in Step 2:

$$V_{wshed} = V_{land-use1} + V_{land-use2} + \ldots + V_{land-usei} \quad (8)$$

where the same randomly selected rainfall event was used to calculate runoff volume in each of the land-use areas.

Step 4B - The total pollutant load from the watershed was calculated by:

$$L_{wshed} = V_{land-use1} C_{land-use1} + \ldots + V_{land-usei} C_{land-usei} \quad (9)$$

where the concentration in each individual land-use area was calculated with equation (7) discussed in step 3.

Step 4C - The average pollutant concentration in runoff from the entire watershed from a single storm event was calculated by dividing the total watershed load (Step 4B) by the total watershed runoff volume (Step 4A):

$$C_{wshed} = L_{wshed} / V_{wshed} \quad (10)$$

Model steps up to 4C (Eq 10) were used in the model calculations for catchments with and without modeled BMPs. The resulting values from Equation 9 and Equation 10 represent the end model output for catchments without modeled BMPs and represent intermediate calculations for catchments with modeled BMPs

Catchments with treatment BMPs used additional calculations to determine the reduction in pollutant load and concentration achieved with treatment BMPs. The fraction of stormwater runoff receiving treatment was calculated for each storm event, using the capture efficiency associated with that event, as described in Section B.2.5. BMP performance was modeled using a randomly selected effluent concentration achieved within the BMP for each water quality pollutant.

Step 4D - The total pollutant load from watersheds with treatment BMPs was calculated by:

$$L_{wshed_BMPs} = \left[Cap_{\%} \times V_{wshed} \times C_{eff} \times (1 - VR\%)\right] + \left[(1 - Cap_{\%}) \times V_{wshed} \times C_{wshed}\right] \quad (11)$$

where:

$Cap_{\%}$ is the volumetric percent capture of the BMP.

C_{eff} is the randomly determined effluent concentration from the BMP. C_{eff} was determined from sampling from the lognormal distribution described by the parameters contained in Table B-16.

$VR\%$ is the percent reduction in effluent volume achieved by the BMP (see Section B.2.5.1.3).

V_{wshed} and C_{wshed} were calculated per Steps 4A and 4C, respectively

Step 4E - The average pollutant concentration in runoff from the entire watershed with treatment from a single storm event was calculated by dividing the total watershed load with treatment by the total watershed runoff volume less the volume lost in BMPs:

$$C_{wshed_BMPs} = L_{wshed_BMPs} / V_{wshed_BMPs} \quad (12)$$

where:

$$V_{wshed_BMPs} = V_{wshed} \times \left[1 - \left(Cap_{\%} \times VR\%\right)\right] \quad (13)$$

The results of step 4D (Eq 11) and step 4E (Eq. 12) were used to compute model results for developed conditions with treatment.

Figure 1-12 provides a diagrammatic representation of these water quality calculations.

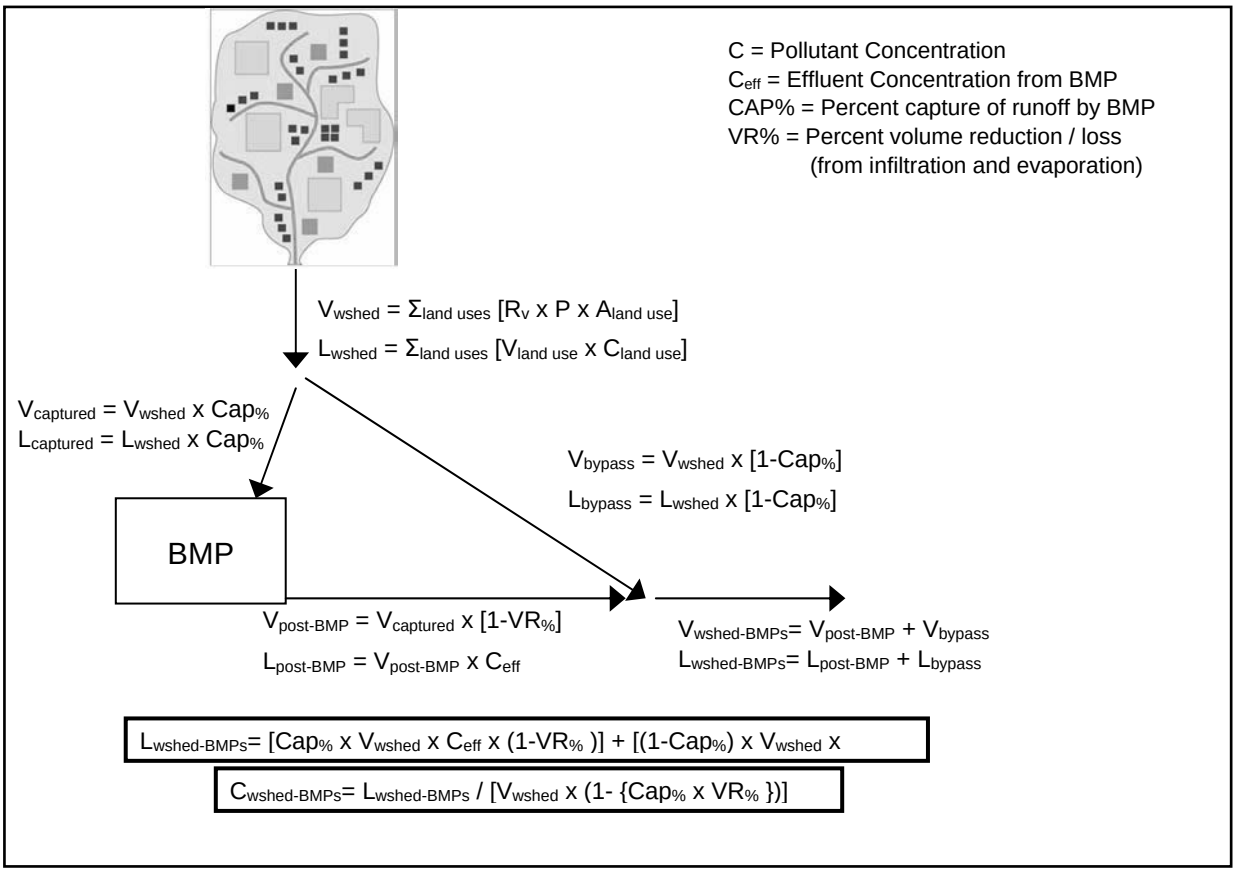


Figure 1-12: Diagrammatic representation of water quality calculations.

1.3.3. Annual Pollutant Loads, Concentrations, and Distributions (steps 5, 6, & 7)

Step 5 – Calculate a Total Annual Pollutant Load
The annual pollutant load is simply the sum of pollutant loads generated from all storms in a given year, based on the random selection described in Step 1. Therefore, steps 2-4 were repeated N_{storms} times (where N_{storms} was randomly selected per step 1), recording the total pollutant load from each randomly selected storm event. The individual storm loads were summed to obtain the total annual pollutant load.

Step 6 & 7 – Determine Distribution of Storm Concentration and Annual Loads
Steps 1-5 were repeated a total of 20,000 times, recording the pollutant concentration and annual load from each iteration. The resultant distributions can be used to present a frequency distribution for pollutant concentrations or loads using statistics calculated from the 20,000 Monte-Carlo iterations.

1.3.4. Model Methodology Assumptions

The following five key assumptions are made for the Monte Carlo water quality modeling methodology:

1. The assumed probability distributions of model parameters;
2. The assumption of independence between model parameters (i.e. no correlation between randomly determined variables);
3. Assigning a Lower Limit to BMP Effluent Concentrations;
4. Limiting pollutant removals to pollutants with data; and
5. Modeling structural BMPs to only remove pollutants and not acting as a source.

The implications of each of these assumptions to the water quality projections are discussed below.

<u>1) Distribution Assumptions</u>: Probability distributions are assumed to represent the number of storms per year, stormwater pollutant concentrations, and BMP effluent concentrations. Observed rainfall data (i.e., storm frequency) and stormwater monitoring data are fit with either a normal or lognormal distribution using standard statistical procedures. The values of storms per year, rainfall depth, runoff pollutant concentration, and BMP effluent concentrations used in given iteration in the Monte Carlo analysis are governed by the selected distributions. Large samples of these estimated variables will approximate the assumed distributions, and will have the same mean and variance that was observed in the rainfall and monitoring data. The following describes the distributions for various input parameters.

Storms per Year: Figure 1-11: Distribution of Storms per Year at the Newhall Gauge shows the number of storms per year occurring at the Newhall rain gauge (augmented with data from the San Fernando gauge). The number of storms occurring per year at the Newhall gauge appears to lie between the normal and lognormal distributions. The normal distribution was used to

determine the number of storms per year simulated in the water quality model, as use of the lognormal distribution would overestimate the average annual rainfall, as well as its variability, when the distribution of the data is not heavily skewed. As discussed in Section 1.2.6, use of rainfall data collected at the Newhall gauge already tends to overestimate the average annual rainfall for the Project site. When using the normal distribution to randomly determine the number of storm per year, the resulting average annual rainfall output from the water quality model is typically in the range of 17.9 to 18.0 inches per year. This is in close agreement with the average annual rainfall from runoff producing storms of 17.9 inches determined directly from the rainfall data (see Table 1-1).

Stormwater Pollutant Concentrations: The Shapiro-Wilk Test was used to determine the statistical distribution that best represents the raw stormwater runoff monitoring data collected in Los Angeles and Ventura Counties. In most instances the data were found to be log-normally distributed at a confidence level of 0.10. In some instances, the data were not well fit by either the normal or lognormal distributions, but were found to be more closely approximated by the log-normal distribution. For data sets with greater than 50 percent non-detects or that were not log-normally distributed according to the Shapiro-Wilk test, data were analyzed (ROS and bootstrap) in arithmetic space as to not unreasonably overestimate the standard deviation of the data set. Since stormwater pollutant concentrations, in general, tend to be well approximated by the lognormal distribution (Helsel and Hirsh, 2002), the data sets that did not meet the lognormal criterion are still believed to belong to a log-normally distributed population, but the number of data points is too few to statistically confirm that this is the case. Therefore, simulations of stormwater concentrations in the water quality model were still conducted in lognormal space. This assumption is believed to result in a more accurate prediction than would the application of the normal distribution.

BMP Effluent Concentrations: Goodness-of-fit tests conducted on the raw BMP effluent monitoring data from the International BMP Database with the Shapiro-Wilk Test either resulted in (1) confirmation of the appropriateness of the lognormal distribution for the data; or (2) in the instances when the data did not meet the significance criteria of a p value > 0.1, that the data were more closely approximated with the lognormal distribution than the normal. The use of the lognormal distribution to represent BMP effluent concentrations results in higher average estimates of BMP effluent concentration. This is believed to be a more accurate estimation of BMP performance than use of the normal distribution, and is considered a more conservative assumption (leading if anything to higher than anticipated effluent concentrations).

2) <u>Assumption of No Correlation between Model Parameters</u>: The water quality model randomly samples for stormwater pollutant concentrations independent of the storm depth or antecedent dry period. The validity of this assumption is supported by analyses conducted by Environmental Defense Sciences (2002) who did not find a strong correlation between rainfall volume and event mean concentrations (EMCs) in the LA County data for the education land-use site. Data analyses for the single family residential land use were found to be weakly correlated

(R^2 of 0.6 ± 0.1) for some pollutants with storm depth; however some pollutant showed little correlation between these variables. Where weak correlations were present, stormwater pollutant concentrations decreased with storm size

Correlations between pollutant concentration and antecedent dry period were similarly variable. For the single family land use correlations between pollutant concentration and antecedent dry period were moderately significant for a few pollutants (R^2 of 0.8 ± 0.03), and weak for other pollutants. Correlations between pollutant concentration and antecedent dry period varied widely for the educational and multi-family land uses.

The results of these analyses indicated that no consistent level of correlation was determined between the stormwater EMCs and the rainfall depth or the antecedent dry period where a significant correlation was found to exist; most pollutants and land-uses showed weak correlations or no correlation. On this basis, stormwater pollutant concentrations are sampled independent of storm depth and antecedent dry period in the water quality model.

Effluent concentrations are considered more reliable estimator of treatment performance than percent removal (Strecker et al. 2001). BMP effluent concentrations were sampled independently of stormwater concentrations (i.e. influent concentration to the BMP) in the water quality model. As with the pollutant EMCs, independent sampling of effluent concentrations preserves the mean and standard deviation in the monitoring data.

3) <u>BMP Performance – Irreducible Pollutant Effluent Concentrations</u>: When sampling from the lognormal distribution to estimate BMP performance with an effluent concentration it is possible to select values approaching or equal to zero. While well functioning BMPs are capable of achieving high rates of pollutant removal, it is generally accepted that BMPs cannot completely remove pollutants from the water column. In effect BMPs, at best, can achieve what is called an "irreducible pollutant concentration" (Schueler, 1996). In an effort to prevent overestimating BMP performance in the model, lower limits were set for the effluent concentrations of each modeled pollutant and BMP. The lowest observed effluent value in each pollutant data set was used as the irreducible pollutant effluent concentration in the water quality model.

4) <u>BMP Performance – Limiting Pollutant Removal Estimates to Available Data</u>: Table 1-12: Summary of Lognormal Effluent Quality Statistics & Arithmetic Mean Effluent Quality for Modeled BMPs. presents model parameters for estimating BMP pollutant effluent concentrations. Pollutant removal is only simulated for those pollutants with available data from the International BMP Database. In instances where data is not available for a parameter, no treatment is assumed for that parameter. This does not prevent the model from calculating load reductions of the pollutant as a result of hydrologic source control.

5) <u>BMP Performance – BMPs are not a Source of Pollutants</u>: In instances when the randomly determined BMP effluent concentration exceeds the modeled influent concentration, no pollutant

removal occurs and the effluent concentration is modified to equal the influent concentration. This prevents BMPs from acting as a source of pollutants in the water quality modeling. The commitment to regular and effective maintenance of the stormwater BMPs provides support for this assumption.

Conclusions: The above assumptions are expected to improve the accuracy of the water quality model estimates. The net result for the model outputs are somewhat conservative estimates of pollutant loads and concentrations due to estimation of model input parameters that are not compromised by the model methodology.

1.4. Model Reliability

Factors that affect model reliability include variability in environmental conditions and model error. To account for environmental variability, a statistical modeling approach was used that takes into account the observed variability in precipitation from storm to storm and from year to year. The model also takes into account the observed variability in water quality from storm to storm, and for different types of land uses. One way to express this variability is the coefficient of variation (COV) which is the ratio of the standard deviation of the variable to the mean value. Based on the statistical model, the range of COVs for pollutant loads was from 0.5 to 0.8 on an average annual basis, depending on the pollutant. This variability, or greater, is expected in typical storm water runoff.

Model error relates to the ability of the model to properly simulate the processes that affect storm water runoff, concentrations, and loads. Ideally model error is measured through calibration, but calibration is not feasible when considering a future condition. We are confident that the model is a reasonable reflection of storm water processes because the model relies largely on measured regional data. For example, the runoff water quality data are obtained from a comprehensive monitoring program conducted by LA County that has measured runoff concentrations from a variety of land use catchments and for a statistically reliable number of storm events. In addition parameter estimation is fairly conservative resulting in moderately conservative estimates of pollutant concentrations and loads.

1.5. References

ASCE/EPA (American Society of Civil Engineers Urban Water Resources Research Council and United States Environmental Protection Agency) 2003, International Stormwater Best Management Practices Database (www.bmpdatabase.org).

Devore, J.L. (1995). *Probability and Statistics for Engineering and the Sciences. Fourth Ed.* Brooks/Cole Publishing Co., Pacific Grove, CA.

Environmental Defense Sciences, 2002. Memo from Susan Paulson and John List of Environmental Defense Sciences to Dan Hedigan and Sat Tamaribuchi of the Irvine

Company, regarding Preliminary review of Northern Sphere Area Draft EIR, dated February 20.

Helsel, D.R. and T. A. Cohn 1988. "Estimation of descriptive statistics for multiply censored water quality data." *Wat. Resour. Res.* 24, 1997-2004.

Helsel, D.R. and Hirsch, R.M. (2002). *Statistical Methods in Water Resources*. U.S. Geological Survey, Techniques of Water-Resources Investigations Book 4, Chapter A3. Water Resources Division, USGS. Reston, VA

Hirsch, R.M., and J. R. Stedinger 1987. "Plotting positions for historical floods and their precision," *Wat. Resour. Res.*, 23(4), 715-727

James, W. and R. C. James 2000. Hydrology: A Guide to the Rain, Temperature and Runoff Modules of the USEPA SWMM4. Computational Hydraulics International, Ontario, Canada.

Los Angeles County (LA County), 2006. Los Angeles County Hydrology Manual, Department of Public Works, Alhambra, California

Los Angeles County (LA County), 2000. Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report.

Los Angeles County (LA County), 2001. Los Angeles County 2000-2001 Stormwater Monitoring Report.

Maidment, D.R. (ed.), Handbook of Hydrology. McGraw-Hill Inc., New York, NY (1993).

Royston, P. 1992. "Approximating the Shapiro-Wilk W test for Non-Normality." *Statistics and Computing*; 2:117-119.

Schueler, T., 1987. "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs," Publication No. 87703, Metropolitan Washington Council of Governments, Washington, DC.

Schueler, T. 1996. Irreducible Pollutant Concentrations Discharged from Urban BMPs. *Watershed Protection Techniques*, 1(3): 100-111. *Watershed Protection Techniques* 2(2): 361-363.

Shumway, R.H., Azari, R.S., and Kayhanian, M. 2002. "Statistical approaches to estimating mean water quality concentrations with detection limits." *Environ. Sci. Technol*. 36, 3345-3353.

Singh, A.K., A. Singh, and M. Engelhardt 1997. "The lognormal distribution in environmental applications." *EPA Technology Support Center Issue*, EPA 600-R-97-006.

Strecker, E., Quigley, M., Urbonas, B., Jones, J., and Clary, J., 2001. "Determining Urban Stormwater BMP Effectiveness," *Journal of Water Resources Planning and Management* May/June 2001.

Strecker, E.W., Quigley, M.M., Urbonas, B. and J. Jones., 2004. Analyses of the Expanded EPA/ASCE International BMP Database and Potential Implications for BMP Design, In Proceedings of the World Water and Environmental Resources Congress, Salt Lake City, Utah, American Society of Civil Engineers.

Ventura County Flood Control Department (VCFCD) October, 2003. *Ventura Countywide Stormwater Monitoring Program: Annual Report for Permit Year 3, Reporting Year 9.*

Ventura County Flood Control Department (VCFCD) October, 2002. *Ventura Countywide Stormwater Monitoring Program: Annual Report for Permit Year 2, Reporting Year 8.*

Ventura County Flood Control Department (VCFCD) July 2001. *Ventura Countywide Stormwater Monitoring Program: 2000/01 Monitoring Status Report*

Ventura County Flood Control Department (VCFCD) November 1999. *Ventura Countywide Stormwater Monitoring Program: Annual Report for Permit Year 5*

Ventura County Flood Control Department (VCFCD) November 1998. *Ventura Countywide Stormwater Monitoring Program: Annual Report for Permit Year 4*

Ventura County Flood Control Department (VCFCD) November 1, 1997. *Ventura Countywide Stormwater Monitoring Program: Annual Report for Permit Year 3*

United States Environmental Protection Agency (USEPA), 1989. Analysis of Storm Event Characteristics for Selected Rainfall Gages throughout the United States, Prepared by Woodward-Clyde Consultants: E.D. Driscoll, G.E. Palhegyi, E.W. Strecker, and P.E. Shelley.

APPENDIX C

NEWHALL RANCH STORMWATER MONITORING DATA

March 6, 2000

Newhall Ranch Monitoring Station	Hardness mg/L	Calcium mg/L	Magnesium mg/L	Potassium mg/L	Sodium mg/L	Alkalinity mg/L	Sulfate mg/L	Chloride mg/L	Nitrate mg/L	E.Coli MPN/100 mL	TDS mg/L
A-Mouth of Potrero	2360	324	378	30	1360	400	3690	780	16.1	8160	7530
B-Mouth of San Martinez	1070	229	122	8	392	210	1520	130	2.8	3090	2690
D-Mouth of Middle Canyon	44	11	4	6	9	30	16	3	12.4	133	160
E-Top of Chiquito Canyon	61	18	4	8	13	40	37	9	2.6	213	150

	Boron mg/L	Copper ug/L	Iron ug/L	Manganese ug/L	Zinc ug/L	Aluminum ug/L	Arsenic ug/L	Barium ug/L	Berylium ug/L	Cadmium ug/L	Chromium ug/L
A-Mouth of Potrero	2.6	20	4770	880	50	4570	5	155	0.6	0.4	7
B-Mouth of San Martinez	0.8	150	51500	4230	300	44000	21	391	7	8.8	47
D-Mouth of Middle Canyon		10	1290	350	30	2230		136	0.4	0.4	2
E-Top of Chiquito Canyon		40	11700	970	150	6280	3	210	1.4	1	10

	Lead ug/L	Mercury ug/L	Nickel ug/L	Selenium ug/L	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml	TSS mg/L	VS mg/L	pH
A-Mouth of Potrero	8	0.01	22	12	50000	1600	1180	32800	8.2
B-Mouth of San Martinez	47.7	0.06	180	11	160000	1700	28000	40000	8
C-1/2 Mile Upstream of Onion Field					90000	11000			
D-Mouth of Middle Canyon	7.7	6			>160000	>160000	600	4100	7.5
E-Top of Chiquito Canyon	19.1		25		2400	2400	3490	9300	7.1

SS = suspended solids
VS = volatile solids

March 8, 2000

Newhall Ranch Monitoring Station	Hardness mg/L	Calcium mg/L	Magnesium mg/L	Potassium mg/L	Sodium mg/L	Alkalinity mg/L	Sulfate mg/L	Chloride mg/L	Nitrate mg/L	E.Coli MPN/100 mL	TDS mg/L
A-Mouth of Potrero	2090	266	347	39	1470	360	3700	960	18.8	6470	7230
B-Mouth of San Martinez	1340	304	142	10	413	210	1900	120	3.1	2430	2960
C-1/2 Mile Upstream of Onion Field	147	44	9	3	10	80	87	3	1.6	323	190
D-Mouth of Middle Canyon	73	21	5	6	10	40	17	3	18.1	162	160
E-Top of Chiquito Canyon	153	43	11	11	18	70	119	12	2.9	420	260

	Boron mg/L	Copper ug/L	Iron ug/L	Manganese ug/L	Zinc ug/L	Aluminum ug/L	Arsenic ug/L	Barium ug/L	Berylium ug/L	Cadmium ug/L	Chromium ug/L
A-Mouth of Potrero	2.9	10	2460	510	30	1580	5	94.4	0.3	0.2	4
B-Mouth of San Martinez	0.8	200	47500	5210	360	69700	27	573	20	13.6	70
C-1/2 Mile Upstream of Onion Field		170	44600	6950	330	85100	13	2360	14	2	39
D-Mouth of Middle Canyon			1510	300	30	2300		132	0.5	0.4	2
E-Top of Chiquito Canyon		100	30700	2110	300	2360	6	470	4.4	2.7	27

	Lead ug/L	Mercury ug/L	Nickel ug/L	Selenium ug/L	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml	TSS mg/L	VS mg/L	pH	TOC mg/L	Diazinon ug/L
A-Mouth of Potrero	4.2	0.03	15	12	30000	7000	490	850	8.2	21.2	ND
B-Mouth of San Martinez	59.2	0.24	330	11	>160000	205	54200	1840	7.8	11.6	ND
C-1/2 Mile Upstream of Onion Field	95.2	0.45	103	4	160000	1600	36000	1460	8.1	9.4	4
D-Mouth of Middle Canyon	7.6	0.02	6		50000	2400	10700	160	7.9	4	ND
E-Top of Chiquito Canyon	54.5	0.14	64	2	>160000	160000	9800	750	8	15.5	

SS = suspended solids
VS = volatile solids

APPENDIX D

“REVIEW OF BACTERIA DATA FROM SOUTHERN CALIFORNIA WATERSHEDS”

Flow Science Incorporated
723 E. Green St., Pasadena, CA 91101
(626) 304-1134 • FAX (626) 304-9427

REVIEW OF BACTERIA DATA FROM SOUTHERN CALIFORNIA WATERSHEDS

Prepared
for

The Irvine Company
550 Newport Center Drive
Newport Beach, CA 92660

Reviewed By

E. John List, Ph.D., P.E.
Principal Consultant

Prepared by

Susan Paulsen, Ph.D., P.E.
Vice President, Senior Scientist

Alex Anderson
Associate Engineer

FSI 057015
April 2005

TABLE OF CONTENTS

SUMMARY **1**

INTRODUCTION **2**

BACKGROUND: BACTERIA WATER QUALITY STANDARDS **2**

ADDITIONAL GUIDELINES FOR BACTERIA **5**

COMPARISON LEVELS USED IN THIS REPORT **6**

MONITORING DATA AND RESULTS **7**

REVIEW OF DATA FROM ORANGE COUNTY COASTAL WATERSHEDS 7
BACTERIA CONCENTRATIONS IN INLAND WATERS IN THE SANTA ANA REGION 9
LOS ANGELES COUNTY MONITORING DATA 11

ADDITIONAL DATA ON SOURCES AND CONCENTRATIONS OF BACTERIA IN RUNOFF **13**

REFERENCES **17**

LIST OF TABLES

TABLE 1. WATER QUALITY CRITERIA FOR BACTERIA RECOMMENDED BY EPA FOR FRESH RECREATIONAL WATERS 4
TABLE 2. WATER QUALITY CRITERIA FOR ENTEROCOCCI RECOMMENDED BY EPA FOR MARINE RECREATIONAL WATERS 5
TABLE 3. APPROXIMATE LAND USE DISTRIBUTIONS IN THE WATERSHEDS OF CDM'S SIX DETAILED STUDY SITES 10
TABLE 4. BACTERIA CONCENTRATION MEANS, MEDIANS AND COEFFICIENTS OF VARIATION (C.V.) FROM LOS ANGELES COUNTY LAND USE SITES 12

LIST OF APPENDICES

APPENDIX A **DATA FROM ORANGE COUNTY COASTAL CREEKS**
APPENDIX B **DATA FROM SANTA ANA REGION**
FIGURES REPRODUCED FROM CDM (2005)
APPENDIX C **DATA FROM ALISO CREEK**

SUMMARY

Available data from Southern California watersheds demonstrate that both existing and EPA-recommended bacteria water quality criteria are routinely exceeded in fresh water creek and river flows, often by one or more orders of magnitude. Exceedances of criteria occur even for flows from largely natural, undeveloped watersheds with little human influence. Even in urbanized watersheds, there is strong evidence that the predominant source of indicator bacteria may be natural (not anthropogenic) – including, for example, bacteria from wildlife, birds, and regrowth within the environment, including sediments. Both measurement data and numerous literature sources have shown that both wet and dry weather bacteria concentrations frequently exceed objectives in creeks and rivers, and that bacteria concentrations rise dramatically during wet-weather periods.

Data from Orange County coastal watersheds indicate that although bacteria in storm water runoff may be elevated within urban storm drain systems, the level of development within these watersheds has little if any effect on the concentrations of indicator bacteria in the receiving waters. These results are consistent with data from other watersheds within Orange County and in other parts of Southern California. No clear trend is evident in bacteria concentrations over time, with concentrations remaining relatively steady, even in areas where land use characteristics have changed over time. Both the concentrations of bacteria in runoff and the impacts of elevated bacteria concentrations on downstream water quality appear to vary by site and with the size of the contributing stream, and thus are likely a function of the dominant sources of bacteria, local hydrologic conditions and climate, and other site-specific factors.

INTRODUCTION

Flow Science was retained by The Irvine Company to review available data and information on the concentrations of indicator bacteria in storm water and dry weather runoff. The goals of this study were to evaluate variations in the concentrations of bacteria during both wet and dry conditions, variations in bacteria levels with the level of development in a watershed or drainage area, changes in bacteria levels over time or with changes in development or land use areas, and the sources of bacteria in runoff and in receiving waters.

In conducting the analysis, Flow Science utilized water quality criteria and thresholds to evaluate available data. These thresholds were obtained from the Water Quality Control Plan (Basin Plan) for the Santa Ana Region, which contains fecal coliform water quality objectives for inland surface waters that apply to the beneficial uses of water contact recreation (REC-1)[1] and non-water contact recreation (REC-2)[2], from proposed EPA water quality criteria, and from Title 17 "beach posting" thresholds. These thresholds are discussed in greater detail below.

Flow Science evaluated data on bacteria concentrations in Southern California. Data were available for watersheds along the Newport Coast, for inland watersheds, and from Los Angeles County. In addition, Flow Science reviewed literature and studies conducted by others.

BACKGROUND: BACTERIA WATER QUALITY STANDARDS

The Basin Plan bacteria objectives currently contained in the Santa Ana Basin Plan were originally developed by the National Technical Advisory Committee (NTAC) to the Federal Water Pollution Control Administration in 1968.[3] These recommendations were based upon prospective

---

[1] See Basin Plan at p. 4-6: "REC-1 Fecal coliform: log mean less than 200 organisms/100 mL based on five or more samples/30 day period, and not more than 10% of the samples exceed 400 organisms/100 mL for any 30-day period."

[2] See Basin Plan at p. 4-6: "REC-2 Fecal coliform: average less than 2000 organisms/100 mL and not more than 10% of samples exceed 4000 organisms/100 mL for any 30-day period."

[3] See *Water Quality Criteria, a Report of the National Technical Advisory Committee to the Secretary of the Interior*, Federal Water Pollution Control Administration: Washington, D.C., April 1, 1968, at p. 8 and p. 12:

"Surface waters should be suitable for use in "secondary contact" recreation – activities not involving significant risks of ingestion – without reference to official designation of recreation as a water use. For this purpose, in addition to aesthetic criteria, surface waters should be maintained in a condition to minimize potential health hazards by utilizing fecal coliform criteria. In the absence of local epidemiological experience, the Subcommittee recommends an average not exceeding 2,000 fecal coliforms per 100 ml and a maximum of 4,000 per 100 ml, except in specified mixing zones adjacent to outfalls."

epidemiological studies conducted by the United States Public Health Service in 1948, 1949, and 1950. These studies found an "epidemiologically detectable health effect" at levels of 2300 to 2400 coliforms per 100 ml at bathing beaches on Lake Michigan (at Chicago) and in the Ohio River. Later work conducted in the mid-1960s showed that approximately 18% of the coliforms present in the mid-1960s at the Ohio location belonged to the fecal coliform subgroup. The recreational contact water quality criteria suggested by the committee were based upon the fraction of coliforms present as fecal coliforms and a factor of safety of two.

The fecal coliform standards recommended in 1968 were adopted by many states and municipalities and remain in use in many locations (including in the Santa Ana Region). Several studies conducted since 1968 have questioned these criteria and recommended use of alternatives.[4] As early as 1972, a Committee formed by the National Academy of Science-National Academy of Engineers noted the deficiencies in the study design and data used to establish the recreational fecal coliform criteria, and stated that it could not recommend a recreational water quality criterion because of a paucity of valid epidemiological data (Committee on Water Quality Criteria, 1972).

In response to these concerns, EPA in 1972 initiated studies at marine and freshwater bathing beaches that were designed to correct the deficiencies in the earlier studies and analyses. These studies were conducted at sites contaminated either with pollution from multiple point sources (usually treated effluents that had been disinfected) or by effluents discharged from single point sources. The studies examined three bacterial indicators of fecal pollution (*E. coli*, enterococci, and fecal coliforms) and found that fecal coliform densities showed "little or no correlation" to gastrointestinal illness rates in swimmers. In contrast, a good correlation was found between swimming-associated gastrointestinal symptoms and either *E. coli* or enterococci in swimming waters (Dufour, 1984). Based on these studies, EPA in 1986 proposed section 304(a) criteria for full body contact recreation based upon *E. coli* and/or enterococci but noted that "it is not until their adoption as part of the State water quality standards that the criteria become regulatory" (USEPA, 1986).

EPA's current recommendations for bacteria water quality objectives (USEPA, 2003) include the use of *E. coli* and/or enterococci as the basis for water quality criteria to protect fresh recreational waters and the use of enterococci as the basis for marine water quality criteria. The EPA recommends that the use of fecal coliform be discontinued for both freshwater and marine

---

"Fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreation waters. As determined by multiple-tube fermentation or membrane filter procedures and based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content of primary contact recreation waters shall not exceed a log mean of 200/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml."

[4] For a summary of these studies, see the discussion provided on pages 1-3 of the *Ambient Water Quality Criteria for Bacteria – 1986*, USEPA 440/5-84-001, January 1986.

waters. EPA's recommendations recognize that bacteria concentrations are quite variable and are best characterized in terms of a probability distribution. Because bacteria concentrations tend to follow log-normal distributions, EPA's current recommendations specify that compliance should be based upon geometric means computed with data collected over a long-term (e.g., 30 days, or seasonally) and "upper percentile values," clarifying that compliance should not be determined using "single sample maximum" values. Upper percentile values are calculated bacteria densities that are intended to correspond to a known geometric mean-based risk level, and are intended to be used to interpret any single measurement. EPA recommends that states acquire enough sample data to calculate site-specific upper percentile values to characterize water quality for waters where exposure is greatest (e.g., bathing beaches). EPA's recommended water quality criteria for freshwater and marine waters are presented in Tables 1 and 2.

Table 1. Water quality criteria for bacteria recommended by EPA for fresh recreational waters

Risk level[a] [% of swimmers]	Geometric mean density [per 100 ml]	Upper Percentile Value Allowable Density [per 100 ml]			
		75th percentile	82nd percentile	90th percentile	95th percentile
Enterococci criteria					
0.8	33	62	79	107	151
0.9	42	79	100	137	193
1.0	54	101	128	175	247
E. coli criteria					
0.8	126	236	299	409	576
0.9	161	301	382	523	736
1.0	206	385	489	668	940

a) The risk level corresponds to the anticipated excess illness rate. For example, a risk level of 0.8% is believed to correspond to an illness rate of 8 gastrointestinal illnesses per 1,000 swimmers in excess of background illness rates.

Table 2. Water quality criteria for enterococci recommended by EPA for marine recreational waters

Risk level[a] [% of swimmers]	Geometric mean density [per 100 ml]	Upper Percentile Value Allowable Density [per 100 ml]			
		75th percentile	82nd percentile	90th percentile	95th percentile
0.8	4	13	20	35	63
0.9	5	16	24	42	76
1.0	6	19	29	50	91
1.1	8	23	35	61	110
1.2	9	28	42	73	133
1.3	11	34	51	89	161
1.4	14	41	62	107	195
1.5	17	49	75	130	235
1.6	20	60	91	157	284
1.7	24	72	109	189	344
1.8	29	87	132	229	415
1.9	35	105	160	276	502

a) The risk level corresponds to the anticipated excess illness rate. For example, a risk level of 0.8% is believed to correspond to an illness rate of 8 gastrointestinal illnesses per 1,000 swimmers in excess of background illness rates.

The Santa Ana Region currently continues to utilize fecal coliform bacteria to assess water quality applicable to recreational beneficial uses. However, the Santa Ana Regional Board is currently conducting a triennial review of its Basin Plan, and is including an evaluation of recreational beneficial use designations and water quality objectives as part of the Basin Plan update process. We currently anticipate that the Santa Ana Regional Board will likely update fresh water bacteria water quality objectives; updated objectives may be consistent with the recommendations contained in EPA's November 2003 Implementation Guidance (see Tables 1 and 2).

ADDITIONAL GUIDELINES FOR BACTERIA

Although not enforceable as water quality objectives, Orange County beaches and bays are "posted" and access may be restricted when exceedances of certain bacteria levels are observed. The "posting" levels are described in Title 17 of the California Code of Regulations, Section 7958 (Bacteriological Standards):

The minimum protective bacteriological standards for waters adjacent to public beaches and public water-contact sports areas shall be as follows:

(1) Based on a single sample, the density of bacteria in water from each sampling station at a public beach or public water contact sports area shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters, if the ratio of fecal/total coliform

bacteria exceeds 0.1; or

(B) 10,000 total coliform bacteria per 100 milliliters; or

(C) 400 fecal coliform bacteria per 100 milliliters; or

(D) 104 enterococcus bacteria per 100 milliliters.

(2) Based on the mean of the logarithms of the results of at least five weekly samples during any 30-day sampling period, the density of bacteria in water from any sampling station at a public beach or public water contact sports area, shall not exceed:

(A) 1,000 total coliform bacteria per 100 milliliters; or

(B) 200 fecal coliform bacteria per 100 milliliters; or

(C) 35 enterococcus bacteria per 100 milliliters.

COMPARISON LEVELS USED IN THIS REPORT

Flow Science used the following numeric values in analyzing available bacteria data:

Fecal Coliform (from existing Santa Ana Basin Plan water quality standards and Title 17 beach "posting" requirements):

- Single Sample: 400 MPN (or CFU)/100mL[5].
- Geometric Mean: 200 MPN (or CFU)/100mL.

Enterococci (from EPA-recommended criteria):

- Single Sample: 247 MPN (or CFU)/100mL.
- Geometric Mean: 54 MPN (or CFU)/100mL.

Total Coliform (from Title 17 beach "posting" requirements):

- Single Sample: 10,000 MPN (or CFU)/100mL.
- Geometric mean: 1,000 MPN (or CFU)/100mL.

Enterococci criteria used by Flow Science in this report correspond to a proposed 1.0% acceptable risk level, 95th percentile, while fecal and total coliform criteria correspond to beach posting levels. Of course, the beach "posting" requirements apply at the beach, not in upstream freshwater flows, but the numeric values provide a useful threshold value against which data can be compared.

[5] Basin Plan specifies no more than 10% of single samples to exceed this value

MONITORING DATA AND RESULTS

Flow Science examined data on bacteria concentrations from a variety of sources in the Santa Ana Region, including streams in coastal watersheds, the Santa Ana River, and inland streams. Data sources included:

- Bacteria concentrations in stream flows from Orange County coastal watersheds
- Bacteria concentrations in freshwater bodies in the Santa Ana region
- Bacteria concentration in runoff samples collected by the Los Angeles County Department of Public Works

Data from each of these sources are examined in greater detail below.

Review of Data from Orange County Coastal Watersheds

Flow Science has reviewed data from Orange County samples collected between 1986 through 2004.[6] Figures for Orange County coastal watersheds are shown in Appendix A; watersheds and data collection locations are shown in Figures A1- 2. Figures A3, A4, and A5 present long-term geometric mean concentrations, calculated as the geometric mean concentration of all available samples (including both wet and dry weather samples) for the period of record, of enterococci, fecal coliforms, and total coliforms, respectively. As shown in Figure A3, long-term geometric mean concentrations of enterococci exceed EPA's proposed freshwater enterococci water quality criteria in all the coastal creeks for which data were available. Similarly, long-term geometric mean concentrations of fecal coliform in most Newport Coast creeks exceed existing Santa Ana Basin Plan REC-1 fecal coliform water quality criteria. Figures A6, A7, and A8 present long-term geometric mean concentrations of enterococci, fecal coliform, and total coliforms plotted against the percent of development within each watershed. There is no apparent correlation for any of the three indicator bacteria presented in these figures with amount of the watershed that has been developed. Note that Figures A6 through A8 utilize the current (2005) level of development for each watershed.[7]

---

[6] Data were obtained from http://www.ocbeachinfo.com/downloads/data/index.htm on February 11 and March 22, 2005. For enterococci, data were available from March 30, 1999, through December 21, 2004. For fecal coliform and total coliform, data were available from January 7, 1986, through December 21, 2004. No data were available for *E. coli*.

[7] The area of watershed that was developed was initially established by PBS&J in 1999 (PBS&J, 1999). These values have been subsequently updated based on information received from The Irvine Company in 2005. Two watersheds experienced significant development between 1999 and 2005: the Crystal Cove Creek watershed increased from ~5% to ~70% developed, and the Muddy Creek watershed increased from ~1% to ~60% developed. The level of development within the other coastal watersheds remained approximately constant.

To facilitate analysis, individual samples were segregated as follows: wet-weather[8], summer dry-weather[9], and winter dry-weather.[10] As shown in Figure A9, wet weather samples exceed single sample threshold values most frequently, regardless of which indicator bacteria are sampled (72%, 61%, and 39% of wet-weather enterococci, fecal coliform, and total coliform samples, respectively, exceed single sample thresholds). Summer dry weather samples exceed thresholds less frequently than wet-weather samples, and winter-dry weather samples exceed thresholds least frequently. The single sample thresholds used to calculate the percent of samples in exceedance are 247, 400, and 10,000 MPN/100mL for enterococci, fecal coliform, and total coliform, respectively.

Figures A10 through A53 present the following information for each site: a) a time-series scatter plot of single sample concentrations of enterococci, fecal coliform, and total coliform for the wet and dry weather data, b) wet and dry weather cumulative distribution functions for each bacteria, and c) the percentage of individual samples that exceed corresponding thresholds in each month. From this analysis, the following conclusions may be reached:

1. Lowest geometric mean concentrations of each of the three bacteria (enterococci, fecal coliform, and total coliform) occurred at the Pelican Hill Waterfall station (watershed 95% developed, primarily golf course), and highest geometric mean concentrations of each bacteria occurred at the Emerald Bay Drain station (watershed 3% developed). In the Muddy Creek watershed, which experienced substantial development between 1999 and 2005 (see footnote 7), enterococci concentrations appear to have decreased as the watershed became more developed. Trends were less evident for fecal and total coliform levels. Similar patterns emerged in data from the Crystal Cove Creek watershed, the other watershed that experienced significant development between 1999 and 2005. Enterococci and fecal coliform concentrations appear to have decreased, while any trends in the total coliform record are unclear. These results indicate that bacteria concentrations in creeks may decline as the level of development increases, and bacteria concentrations in runoff from developed watersheds may be lower than runoff from creeks in less developed coastal areas.

2. No relationship was found between the percentage of the watershed developed and the long-term geometric mean bacteria concentrations (see Figures A6, A7 and A8).

3. The time series plots indicate that concentrations of indicator bacteria are not increasing over time. By visual inspection, bacteria concentrations may be

[8] "Wet-weather" samples are those samples that were collected within two days of a rainfall event greater than or equal to 0.1 inches as measured by the Newport Beach Harbor Station.

[9] "Summer dry-weather" samples are defined as samples collected from April-November, but not within two days of rainfall greater than or equal to 0.1 inches as measured by the Newport Beach Harbor Station.

[10] "Winter dry-weather" samples are defined as samples collected from December-March, but not within two days of rainfall greater than or equal to 0.1 inches as measured by the Newport Beach Harbor Station.

decreasing over the data record in five catchments (Pelican Point Creek, Muddy Creek, Emerald Bay Drain, El Morro Creek upstream station, and Crystal Cove Creek). At the remaining six stations, no apparent long-term trend in bacteria concentration is observed. Very little if any correlation is evident between long-term trends and percentage of watershed developed, as the apparent slight decrease in bacteria concentrations was observed in watersheds that range from 1-95% developed.

4. Although Figure A9 shows that taken as a whole, wet-weather samples have higher concentrations than dry-weather samples, data from some locations show the opposite trend. At Pelican Point Creek (95% developed), dry weather concentrations for enterococci and fecal coliform are higher than wet weather concentrations. At the Emerald Bay Drain (3% developed), fecal and total coliform dry weather concentrations are significantly greater than wet weather concentrations. At El Morro Creek (1% developed), Broadway Creek (25% developed), and Crystal Cove Creek upstream station (70% developed) there is no significant difference (by visual inspection of Figures A34-36, A50-52, and A38-40, respectively) between wet and dry weather bacteria concentration distributions.

5. The general observation that winter dry-weather samples on average contain fewer bacteria than summer dry-weather samples is evident in many of the scatter plots. Figures A10, A34, A38, A42, and A46 (presenting data from Pelican Point Creek, El Morro Creek, Crystal Cove Creek upstream, Crystal Cove Creek, and Buck Gully) illustrate this behavior most clearly.

These results are consistent with the results from an earlier study (PBS&J, 1999) in which long-term geometric mean concentrations of bacteriological data from November 1996-October 1999 were evaluated.

Bacteria Concentrations in Inland Waters in the Santa Ana Region

As part of the activities conducted by the Stormwater Quality Standards Task Force, CDM has compiled bacteriological data from several agencies within the Santa Ana Region (CDM, 2005). The CDM study included data collected and compiled by Orange County, the Regional Water Quality Control Board (Region 8), the Santa Ana Watershed Project Authority, the County of San Bernardino, the County of Riverside, the United States Environmental Protection Agency (EPA), the United States Geological Survey, and Orange County Coastkeeper. Select figures produced by CDM in this study are shown in Appendix B. CDM performed an overview analysis of all bacteria data collected, and reached the following broad-based and general conclusions:

1. Concentrations of indicator bacteria in samples collected from inland water bodies very frequently exceed existing Basin Plan fecal coliform water quality objectives and EPA-proposed *E. coli* criteria.

2. Bacteria concentrations in samples obtained from upstream, largely undisturbed areas are typically lower than those in samples from downstream areas affected by urbanized land uses. Concentrations in upstream samples are more frequently below water quality objectives and proposed criteria than downstream samples.

3. Winter dry-weather samples are more likely to meet objectives than summer dry-weather samples, consistent with results from the Orange County coastal watersheds.

CDM also conducted a detailed analysis of six sites[11] for which long-term data records were available. These six sites exhibited varying degrees of urbanization and channel modification. A map showing the locations of these six sites is shown in Appendix B as Figure B1. Detailed results from these stations are reproduced in Appendix B as Figures B2 through B13. Land use distributions for the areas tributary to the study sites are shown in Table 3.

Table 3. Approximate land use distributions in the watersheds of CDM's six detailed study sites

Site	% Vacant	% Residential	% Commercial	% Industrial	% Other
Chino Cr.[a]	3.2	61.3	16.7	9.7	9.1
Santa Ana Delhi Channel	0.9	52.4	26.0	9.2	11.5
Temescal Cr.	67.3	16.2	2.4	3.4	10.7
Santa Ana R. at Imperial Highway[b]	-	-	-	-	-
Santa Ana R. at MWD Crossing[c]	-	-	-	-	-
Icehouse Canyon Creek	100	0	0	0	0

a) Chino Creek land use data are for portion of watershed downstream of San Antonio Dam.
b) CDM concluded that any potential relationship between land use and bacteria concentrations in this reach of the Santa Ana River is likely masked by the interception of flows by Prado Dam; consequently, no data land use data were available in the CDM report for this site.
c) CDM did not include land use statistics for this station in its report. The report states that land use is "diverse…a combination of commercial, residential, industrial, and agricultural lands. The upper part of the watershed includes natural undeveloped lands…Residential land is dispersed throughout the contributing area."

11 The six sites examined by CDM include: Chino Creek at Schaeffer Avenue, the Santa Ana Delhi Channel, Temescal Creek at Lincoln Avenue, the Santa Ana River at Imperial Highway, the Santa Ana River at the Metropolitan Water District crossing, and Icehouse Canyon Creek in the Angeles National Forest.

By examining these sites in detail, CDM found the following:

1. In streams where flow rate data are available, high bacteria counts are in many cases but not always associated with high flow events (presumably caused by rainfall). Bacteria concentrations in samples collected from Chino Creek at Schaeffer Avenue (Figure B2) and the Santa Ana Delhi Channel (Figure B3) are frequently elevated and do not exhibit any apparent correlation with flow rate in the channel. In Temescal Creek (Figure B4) and the Santa Ana River at the MWD crossing (Figure B5), the data are widely scattered and patterns are difficult to detect. In the Santa Ana River at Imperial Highway (Figures B6-7), data show that bacteria levels are elevated during high flow events and the levels remain elevated for 1-2 days after the high flow has receded.

2. Bacteria concentrations appear to be decreasing over time at three locations (Chino Creek at Schaeffer Ave. (data record 2002-2004), Santa Ana River at MWD Crossing (data record 1984-2004), and Santa Ana River at Imperial Highway (data record 1981-2004)). At the other three locations, no long-term trends are apparent.

3. All sites except Icehouse Canyon Creek have regularly exceeded current or proposed water quality objectives. As mentioned previously, concentrations at the two Santa Ana River sites have shown a decreasing trend, and since 1998 most samples have been at or below objective levels. Icehouse Canyon Creek, at elevation 5,100 feet in the Angeles National Forest, has only one sample (of 40 total samples; a fecal coliform measurement of 9,400 MPN/100mL) in the data record that does not comply with existing or anticipated water quality objectives, indicating that runoff from remote, undeveloped, forested catchments at higher elevations may have significantly lower bacteria levels than runoff from lower elevation watersheds, including undeveloped watersheds at lower elevations. Figures B8-13 show, for each of the six sites, the percent of months in which single sample thresholds are exceeded when samples are classified as summer dry, winter dry, or wet-weather.

Los Angeles County Monitoring Data

Los Angeles County has prepared an Integrated Receiving Water Impacts Report (Los Angeles County, 2001), which includes bacteria concentrations measured in runoff collected downstream of catchments that exhibited primarily single land use types. Los Angeles County data for indicator bacteria for several major land use types are shown in Table 4 (adapted from Table 4-12 of the L.A. County report).

Table 4. Bacteria concentration means, medians and coefficients of variation (C.V.) from Los Angeles County Land Use Sites

	Total Coliform			Fecal Coliform			Enterococcus		
Land Use Type	**Mean**	**Median**	**CV[a]**	**Mean**	**Median**	**CV[a]**	**Mean**	**Median**	**CV[a]**
Commercial	1,140,000	1,250,000	0.71	528,750	90,000	1.35	86,250	40,000	1.18
Vacant	9,187	2,200	1.25	1,397	500	2.60	679	500	0.98
High density S.F. residential	1,366,667	1,600,000	0.30	933,333	900,000	0.70	610,000	140,000	1.41
Transportation	692,500	600,000	0.82	328,750	205,000	1.22	32,000	32,000	0.65
Light industry	454,000	160,000	1.42	338,220	30,000	2.09	98,200	130,000	0.73

a) "CV" refers to "Coefficient of Variation", calculated by dividing the standard deviation by the mean.

The data shown in Table 4 demonstrate that significantly lower bacteria concentrations were observed in runoff from vacant land areas than in other land use types. These data were collected by Los Angeles County in Sawpit Creek, downstream of Monrovia Creek, in the City of Monrovia; this catchment is in the San Gabriel Mountains in a very steep, sparsely vegetated area far from the ocean. Low concentrations of indicator bacteria from the Sawpit Creek watershed are consistent with low concentrations in samples collected from Icehouse Canyon Creek, both mountainous, high elevation watersheds. These results differ from observations from the Orange County coastal watersheds, which indicate no relationship between percentage development in a watershed and bacteria concentrations. The differences are most likely due to differences in catchment characteristics, local climate, the numbers and types of wildlife present, or to other factors. In any case, both the mean and median concentrations observed for each Los Angeles County land use type exceeded applicable water quality thresholds.

Los Angeles County also measured bacteria concentrations in several "mass emission" stations. These stations were sited to capture runoff from major Los Angeles County watersheds that generally have heterogeneous land use, with the objective of estimating pollutant loads to the ocean and of identifying long-term trends in pollutant concentrations, where possible. The mass emission stations include Malibu Creek (watershed 6% impervious; measurement station near Malibu Canyon Road), Ballona Creek (watershed 45% impervious; measurement station between Sawtelle Boulevard and Sepulveda Boulevard in Los Angeles), the Los Angeles River (watershed 35% impervious; measurement station between Willow Street and Wardlow Road in Long Beach), and the San Gabriel River (watershed 30% impervious; measurement station below the San Gabriel River Parkway in Pico Rivera).

In addition to the land use data reported in Table 4, Los Angeles County reached a number of conclusions using data collected at these mass emission stations. The following conclusions are cited directly from the Los Angeles County report (2001):

- The Malibu Creek station appears to have consistently lower [bacteria] counts than other mass emission stations.

- Every wet weather mass emission bacteria sample taken exceeded the public health criteria for indicator bacteria. All of the dry weather bacteria samples taken for the low flow diversion projects exceeded the public health criteria. Most of the dry weather mass emission bacteria samples taken exceeded the public health criteria. Wet weather flows contained bacteria densities at much higher levels (three to four orders of magnitude) than dry weather flows.

- Except for 1996-97, densities observed during the first storm of each rainy season were not necessarily higher than during consecutive storm events, suggesting that there was no consistent "first-flush" effect in these watersheds. Peak densities were observed at different times each year. In 1995-96, the peak density at all four mass emission stations and one land use station coincided with the peak storm of the season.

- Except for somewhat lower [bacteria] densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.

Consistent with data from Orange County coastal watersheds, the Los Angeles County data show that samples collected during wet-weather exhibit significantly higher bacteria concentrations than samples collected during dry weather.

ADDITIONAL DATA ON SOURCES AND CONCENTRATIONS OF BACTERIA IN RUNOFF

Numerous additional studies and data reports have shown a correlation between elevated bacteria concentrations and rainfall events in Southern California. This correlation is evident in data collected from a variety of environments. For example, elevated concentrations of indicator bacteria have been observed during wet weather conditions at Huntington Beach (Boehm et al.,2002; Kim et al., 2004; Reeves et al., 2004), and northern Orange County and Santa Cruz County (Dwight et al., 2004).

Several studies also indicate that runoff from undeveloped watersheds contains bacteria concentrations that exceed relevant water quality standards. For example, storm water runoff from the head of the Rose Creek watershed in the San Diego Region contains levels of indicator bacteria well in excess of water quality objectives, even though this area is non-urban, contains no sewer lines or lift stations, and is restricted from public access (Schiff and Kinney, 2001). Moore (2001) found that concentrations of indicator bacteria in San Juan Creek sampling stations reflecting rural land uses exceeded water quality criteria, and that rainfall events resulted in higher bacteria concentrations at both rural and urban sites than dry weather. (Moore (2001) also found that storm drains can be major sources of dry weather bacteria pollution.)

The level or type of development is not necessarily indicative of bacteria levels in runoff, or

of the presence of human-derived bacteria. In Mission Bay, a highly urbanized watershed, extensive efforts have been made to eliminate human sources of bacteria by repairing the sanitary sewer system and diverting dry weather flows to a local waste water treatment plant. Source tracking studies suggest that human sources contribute a minor fraction of the total fecal inputs to the Bay, and yet violations of water quality standards continue to occur (see Colford et al., 2005, and references therein). Pednekar et al. (2005) also found that changes in land use associated with the development of agricultural lands[12] within watersheds tributary to Newport Bay did not have a significant impact on bacteria loads, stating "The storm loading rate of coliform…appears to be unaffected by the dramatic shift away from agricultural land-use."

A number of studies have indicated that runoff from urban areas may not be the sole or even the primary source of elevated bacteria concentrations in receiving waters, but that such elevated levels may be caused by non-human sources, such as terrestrial wildlife and birds or even local sediments. Studies conducted at Huntington Beach have indicated that there may be many sources of indicator bacteria to the surf zone, including urban runoff, flow from adjacent wetlands, birds, and sediments (Grant et al., 2001). A recent study by Noblet et al. (2004) indicates that birds may be the source of high concentrations of indicator bacteria at the mouth of the Santa Ana River and in the nearby surf zone, and suggested that local sediments may be the source of fecal steroids, indicating the presence of fecal-associated material in the sediments. Another study by the Los Angeles Regional Water Quality Control Board (2004) erected a bird exclusion structure on Cabrillo Beach, and found that bacteria levels below the structure were reduced up to 60% compared to levels measured outside the structure, while exceedances of water quality standards were reduced by 65% below the structure. The Los Angeles Regional Board also reported that "high bacterial densities may be largely from the beach itself."

Other studies have provided additional evidence that the bacteria found in creeks may result from natural, not urban, sources. Orange County recently studied the efficacy of several best management practices (BMPs) for reducing bacteria concentrations in Aliso Creek, Orange County, California. Results of this study have been summarized by GeoSyntec (2005) (attached as Appendix C). The BMPs that were evaluated include 1) a multimedia filtration and UV sterilization system, and 2) wetland ponds. The study, which was conducted during dry weather, found that both BMPs greatly reduced concentrations of indicator bacteria[13], but that bacteria levels rebounded within a short distance downstream of the BMPs. In the case of the filtration/sterilization, the geometric mean concentration of fecal coliform increased from 317 cfu/100mL at the outlet of the BMP to

[12] Tributary creeks to Newport Bay studied by Pednekar et al. include the San Diego Creek (SDC) and the Santa Ana Delhi Channel (SAD). The SDC watershed remained between 52-60% developed over the study period. Agricultural land-use decreased from 34% to 2%, while commercial land-use increased from 1% to 10%, industrial land-use from 2% to 20%, and residential land-use from 11% to 25%. The SAD watershed remained between 88-92% developed over the study period. Agricultural and residential land-use decreased while commercial land-use increased from 3% to 15% and industrial land-use increased from 19% to 33%.

[13] In comparing influent and effluent, multimedia filtration/UV sterilization resulted in a 99.6% reduction in fecal coliform concentration; wetland ponds achieved a 90-99% reduction in fecal coliform concentrations.

2575 cfu/100mL in a natural channel at a distance of 35 feet downstream of the BMP. In the case of the wetland ponds, effluent was routed through a pipe approximately 200 feet long to the monitoring station, which recorded concentrations approximately two times greater than what could be accounted for based on mass-balance calculations. However, uncertainty in flow measurements, data variability, and the fact that ~37% of the flow is not intercepted by the wetlands indicate that regrowth is not the only possible explanation for the unexpectedly high bacteria concentrations at the pipe outlet.

The link between bacteria concentrations in rivers and streams and downstream water quality, including surf zone water quality, has been examined by a number of authors in addition to those cited above. PBS&J (1999) found that even though Newport coastal creek waters contained high concentrations of indicator bacteria, it did not appear that these waters had a significant impact on bacteria concentrations in the surf zone. Ahn et al. (2005) found that while storm water runoff from the Santa Ana River may lead to "very poor" surf zone water quality, the impact on the surf zone was generally confined to <5 km around the river outlet. Pednekar et al. (2005) studied bacteria concentrations in Newport Bay, California, and found that approximately 70% of the variability in the coliform record could be attributed to rainfall, implying that storm water runoff from the surrounding watershed is a primary source of coliform in Newport Bay. A difference in scale may account for the different conclusions reached by different studies – the Ahn et al. and Pednekar et al. studies found significant impacts on surf zone water quality by examining large creeks and rivers, while PBS&J's conclusion that creek water quality does not significantly affect surf zone water quality is based on a study of small to medium sized creeks – and clearly highlights the need for site-specific evaluations of bacterial water quality.

Presumably, the source of bacteria affects its pathogenicity and risk to human health, but data on human health risks from non-human source bacteria are scarce. Some studies (see, e.g., Schroeder et al., 2002) call into question whether the presence or concentration of indicator bacteria in urban runoff has any relationship with the possible presence of human pathogens. Schroeder et al. sampled paved and grass areas of parks, roofs, residential lawns, ponds, storm drains and similar surfaces to characterize the microbial community that may be present in urban water. Each sample was tested for indicator organisms (coliforms, fecal coliforms, *E. coli*, and enterococci), viruses (adenovirus, enterovirus, hepatitis A virus, and rotavirus), bacteria (enterohemorrhagic Escherichia coli, enterotoxigenic Escherichia coli, Shigella, Salmonella, and Staphylococcus aureus), and protozoa (Giardia lamblia and Cryptosporidium parvum). The study states found that although pathogens can be found in urban drainage, "there does not appear to be a relationship between the presence of pathogens and the concentration or presence of indicator organisms." Of particular note, a recent epidemiological study of health risks due to swimming in Mission Bay (Colford et al., 2005), where concentrations of indicator bacteria are believed to be predominantly from non-human sources, concluded that the risks of swimming-related illness were uncorrelated with exceedances of state water quality thresholds or with levels of indicator bacteria.

In conclusion, the available data from Southern California indicate that bacteria concentrations are often elevated in runoff from both urban and undeveloped watersheds,

particularly during wet weather conditions. The level of development appears to have little effect on bacteria concentrations in storm flows. There is no clear trend in bacteria concentrations over time, with concentrations remaining relatively steady, even in areas where land use characteristics have changed over time. Available data also indicate that multiple sources may contribute to high concentrations of indicator bacteria, including natural sources such as wildlife, birds, and sediments. Regrowth within the environment also occurs, resulting in elevated bacteria concentrations even downstream of the point where relatively bacteria-free flows enter natural channels or man-made conveyances. Finally, the impact of high bacteria concentrations on downstream water quality appears to vary by location and conditions.

REFERENCES

Ahn, J.H., S.B. Grant, C.Q. Surbeck, P.M. DiGiacomo, N.P. Nezlin, and S. Jiang. Coastal water quality impact of storm water runoff from an urban watershed in southern California. Unpublished manuscript, in review. 2005.

Ambient Water Quality Criteria for Bacteria – 1986, USEPA 440/5-84-002, January 1986.

Boehm, A.B., S.B. Grant, J.H. Kim, S.L. Mowbray, C.D. McGee, C.D. Clark, D.M. Foley, and D.E. Wellman. Decadal and shorter period variability of surf zone water quality at Huntington Beach, California. *Environ. Sci. Technol*. 2002, 36 (18), 3885-3892

CDM, Stormwater Quality Standards Study Phase I Study Report. Technical Memorandum 3-Flow and Water Quality Data Inventory and Characterization. January 2005.

Colford, J.M. Jr., T. J. Wade, K. C. Schiff, C. Wright, J.F. Griffith, S.K. Sandhu, S.B. Weisberg. Recreational Water Contact and Illness in Mission Bay, California. Southern California Coastal Water Research Project (SCCWRP), Technical Report 449, March 2005.

Committee on Water Quality Criteria. National Academy of Sciences-National Academy of Engineering. Water Quality Criteria. USEPA R3-73-033, Washington, D.C., 1972.

Dufour, A. P., *Health Effects Criteria for Fresh Recreational Waters*. USEPA 600/1-84-004, August 1984.

Dwight, R.H., D.B. Baker, J.C. Semenza, and B.H. Olson. Health effects associated with recreational coastal water use: Urban versus rural California. *American Journal of Public Health*, 2004, 94 (4), 565-567.

Dwight, R.H., J.C. Semenza, D.B. Baker, and B.H. Olson. Association of urban runoff with coastal water quality in Orange County, California. *Water Environment Research*, 2002, 74 (1), 82-90.

Grant, S.B., B.F. Sanders, A.B. Boehm, J.A. Redman, J.H. Kim, R.D. Mrse, A.K. Chu, M. Gouldin, C.D. McGee, N.A. Gardiner, B.H. Jones, J. Svejkovsky, G.V. Leipzig, and A. Brown. *Generation of Enterococci Bacteria in a Coastal Saltwater Marsh and Its Impact on Surf Zone Water Quality*, 35 *Environ. Sci. Technol.* 2407–16 (2001).

Griffith, J.F., S.B. Weisberg, and C.D. McGee, 2003. Evaluation of microbial source tracking methods using mixed fecal sources in aqueous test samples. *J. Water Health* 01:141-151.

Implementation Guidance for Ambient Water Quality Criteria for Bacteria. DRAFT. USEPA-823-B-03-XXX, November 2003.

Kim, J.H., S.B. Grant, C.D. McGee, B.F. Sanders, and J.L Largier. Locating sources of surf zone pollution: A mass budget analysis of fecal indicator bacteria at Huntington Beach, California. *Environ. Sci. Technol*. 2004, 38 (9), 2626-2636.

Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report. Available at: http://www.ladpw.org/WMD/npdes/IntTC.cfm

Los Angeles Regional Water Quality Control Board. Los Angeles Harbor Bacteria TMDL-Inner Cabrillo Beach and Main Ship Channel. April 2004. Available at: http://www.waterboards.ca.gov/losangeles/index.html.

D. Moore, Bacteriological Survey of San Juan Creek Watershed Task 3 Report for the San Juan Creek Watershed Bacteriological Study (2001).

Noblet, J.A., D.L. Young, E.Y. Zeng., and S. Ensari. Use of fecal steroids to infer the sources of fecal indicator bacteria in the lower Santa Ana River watershed, California: Sewage is unlikely a significant sources. *Environ. Sci. Technol*. 2004, 38, 6002-6008.

Orange County Ocean Water Protection Program data. Available at: http://www.ocbeachinfo.com/downloads/data/index.htm

PBS&J, *Evaluation of Bacteriological Impacts to Runoff and Coastal Waters from the Crystal Cove Development*. November 1999.

Pednekar, A.M., S.B. Grant, Y. Jeong, Y. Poon, and C. Oancea. Water quality in a tidal wetland: influence of climate change, tidal mixing, and watershed urbanization. Unpublished manuscript, in review. 2005.

Reeves, R.L., S.B. Grant, R.D. Mrse, C.M. Oancea, B.F. Sanders, and A.B. Boehm. Scaling and management of fecal indicator bacteria in runoff from a coastal urban water shed in southern California. *Environ. Sci. Technol*. 2004, 38 (9), 2637-2648.

Schiff, K. and P. Kinney. Tracking Sources of Bacteria Contamination in Stormwater Discharges from Mission Bay, California, 73 *Water Environ. Res*. 534–42 (2001).

Schroeder, E.D., W.M. Stallard, D.E. Thompson, F.J. Loge, M.A. Deshussess, and H.J. Cox. *Management of Pathogens Associated with Storm Drain Discharge-Results of Investigations of the Presence of Human Pathogens in Urban Storm Drains.* Prepared for the California Department of Transportation, Division of Environmental Analysis. May 2002.

Williamson, B., and Austin, L., GeoSyntec Consultants. Pathogens & BMP Effectiveness Analysis – Aliso Creek, Memorandum, 2005. Attached as Appendix C.

APPENDIX A

DATA FROM ORANGE COUNTY COASTAL CREEKS

Figure A 1: Location of coastal catchments and surf zone areas along the Newport Coast.

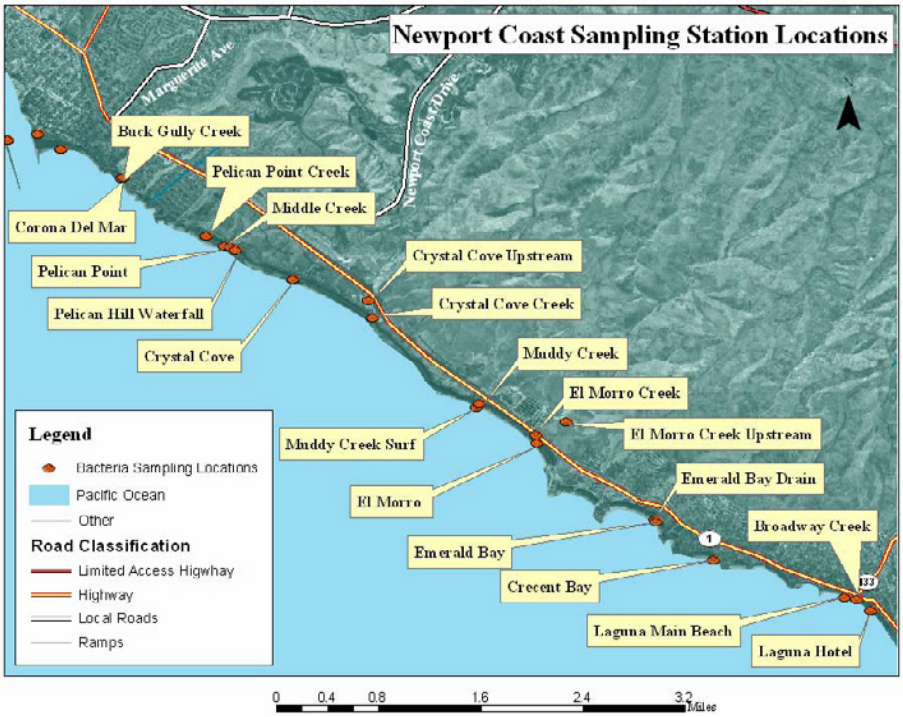


Figure A 2: Additional detail on the catchment areas (information collated from the PBS&J report, 1999 and updated by The Irvine Company, 2005).

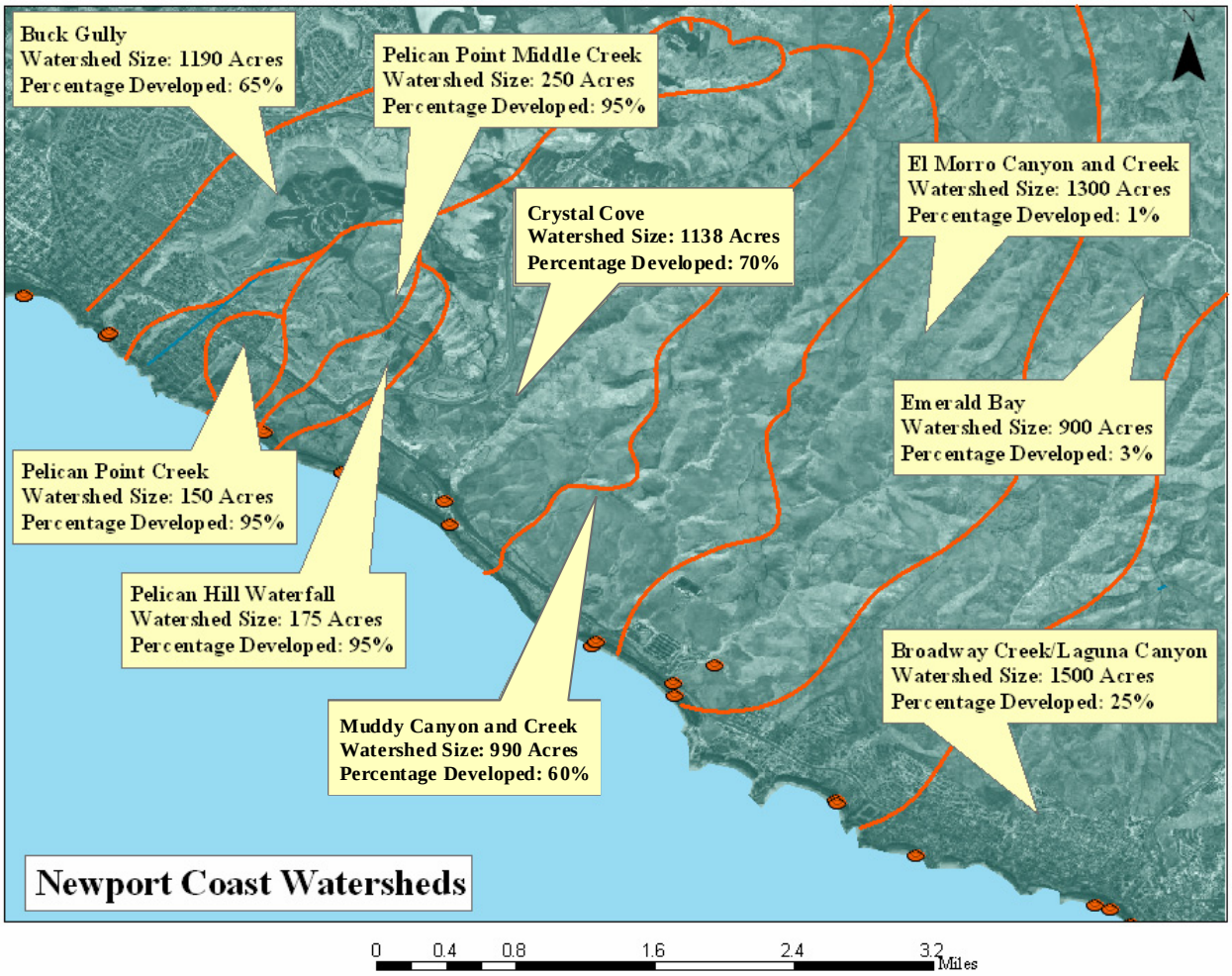


Figure A 3: Long-term geometric mean concentration for enterococci (data from 3/30/99 to 12/21/04). Dashed line represents EPA's suggested 30-day geometric mean water quality criterion for enterococci corresponding to a 1.0% risk level.

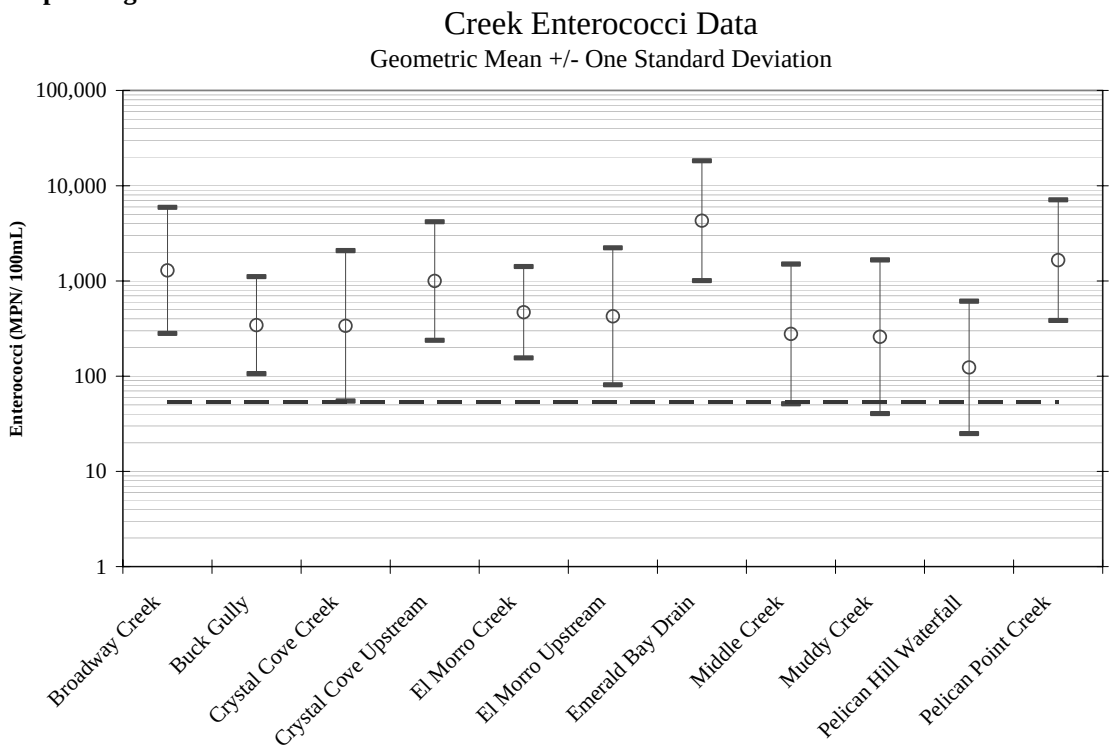


Figure A 4: Long-term geometric mean fecal coliform concentrations (data from 1/7/86 to 12/21/04). Dashed line corresponds to the current Santa Ana Basin Plan water quality criterion for 30-day log mean (geometric mean) fecal coliform concentrations.

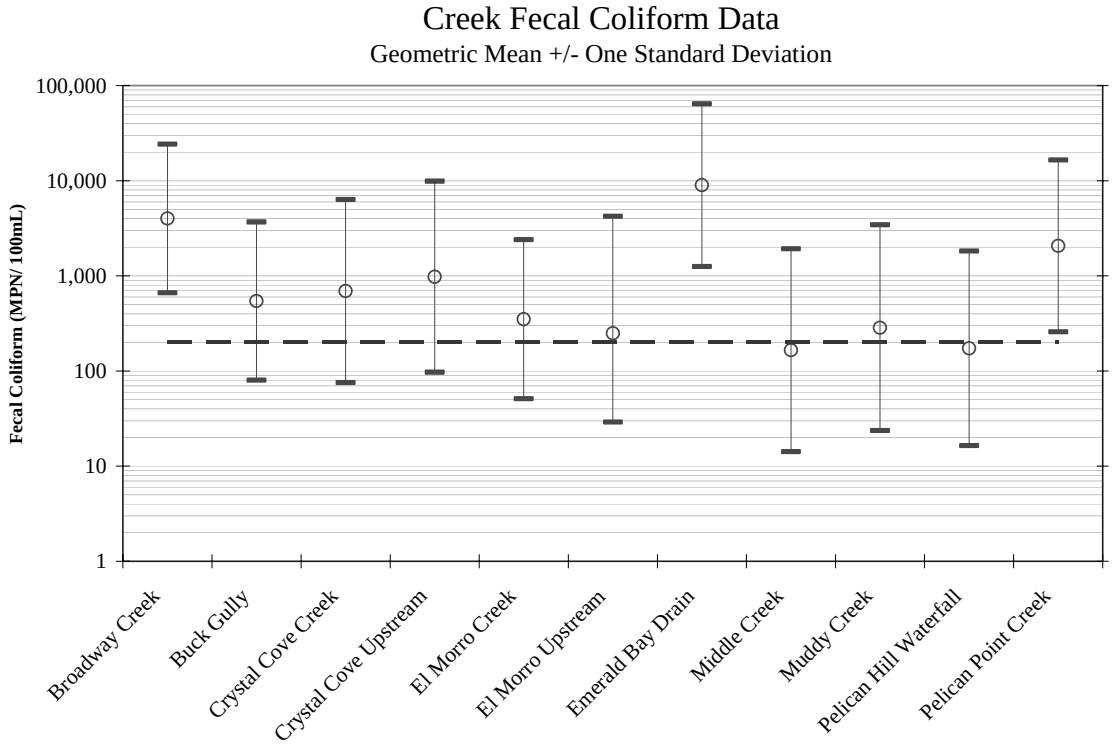


Figure A 5: Long-term geometric mean concentrations for total coliform (data from 1/7/86 to 12/21/04)

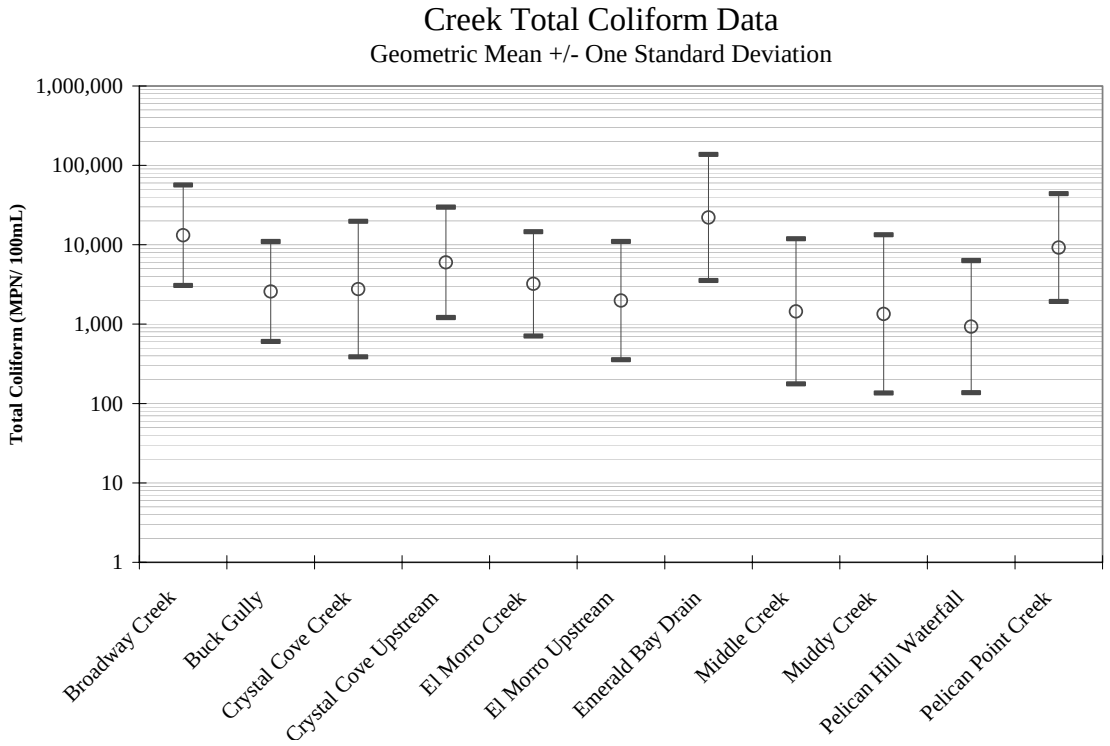


Figure A 6: Relationship between % developed and the long-term geometric mean enterococci concentration (data from 3/30/99 to 12/21/04). Dashed line represents EPA's suggested 30-day geometric mean water quality criterion for enterococci corresponding to a 1.0% risk level.

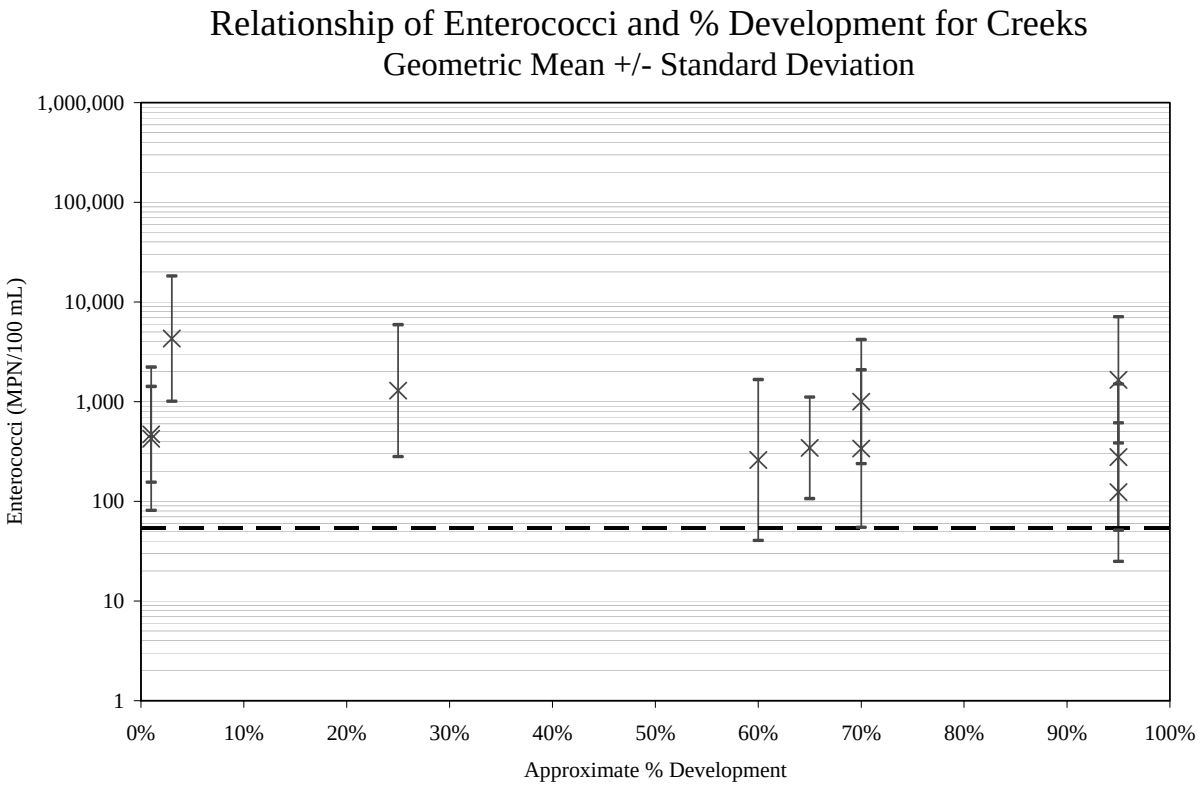


Figure A 7: Relationship between % developed and the long-term geometric mean fecal coliform concentration (data from 1/7/86 to 12/21/04). Dashed line corresponds to the current Santa Ana Basin Plan water quality criterion for 30-day log mean (geometric mean) fecal coliform concentrations.

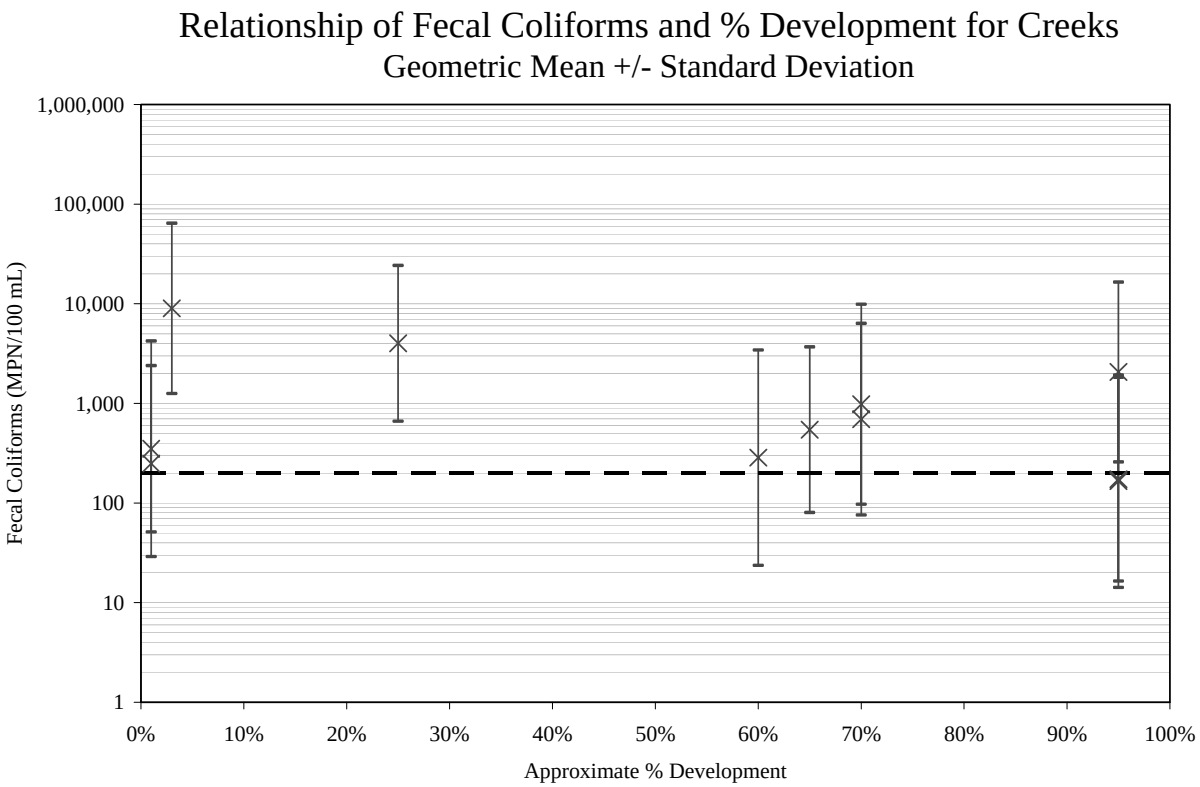


Figure A 8: Relationship between % developed and the long-term geometric mean total coliform concentration (data from 1/7/86 to 12/21/04).

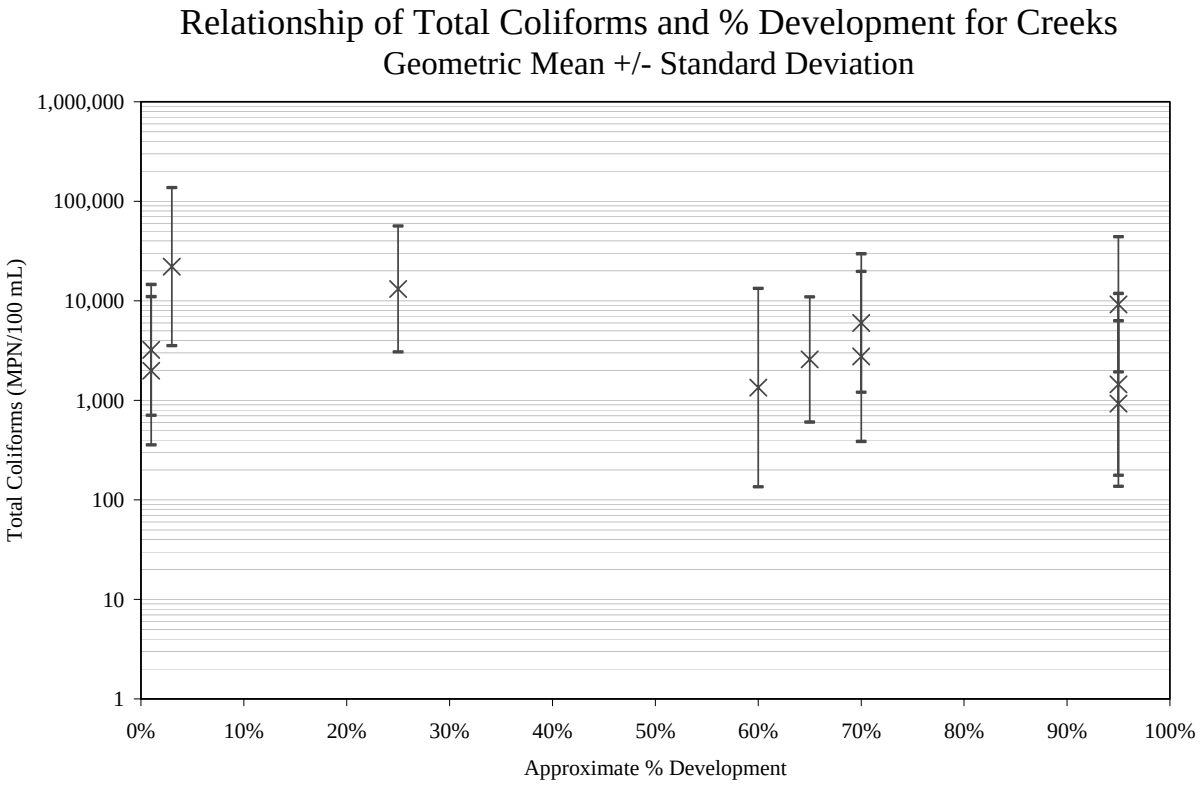


Figure A 9: Percent of samples in exceedance of thresholds by weather type (data from 1/7/86 to 12/21/04 for total and fecal coliform and from 3/30/1999 to 12/21/04 for enterococci). "Wet" data are those within two days of rainfall totaling 0.1" or greater at Newport Harbor. "Summer Dry" samples were collected from April-November, but not within two days of 0.1" or more of rain. "Winter Dry" samples were collected from December-March, but not within two days of 0.1" or more of rain. Threshold values against which data were compared are 247, 400, and 10,000 MPN/100mL, for enterococci, fecal coliform, and total coliform, respectively.

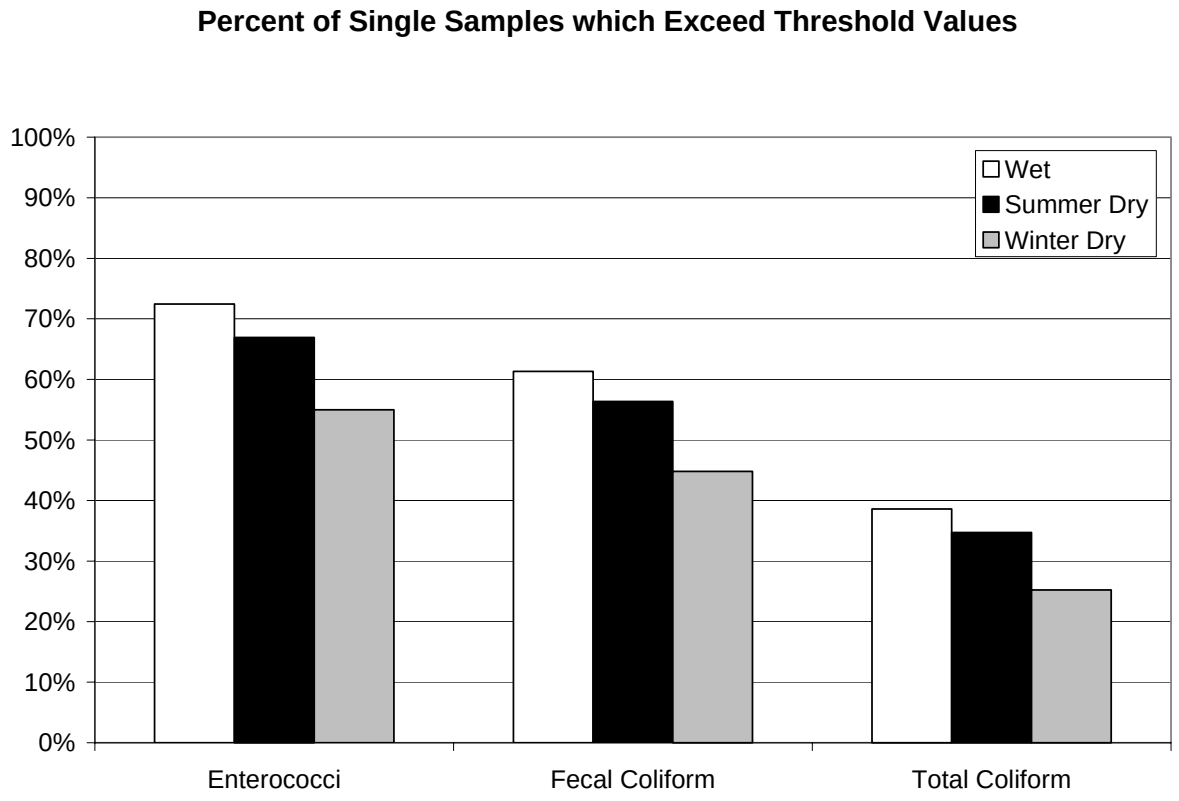
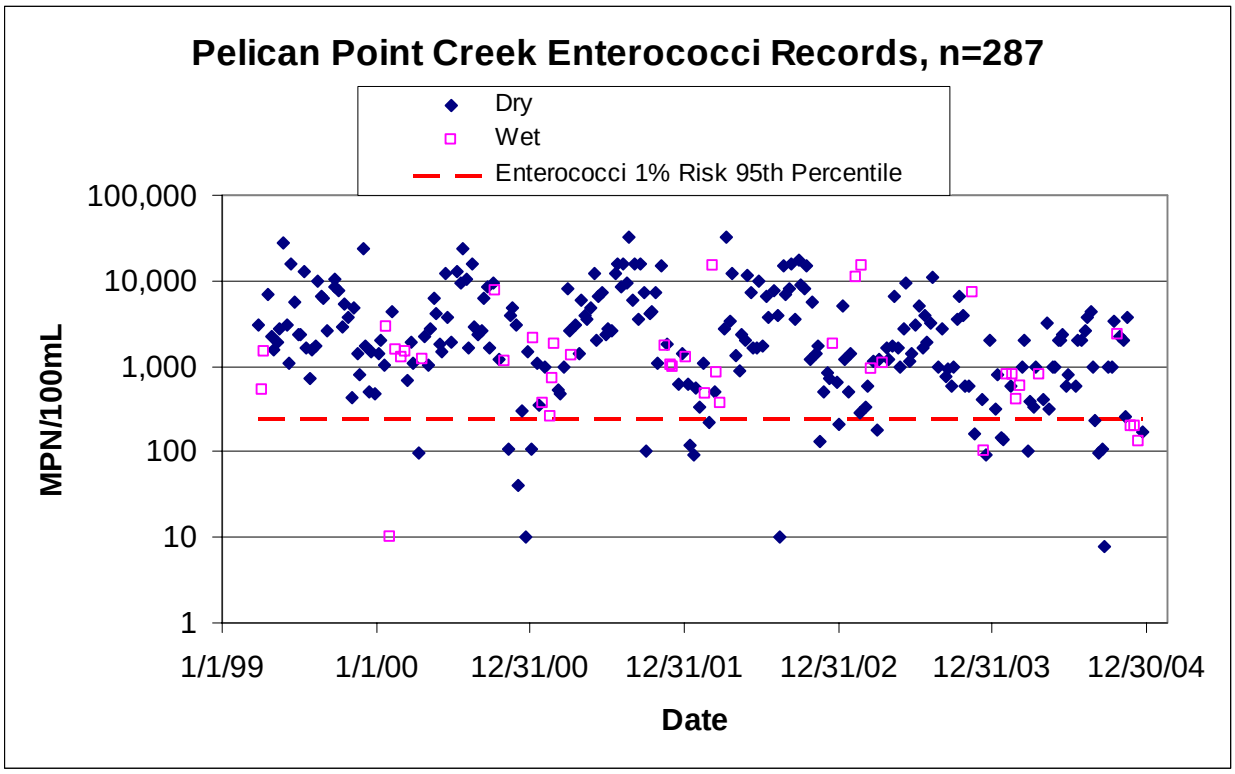


Figure A 10: Pelican Point Creek enterococci data and corresponding cumulative frequency distribution



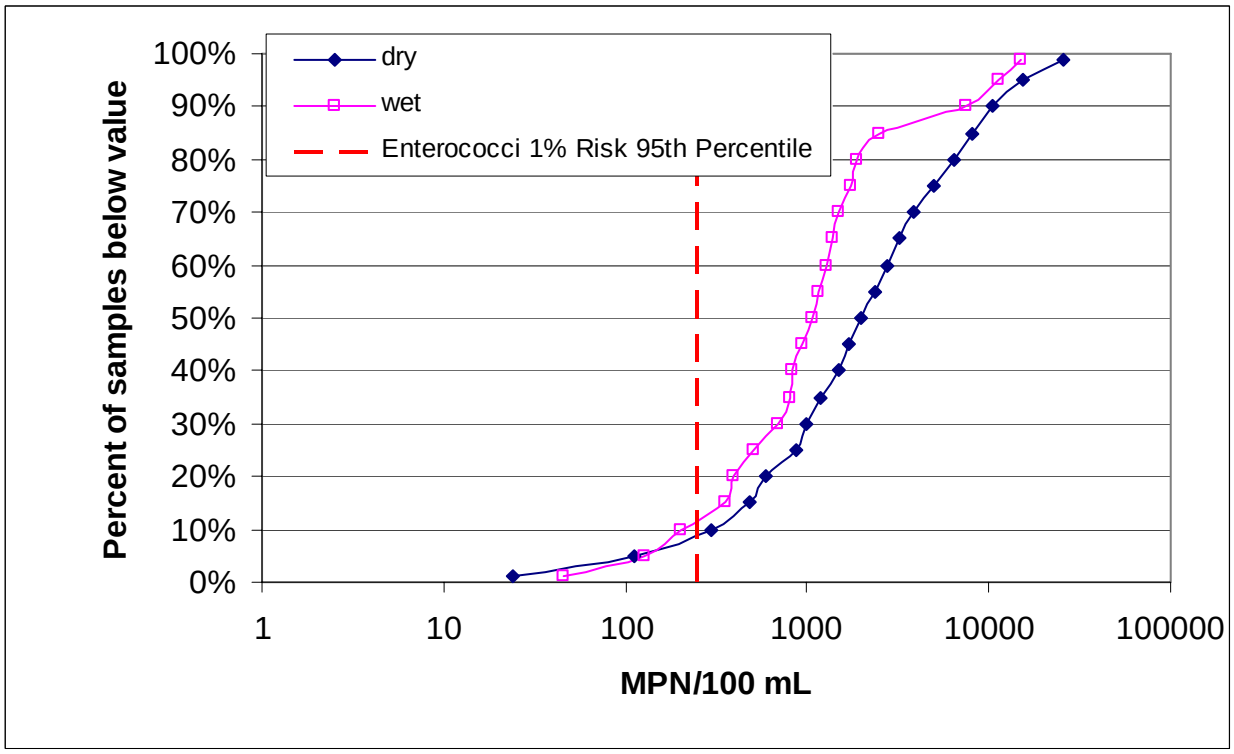
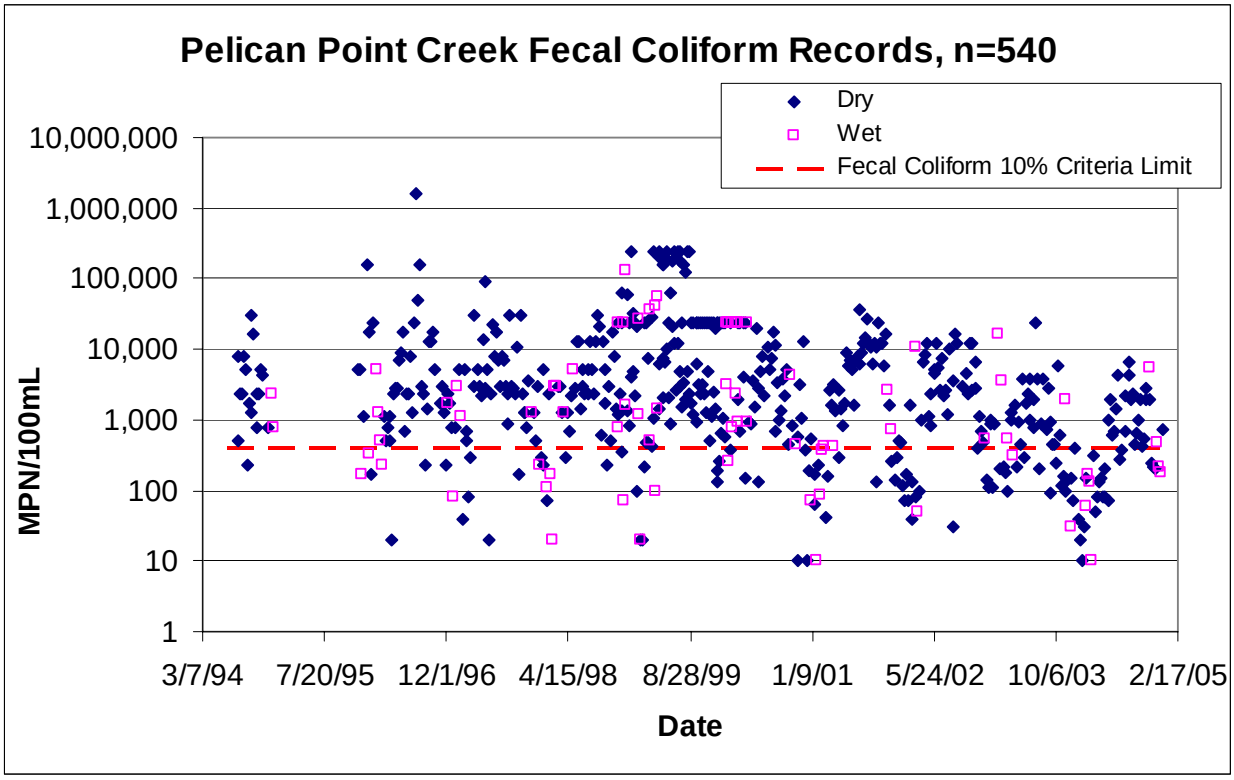


Figure A 11: Pelican Point Creek fecal coliform data and corresponding cumulative frequency distribution



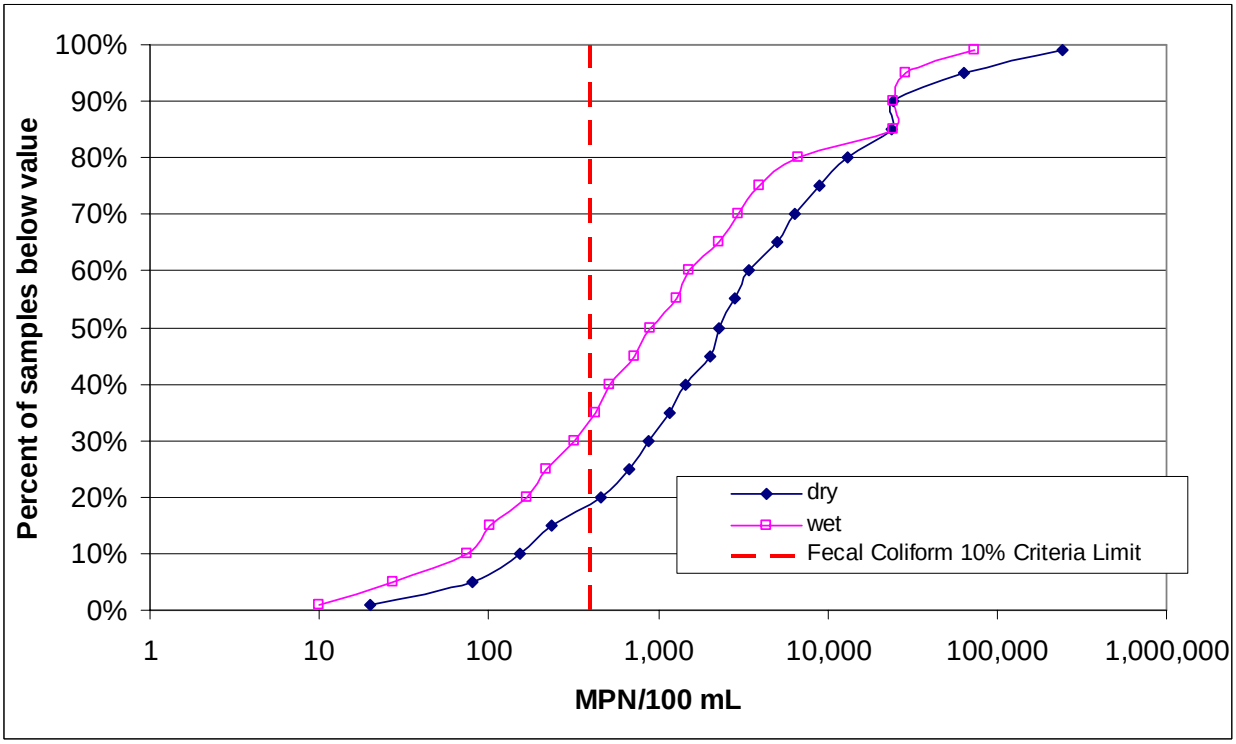
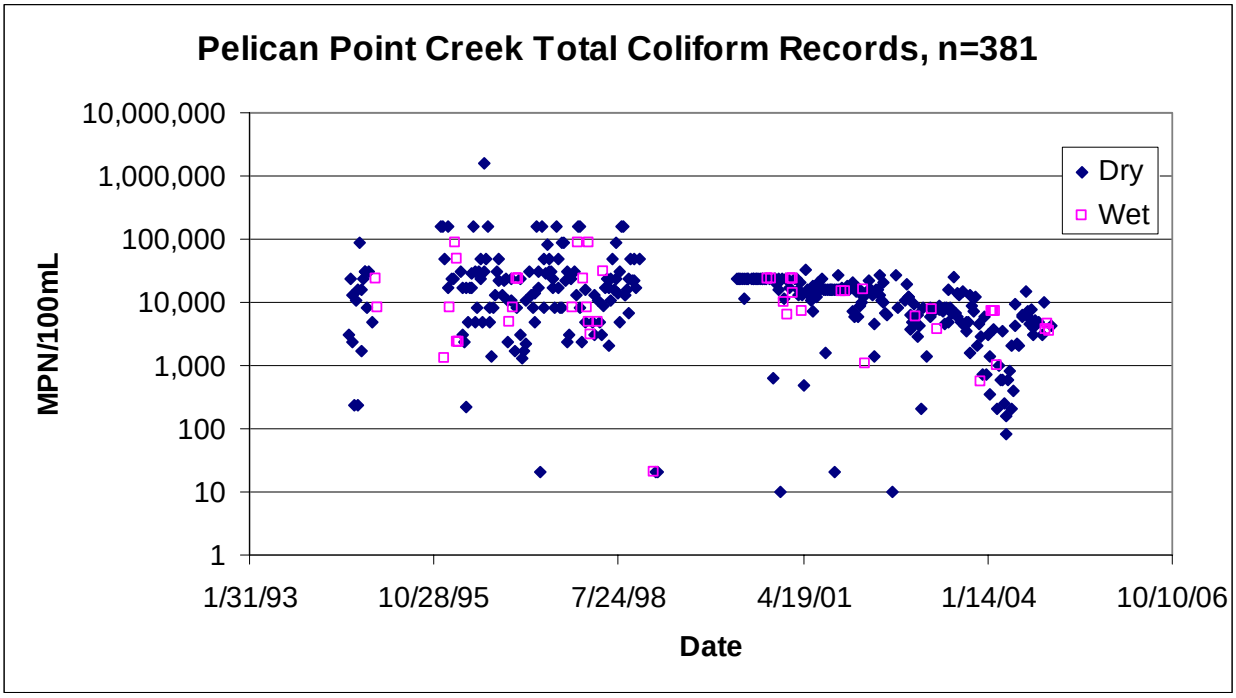


Figure A 12: Pelican Point Creek total coliform data and corresponding cumulative frequency distribution



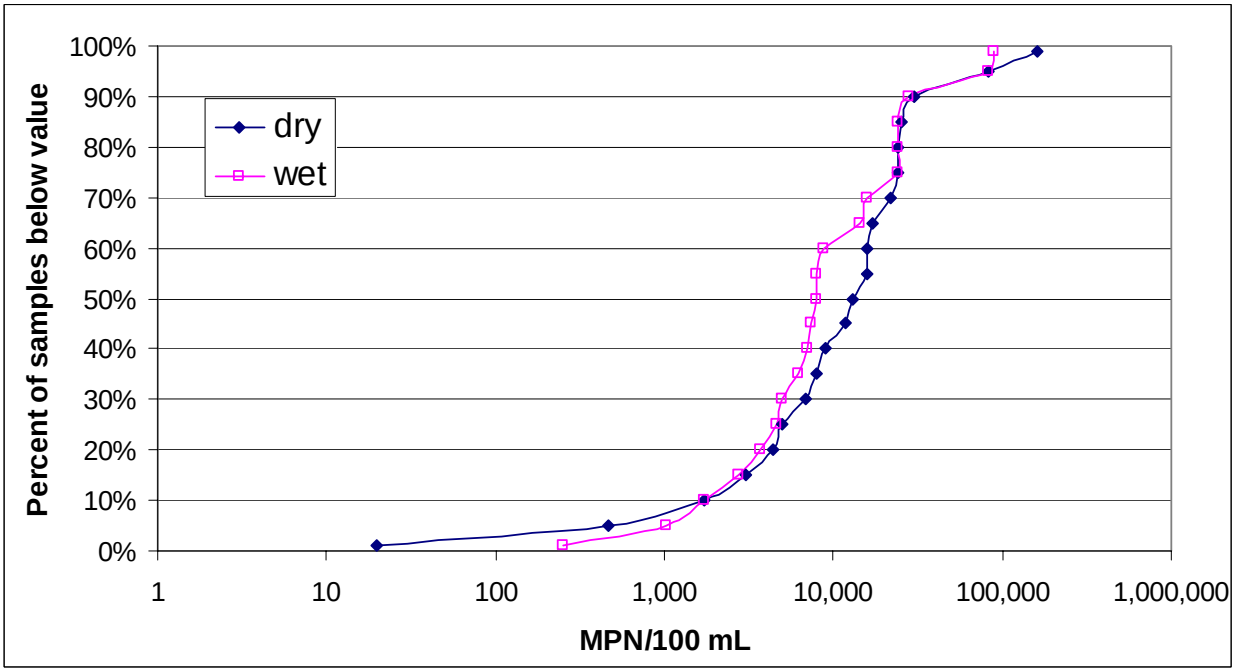


Figure A 13: Percentage of samples from Pelican Point Creek which exceed thresholds, by month

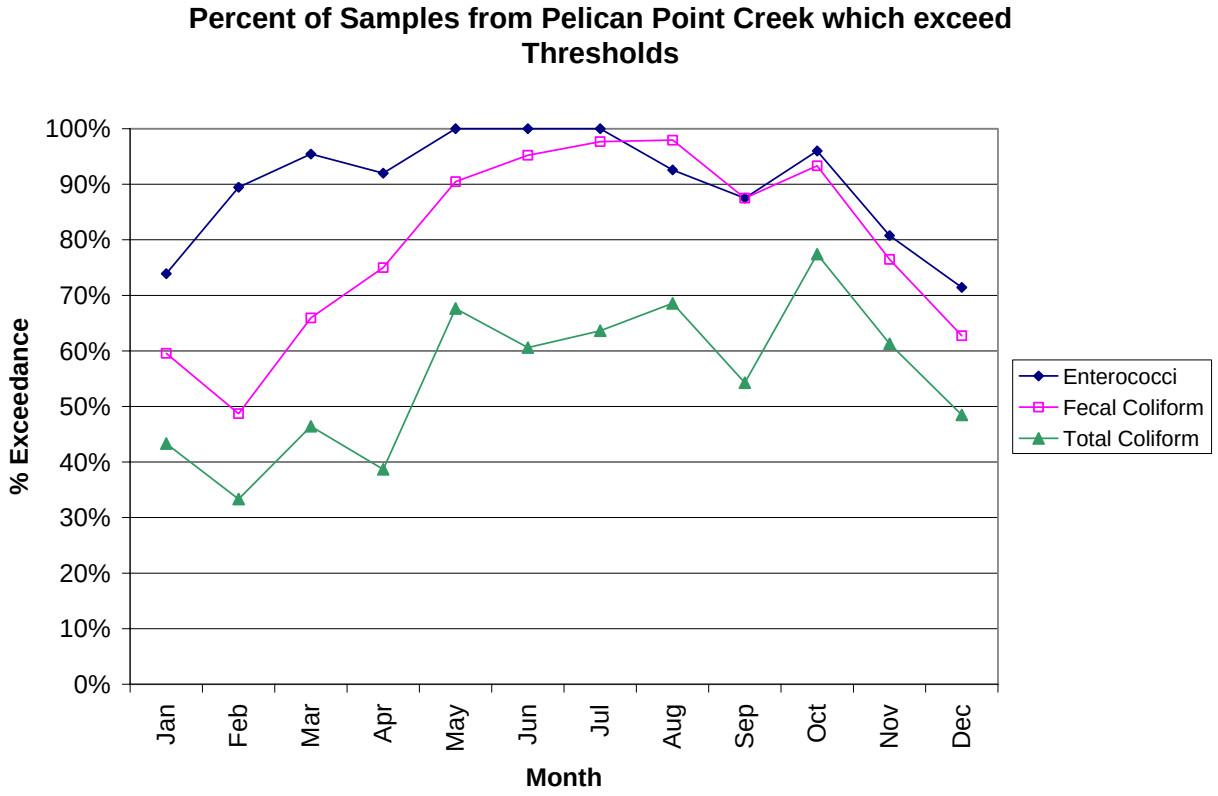
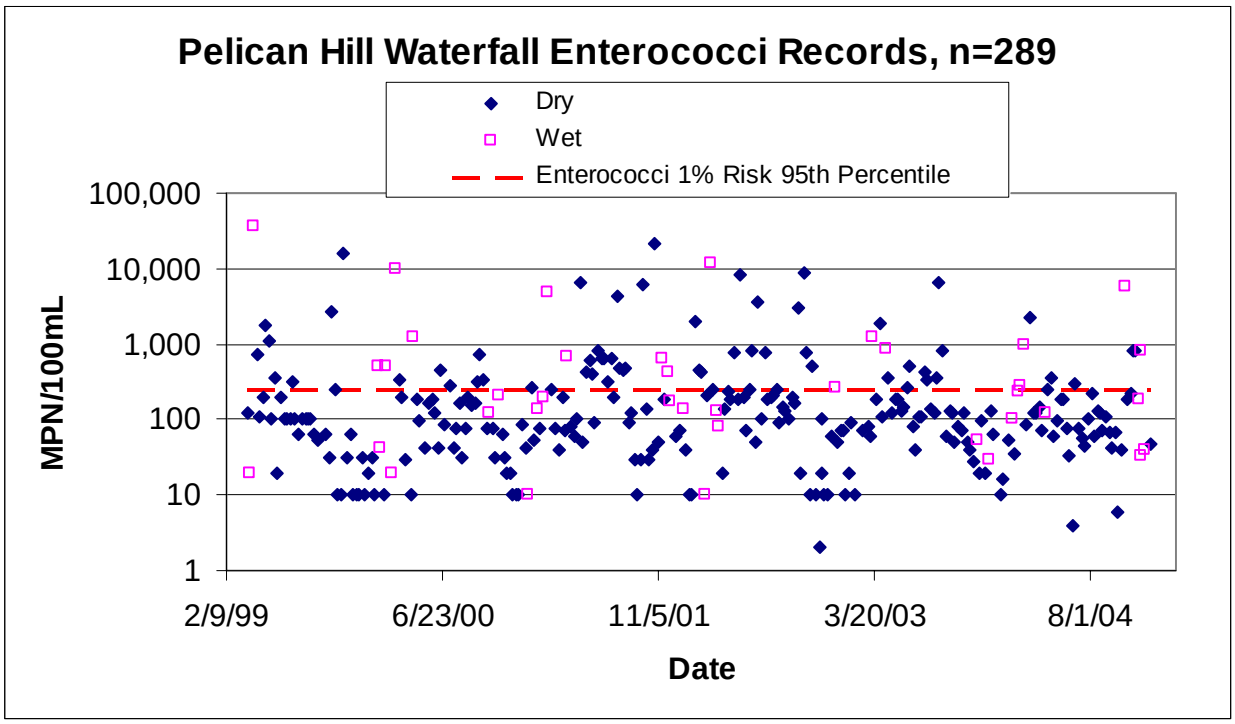


Figure A 14: Pelican Hill Waterfall enterococci data and corresponding cumulative frequency distribution



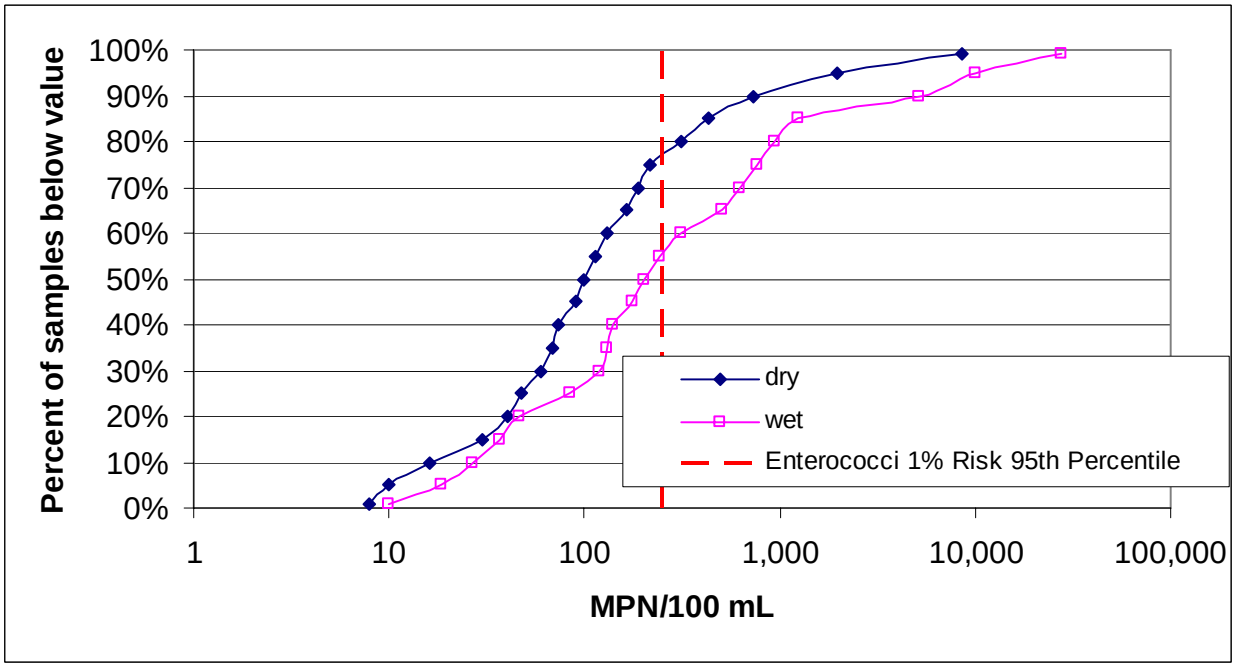
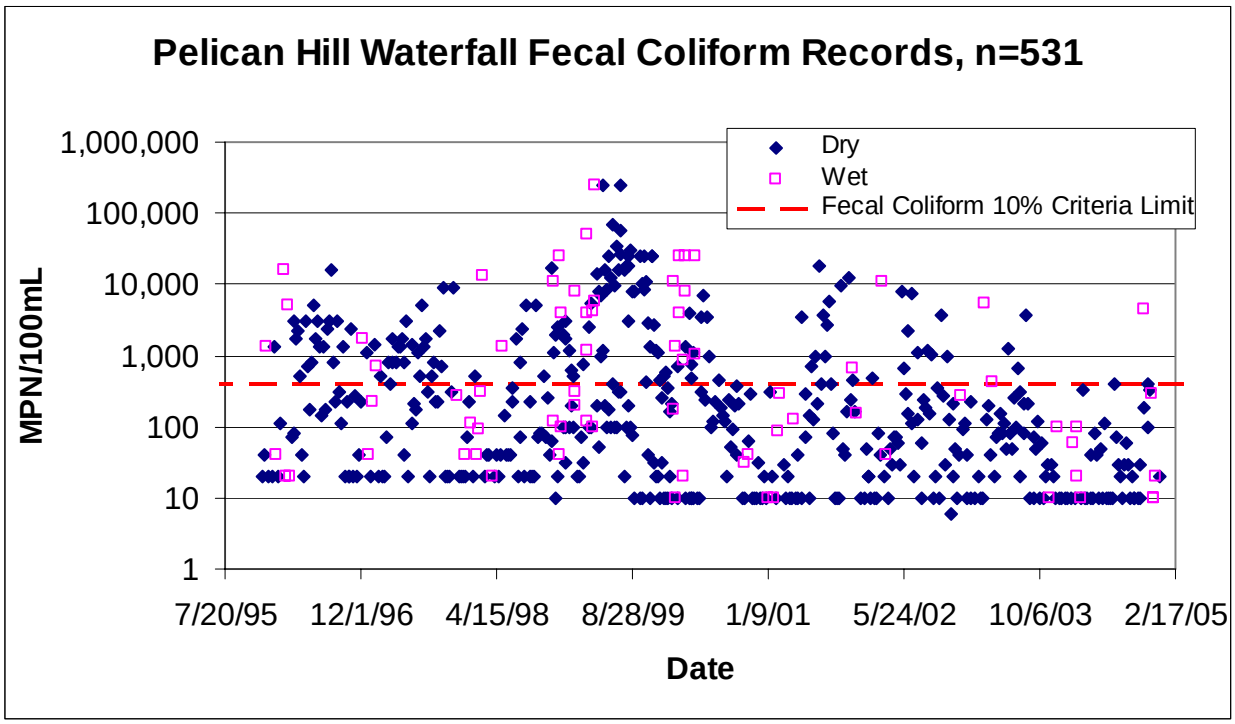


Figure A 15: Pelican Hill Waterfall fecal coliform data and corresponding cumulative frequency distribution



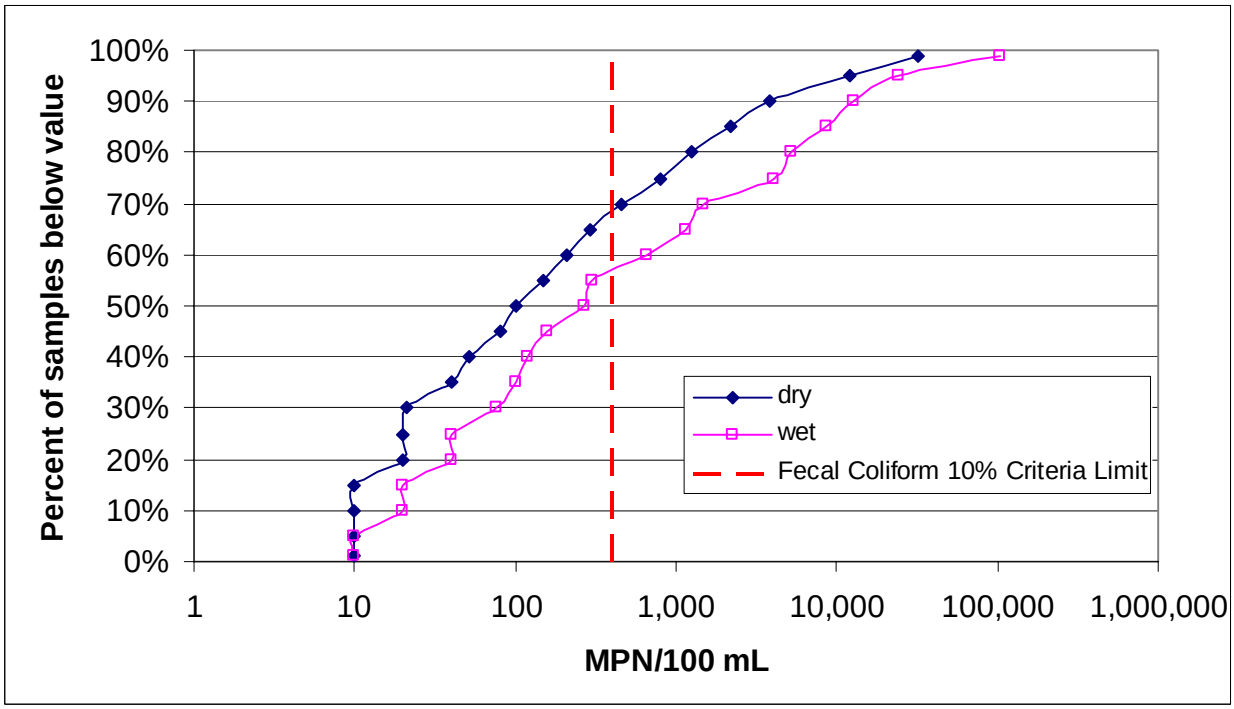
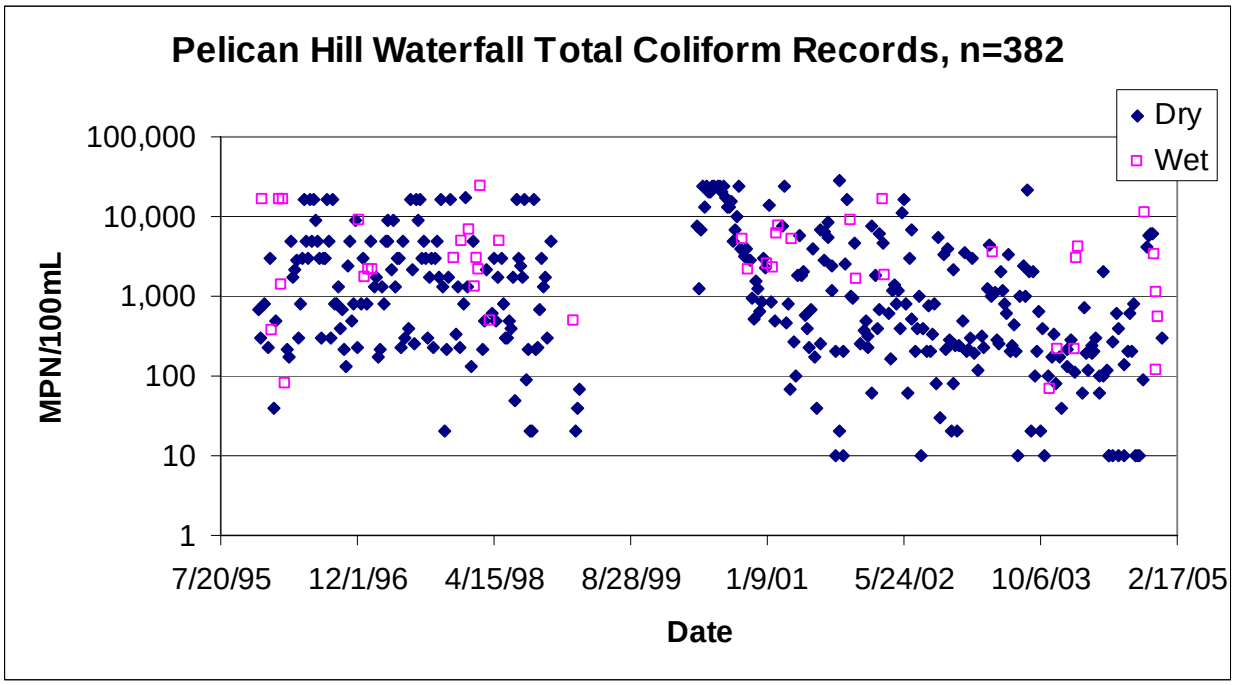


Figure A 16: Pelican Hill Waterfall total coliform data and corresponding cumulative frequency distribution



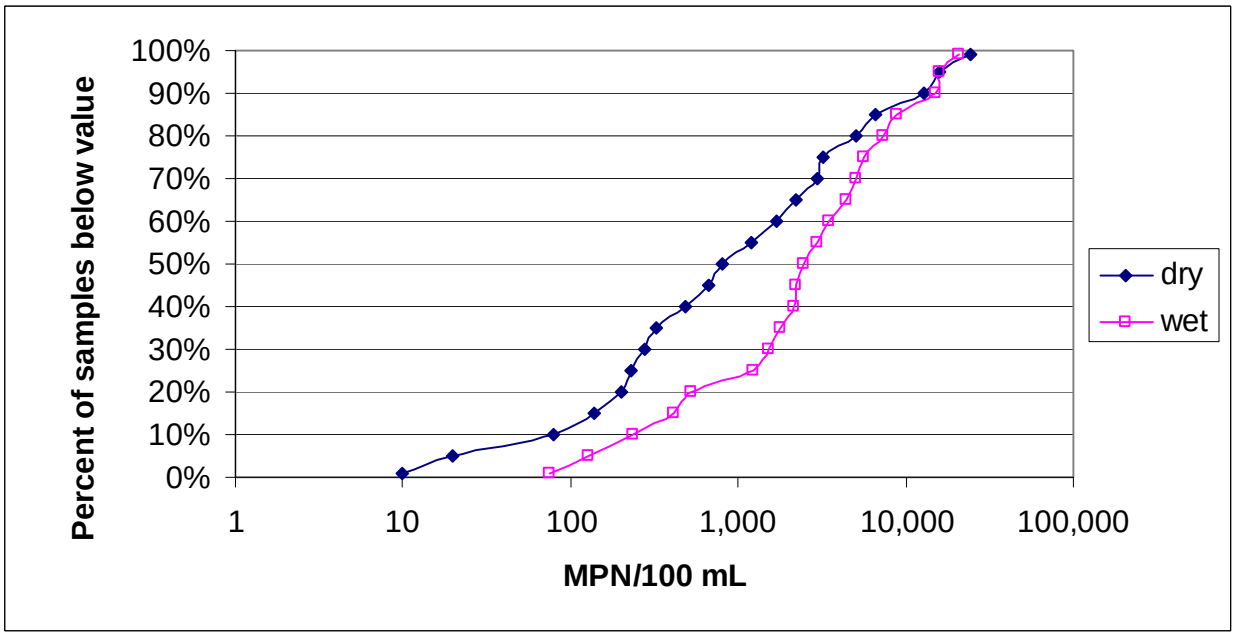


Figure A 17: Percentage of samples from Pelican Hill Waterfall which exceed thresholds, by month

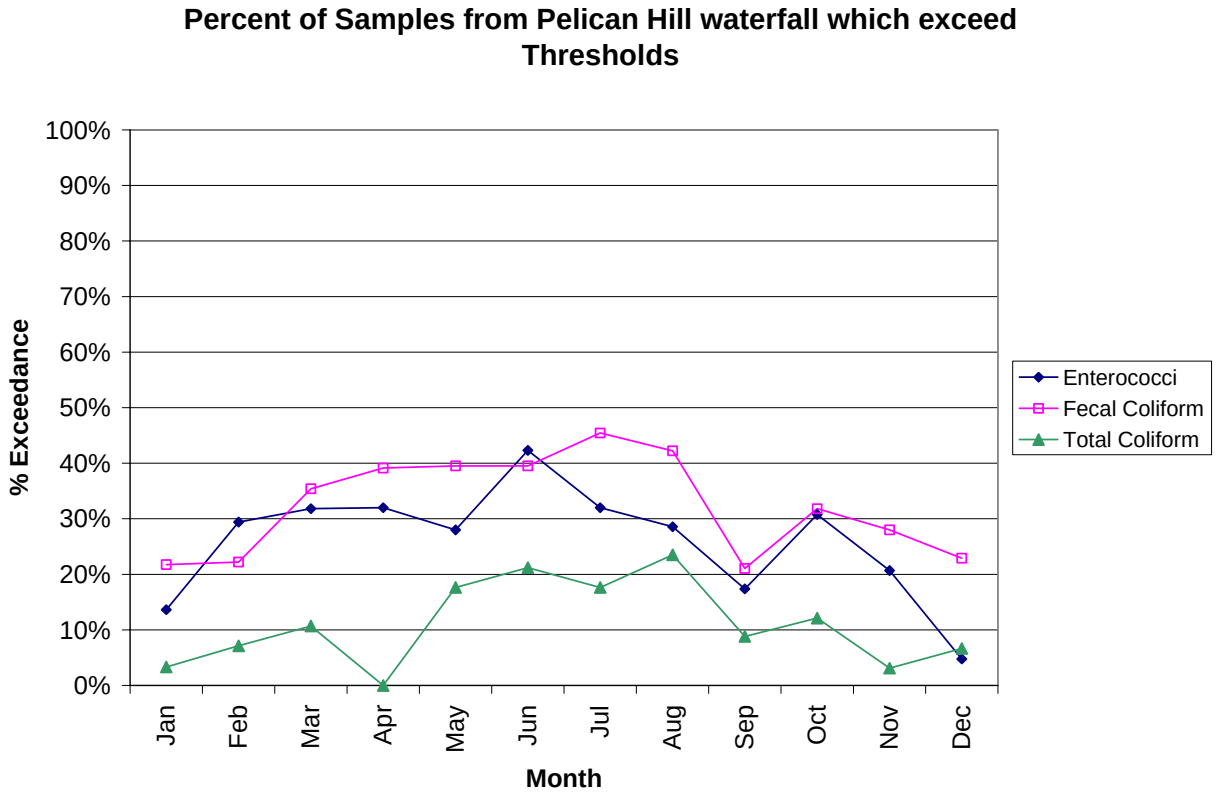
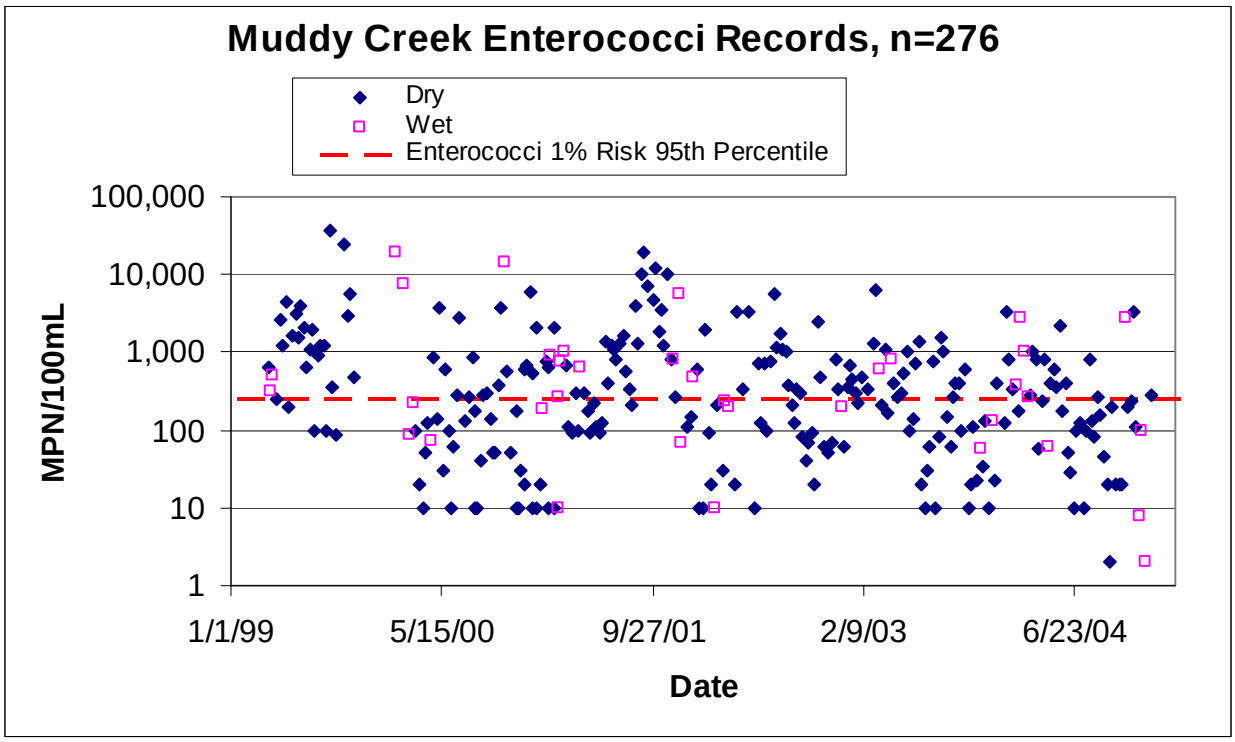


Figure A 18: Muddy Creek enterococci data and corresponding cumulative frequency distribution



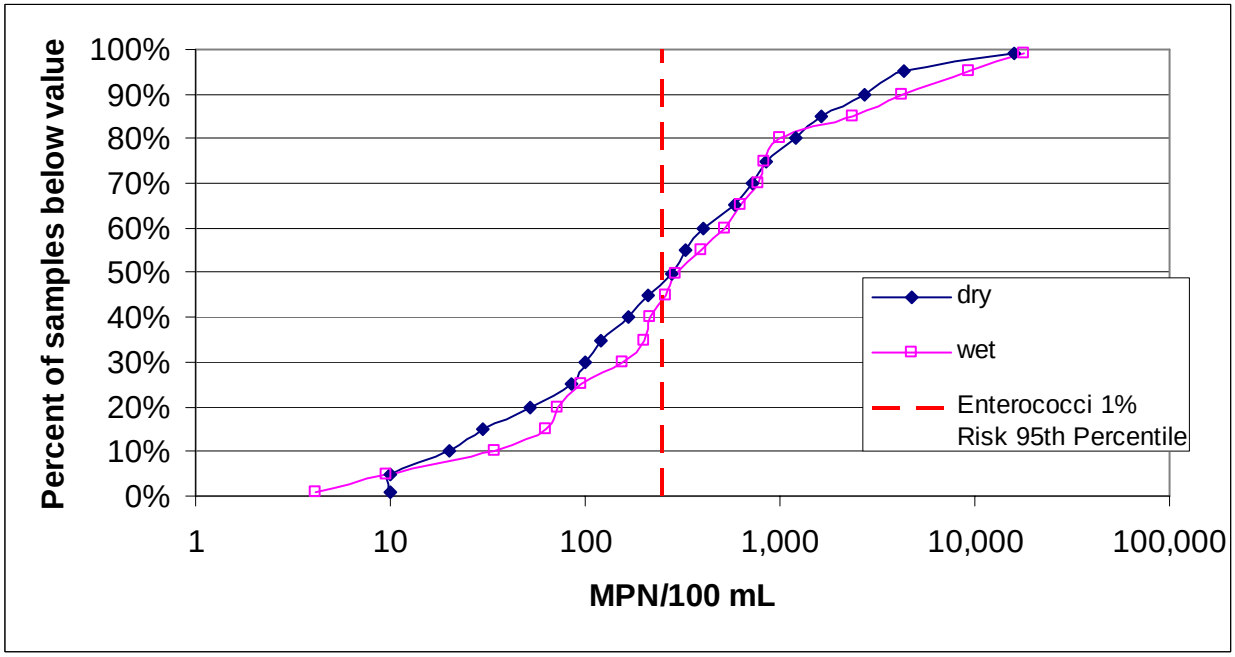
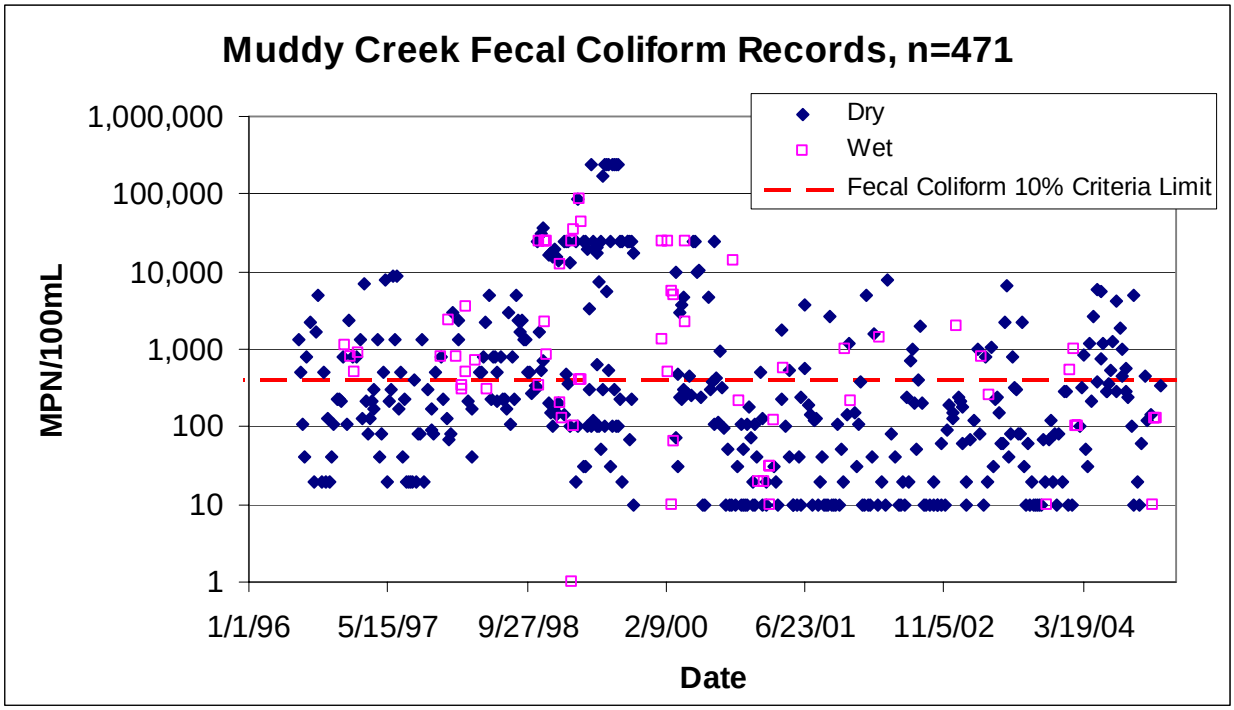


Figure A 19: Muddy Creek fecal coliform data and corresponding cumulative frequency distribution



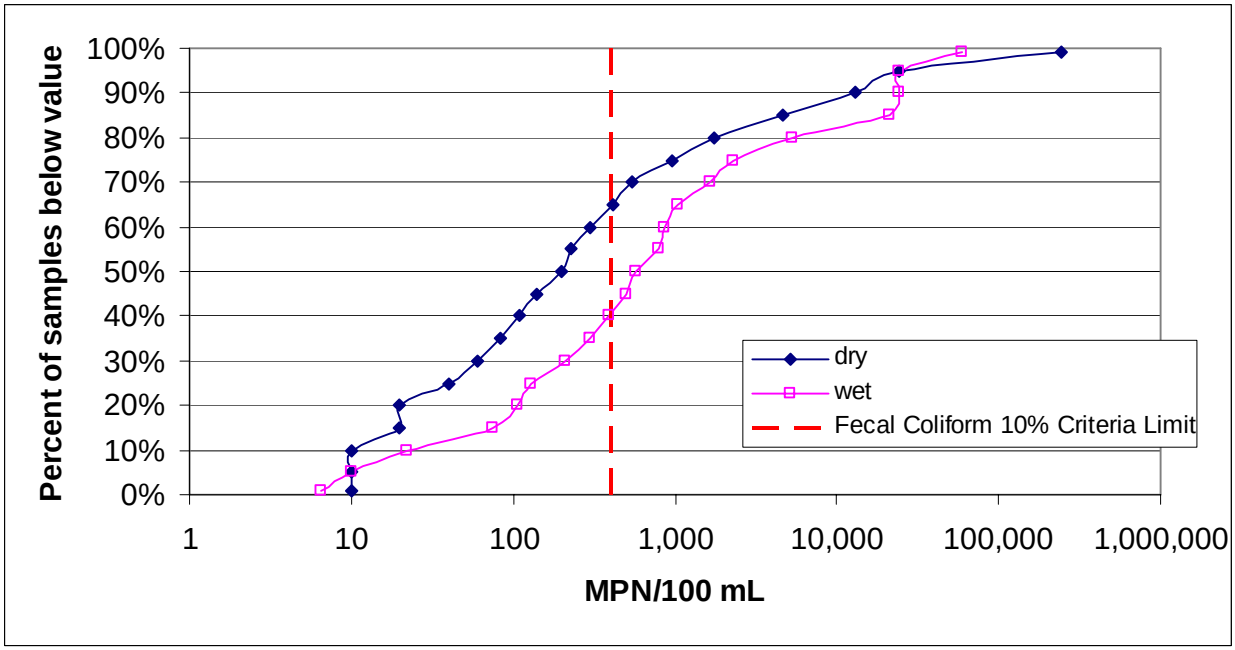
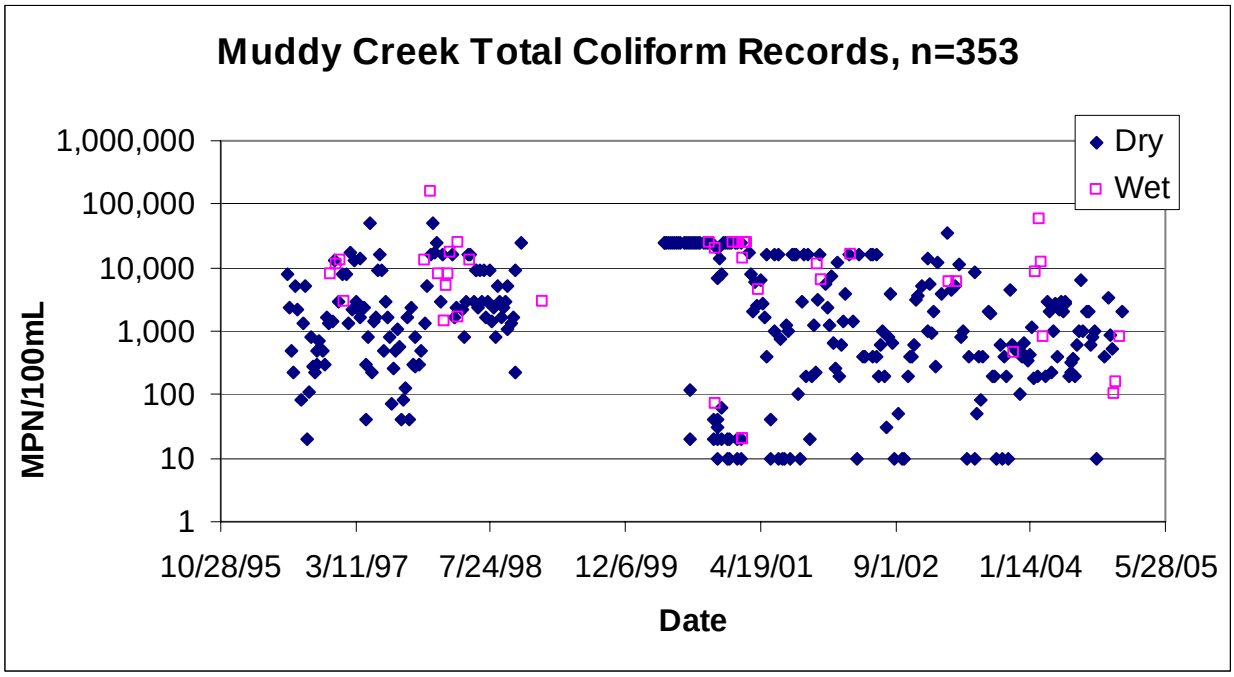


Figure A 20: Muddy Creek total coliform data and corresponding cumulative frequency distribution



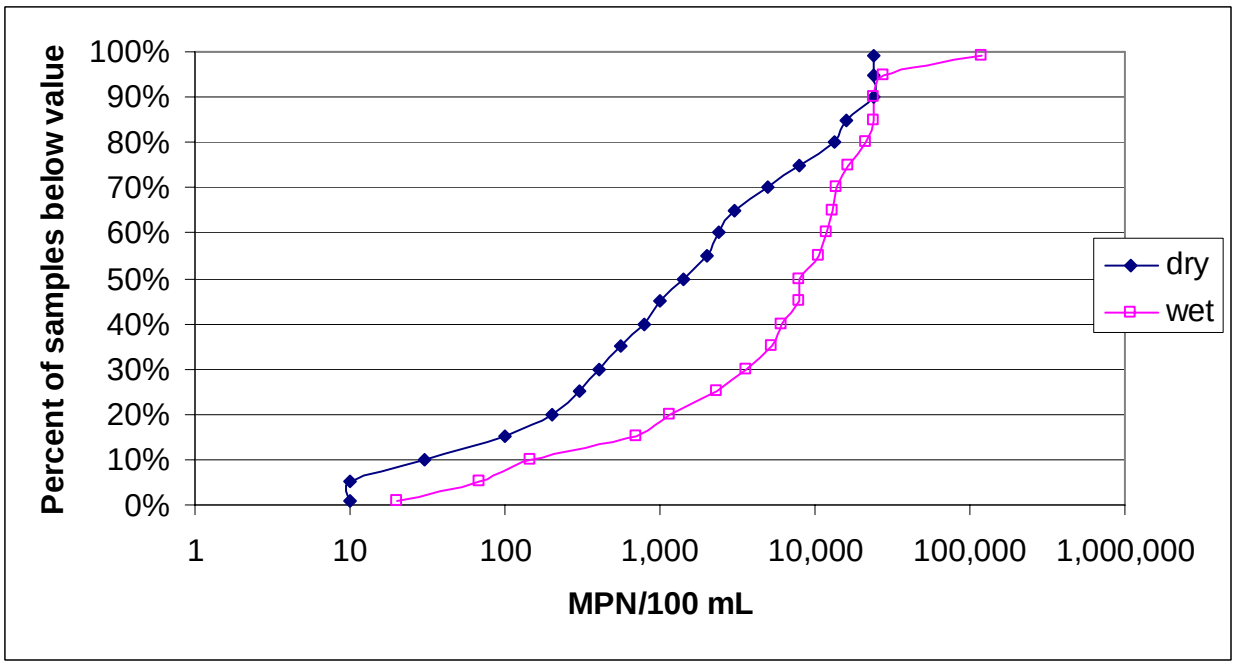


Figure A 21: Percentage of samples from Muddy Creek which exceed thresholds, by month

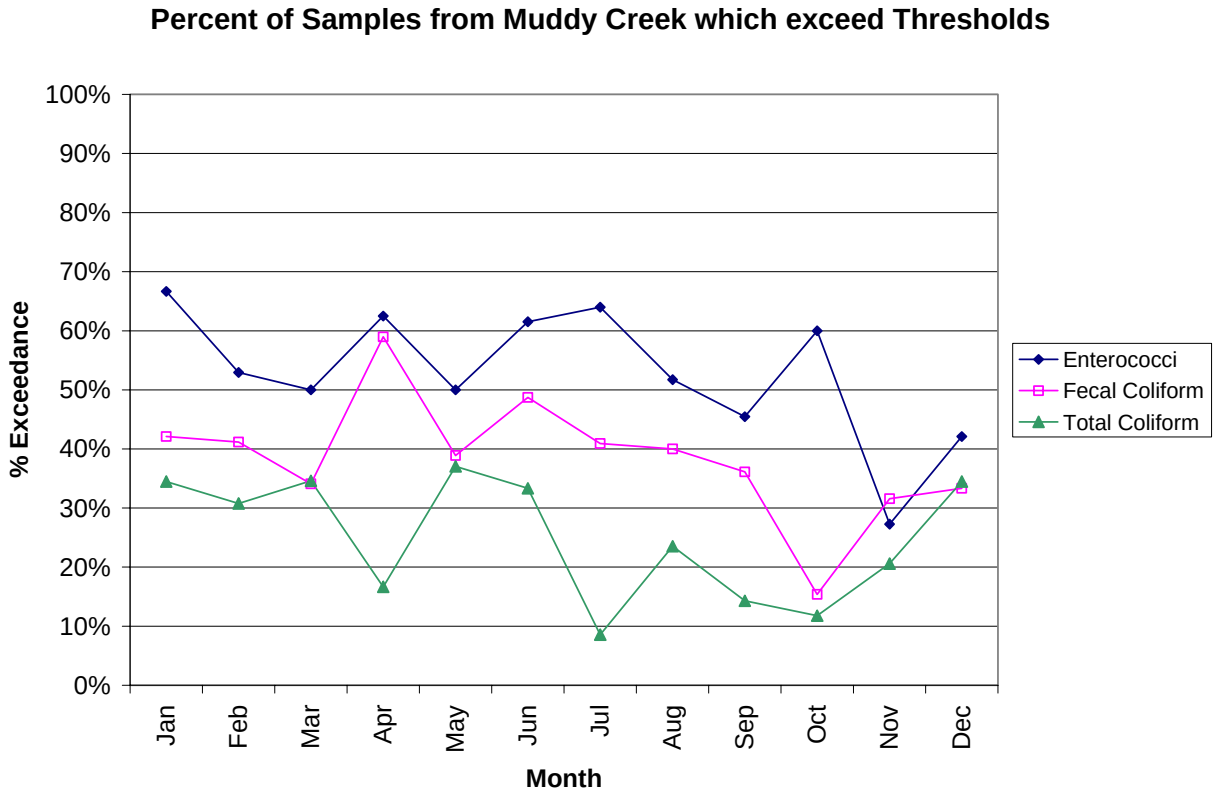
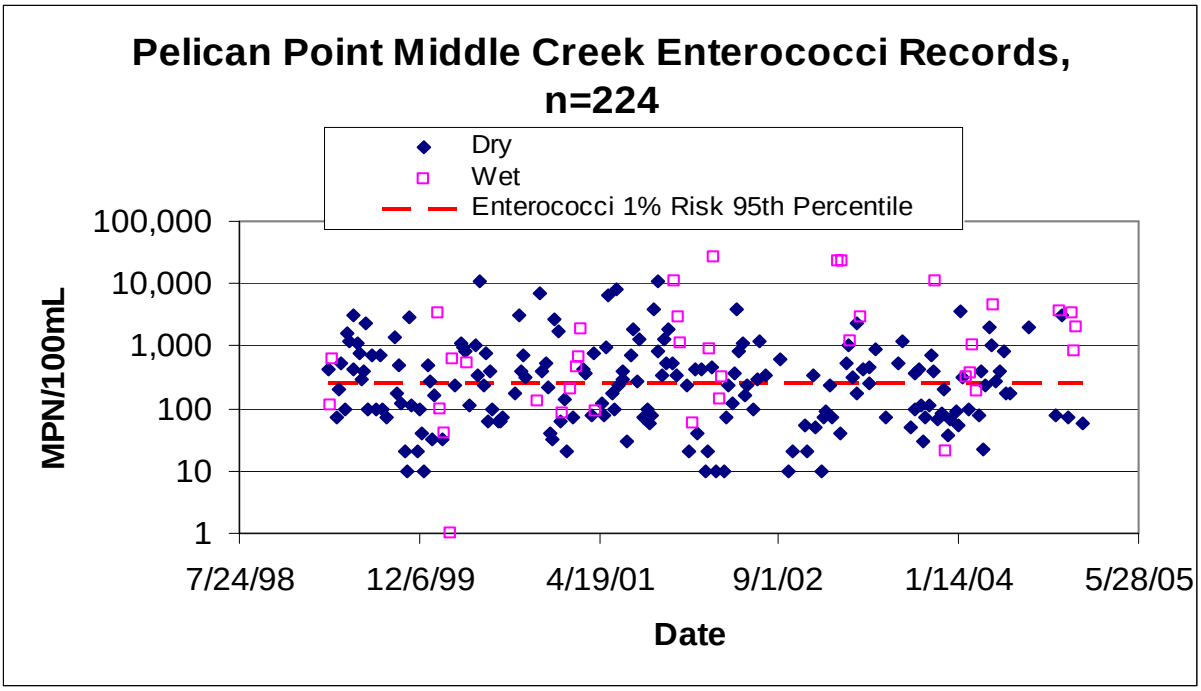


Figure A 22: Pelican Point Middle Creek enterococci data and corresponding cumulative frequency distribution



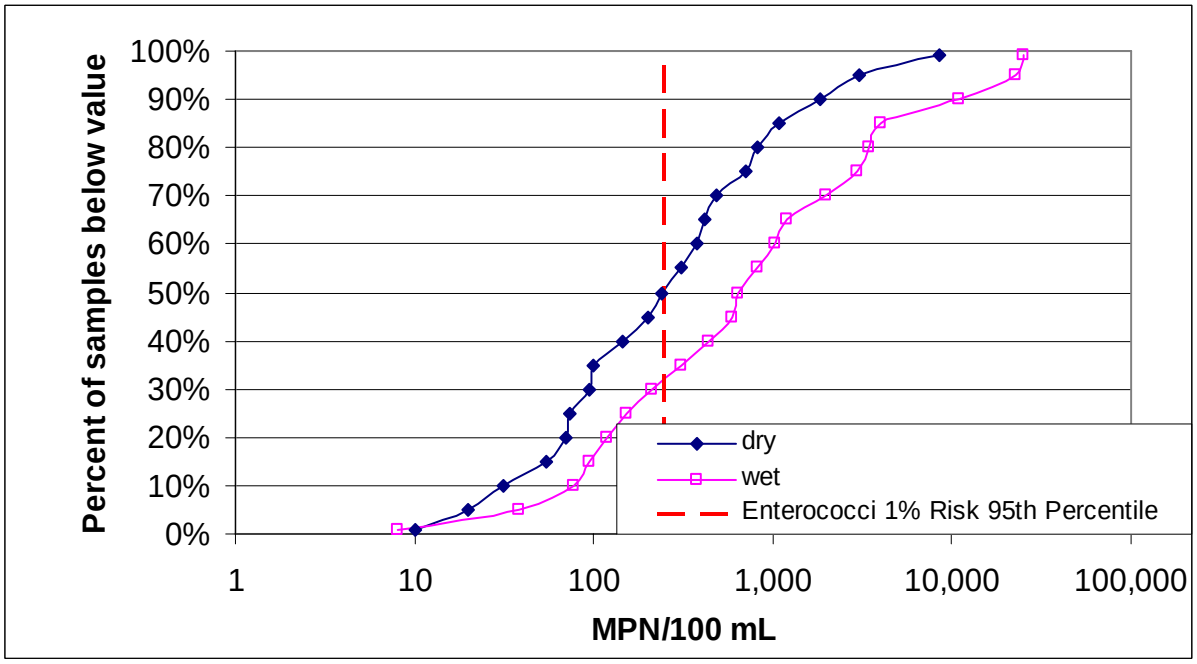
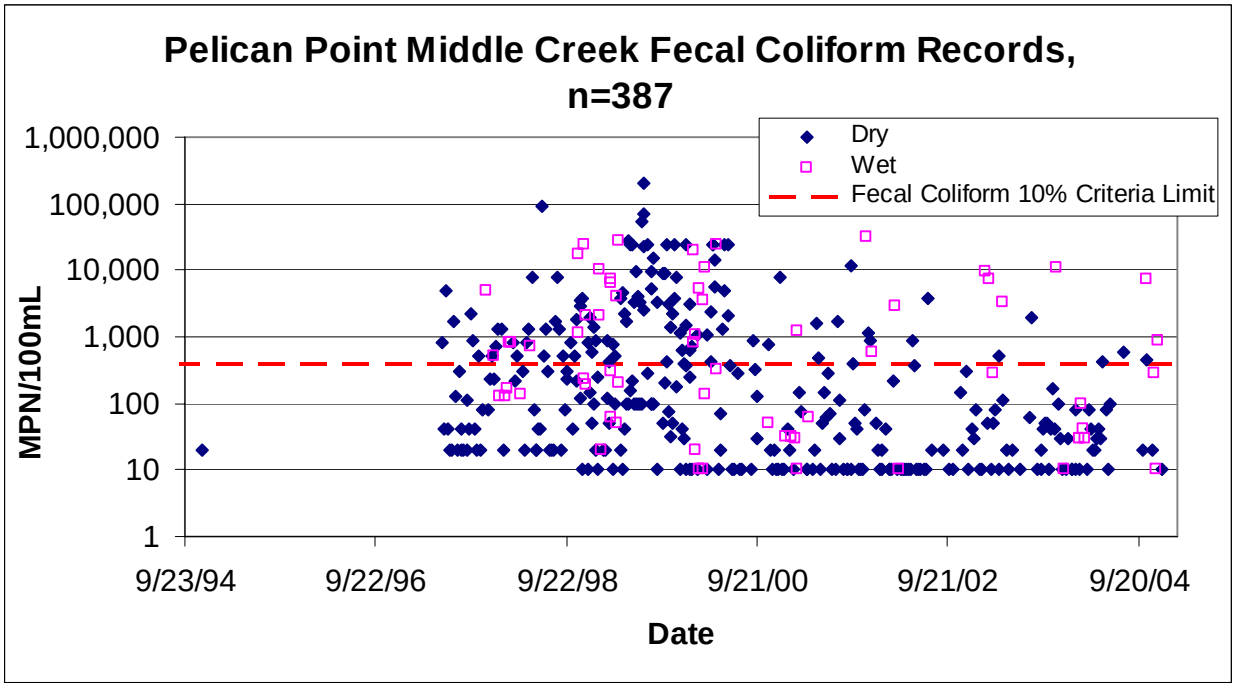


Figure A 23: Pelican Point Middle Creek fecal coliform data and corresponding cumulative frequency distribution



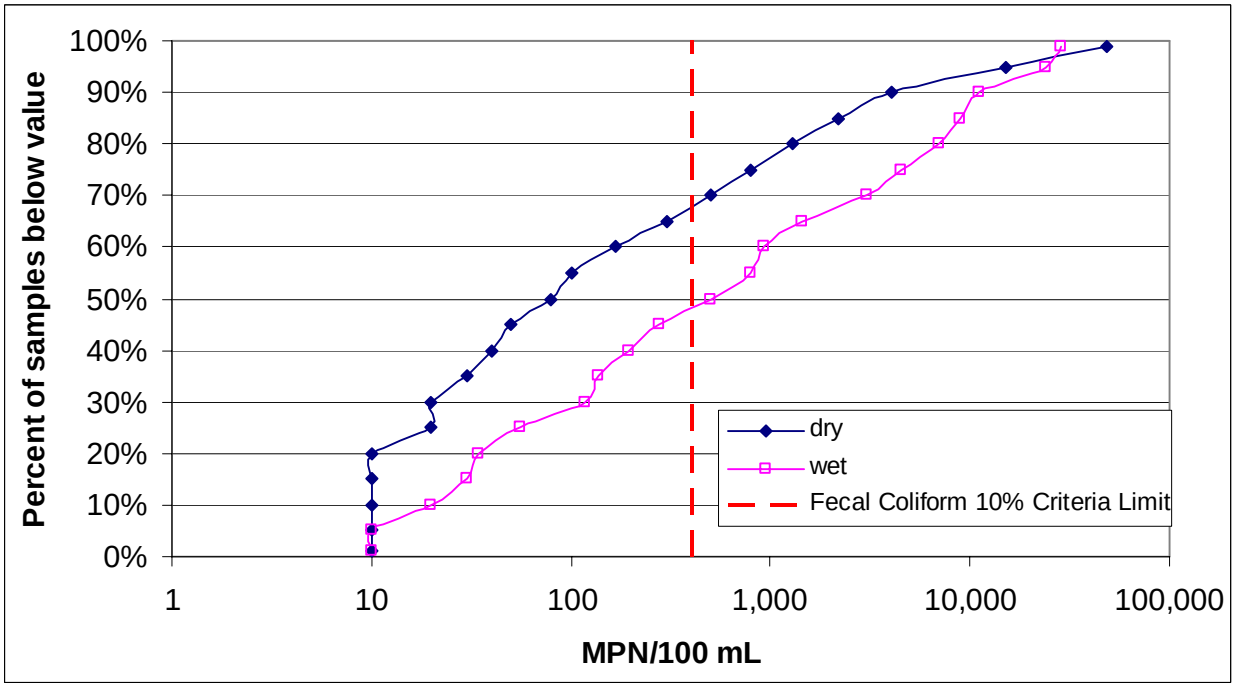
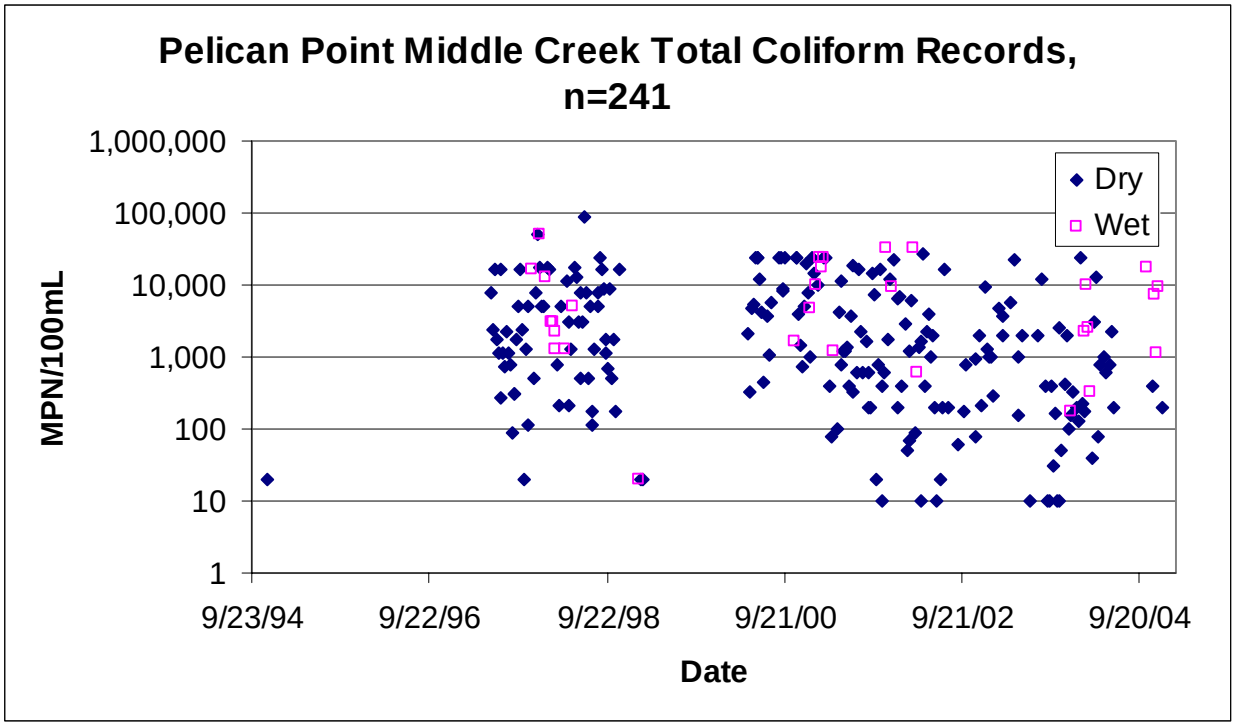


Figure A 24: Pelican Point Middle Creek total coliform data and corresponding cumulative frequency distribution



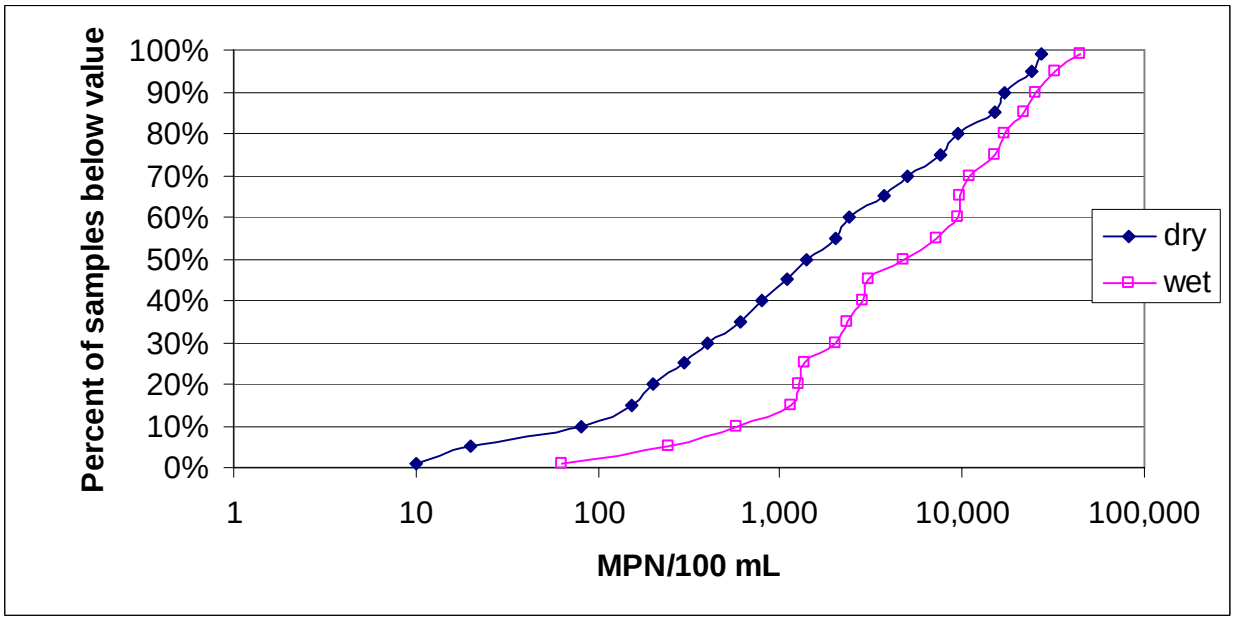


Figure A 25: Percentage of samples from Pelican Point Middle Creek which exceed thresholds, by month

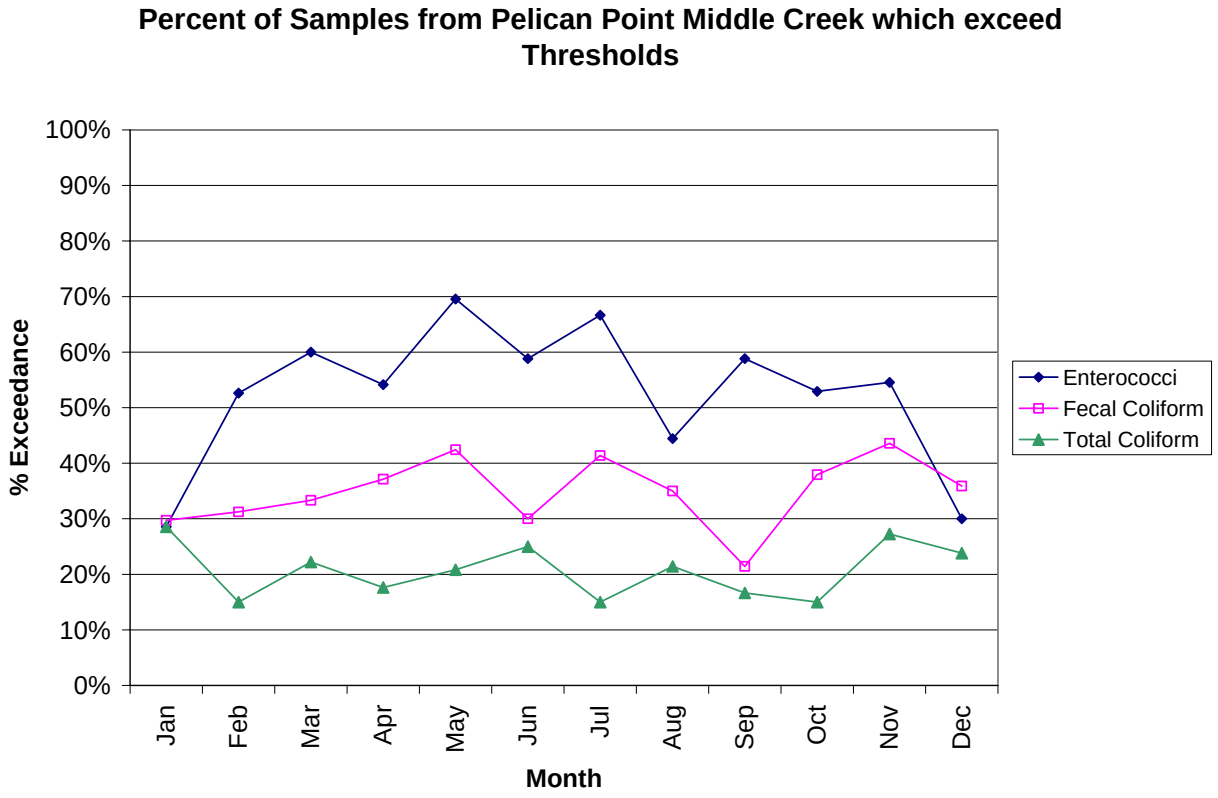
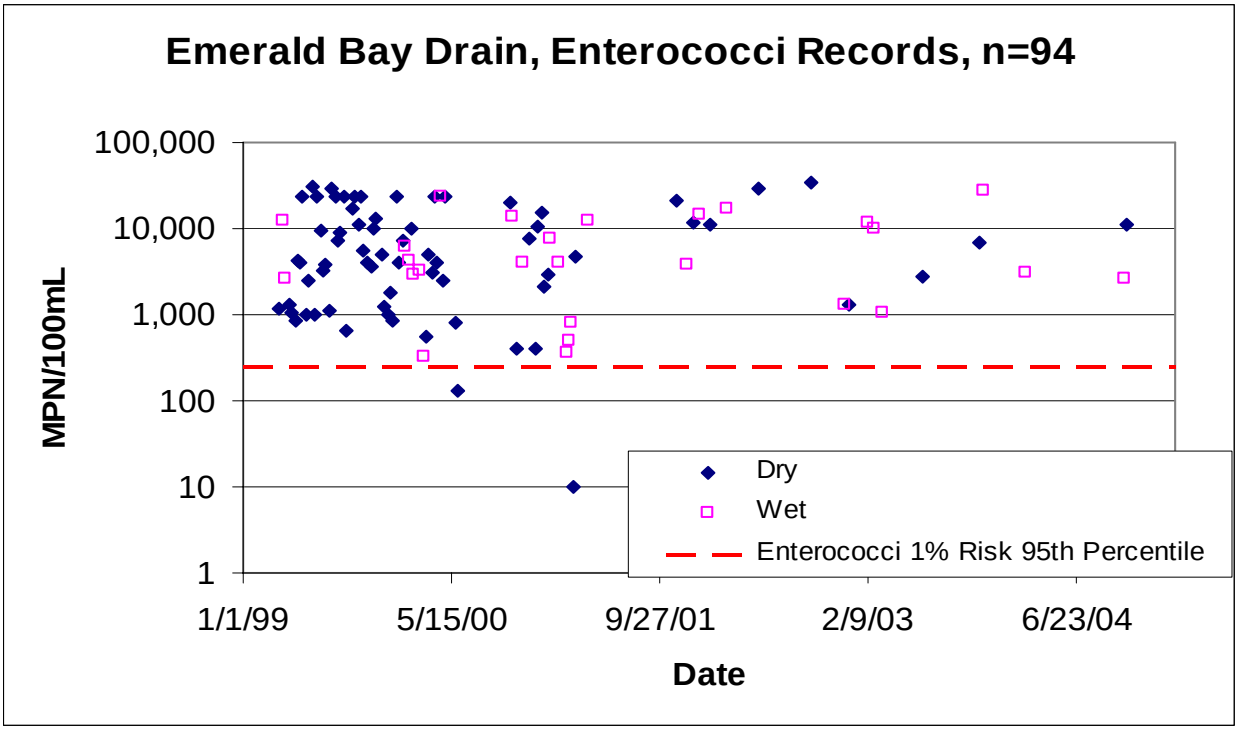


Figure A 26: Emerald Bay Drain enterococci data and corresponding cumulative frequency distribution



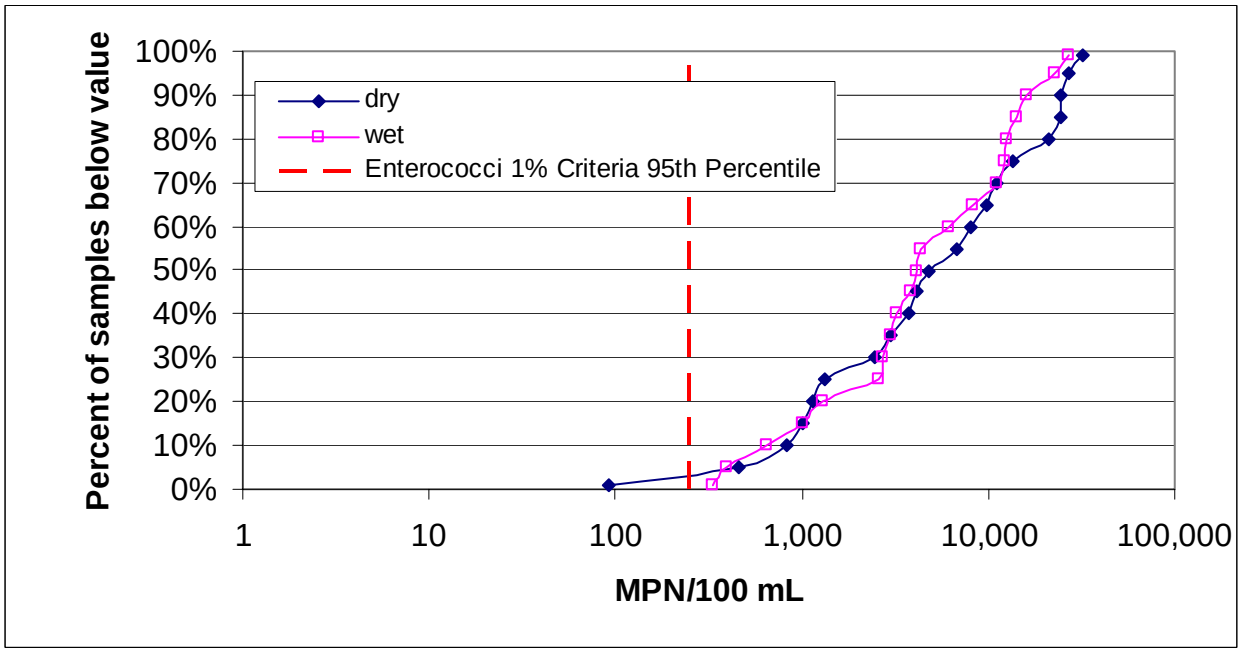
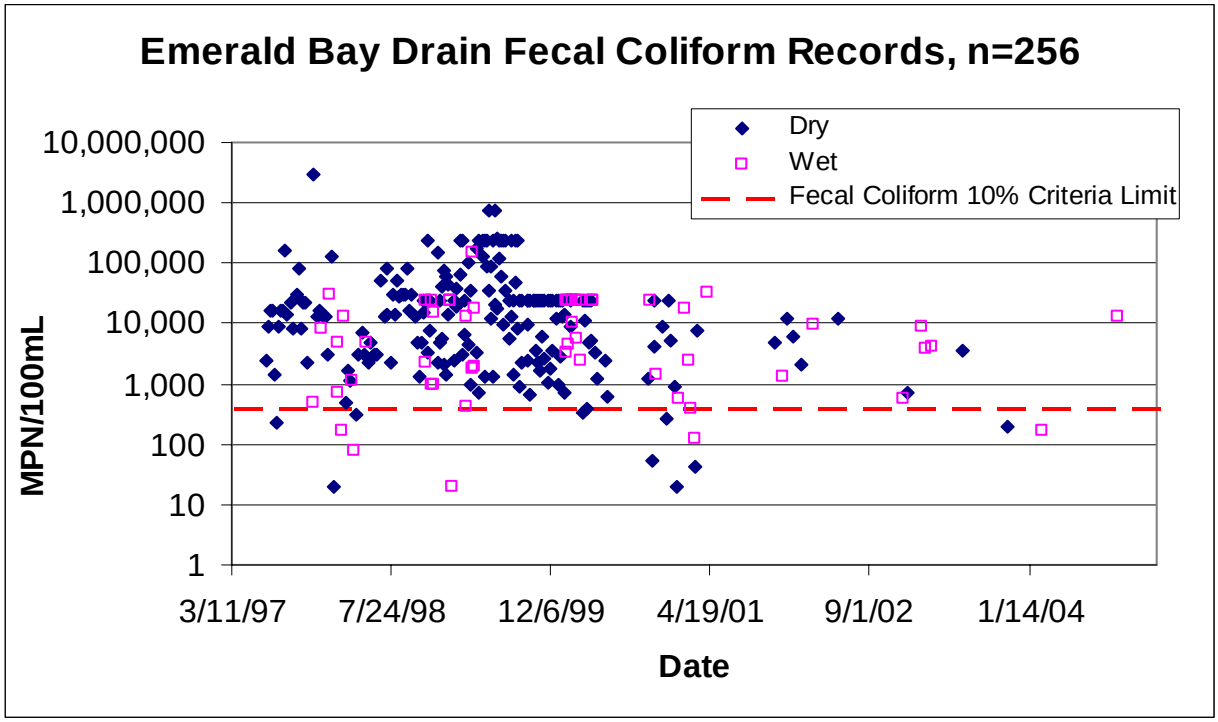


Figure A 27: Emerald Bay Drain fecal coliform data and corresponding cumulative frequency distribution



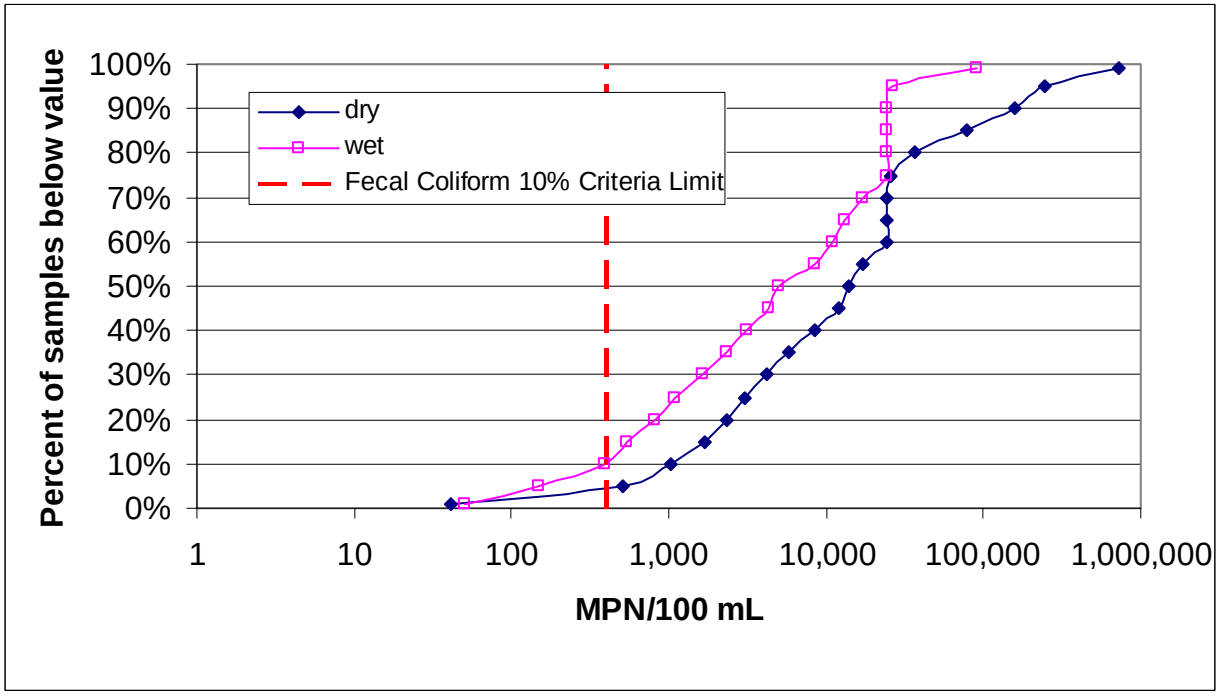
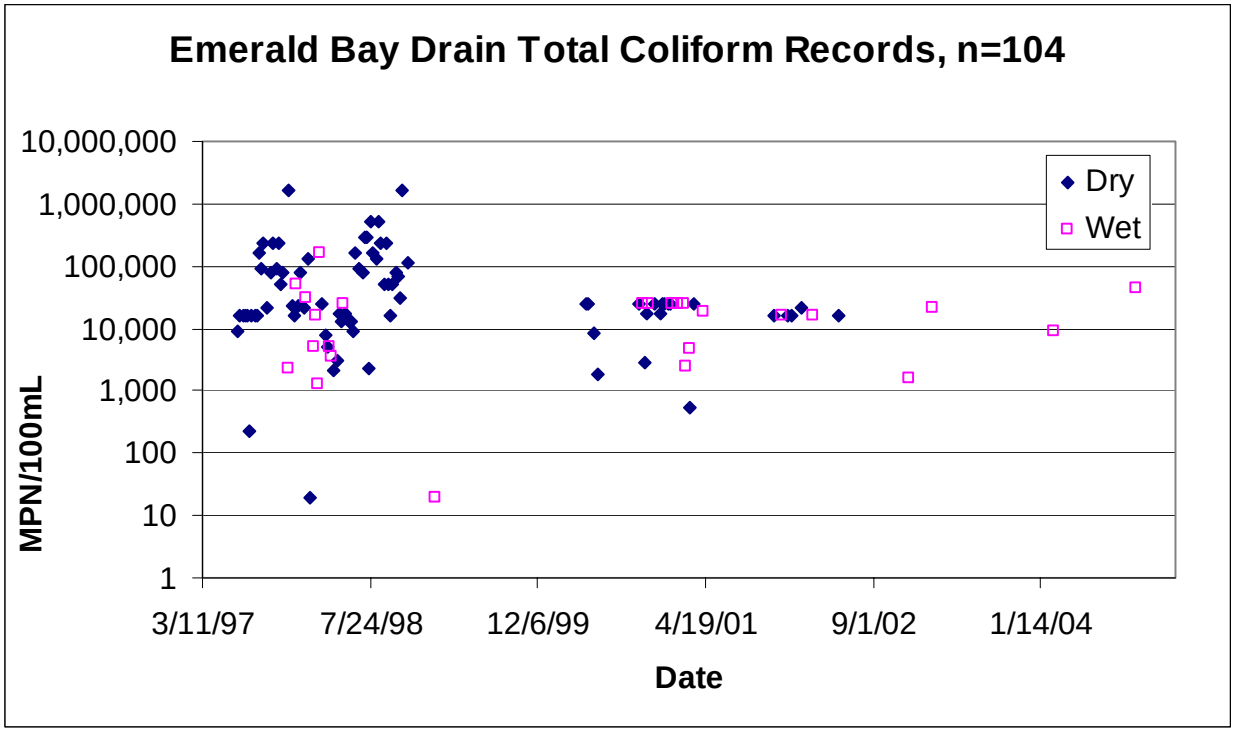


Figure A 28: Emerald Bay Drain total coliform data and corresponding cumulative frequency distribution



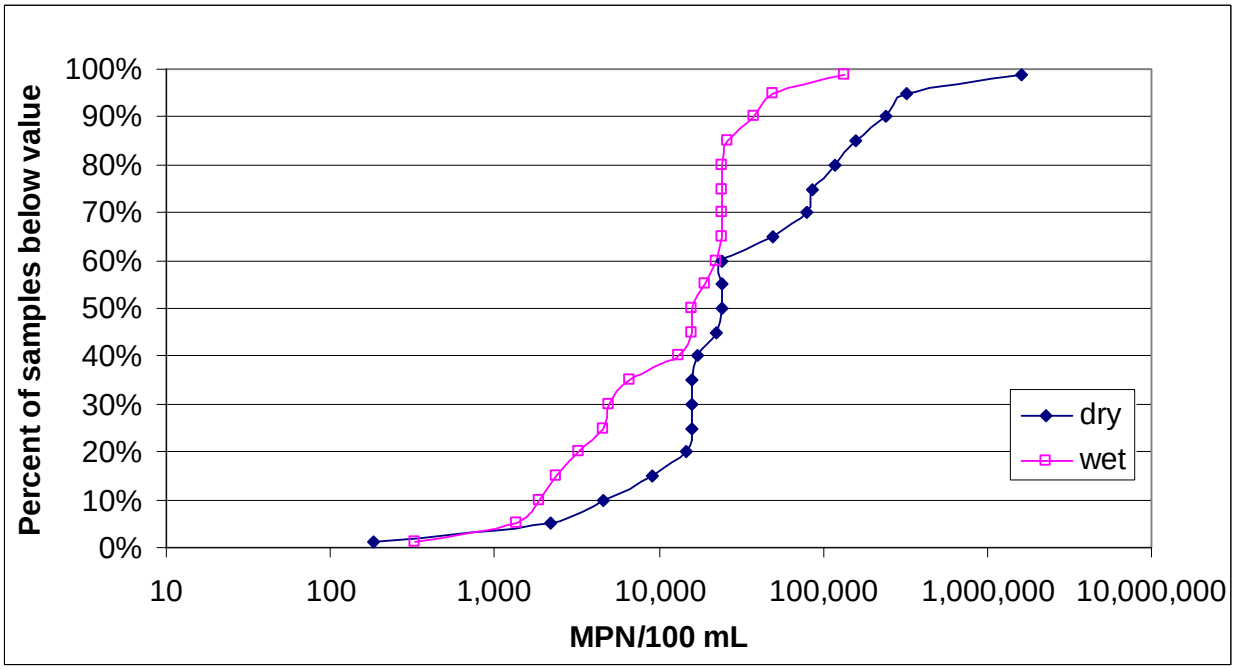


Figure A 29: Percentage of samples from the Emerald Bay Drain which exceed thresholds, by month

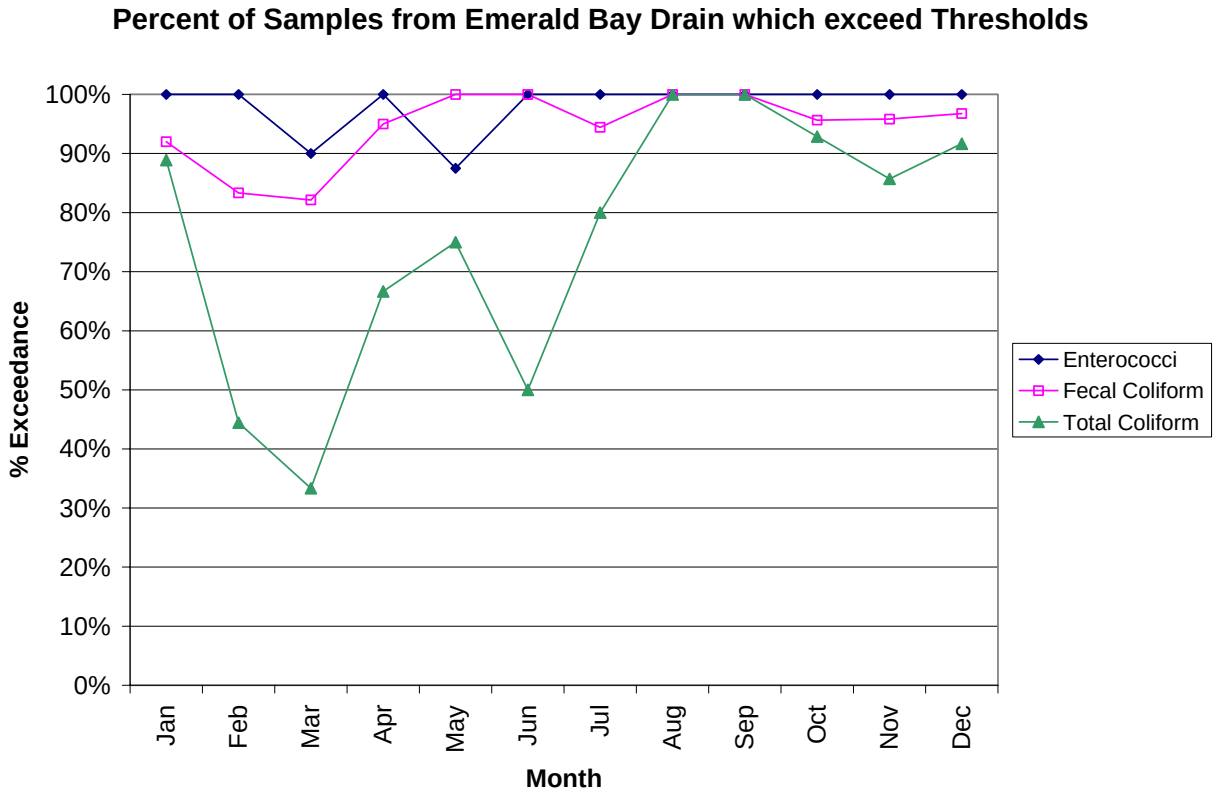
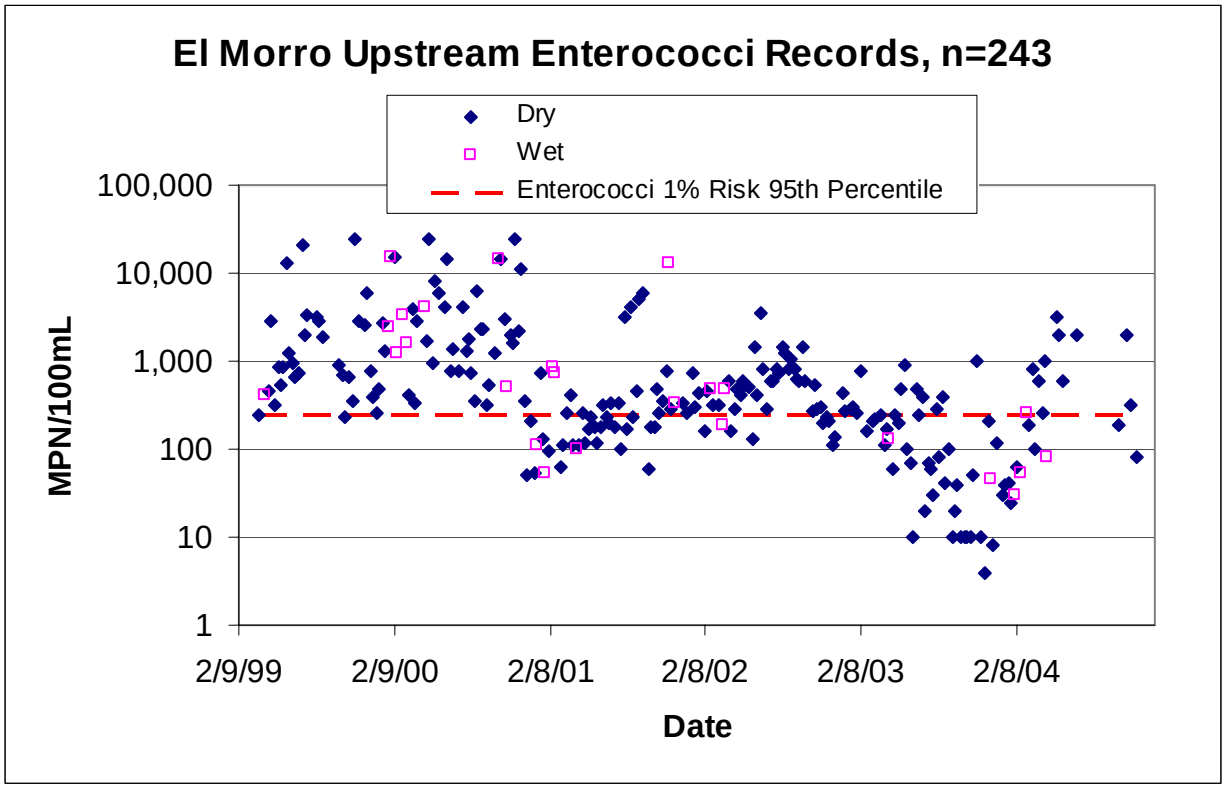


Figure A 30: El Morro Creek Upstream enterococci data and corresponding cumulative frequency distribution



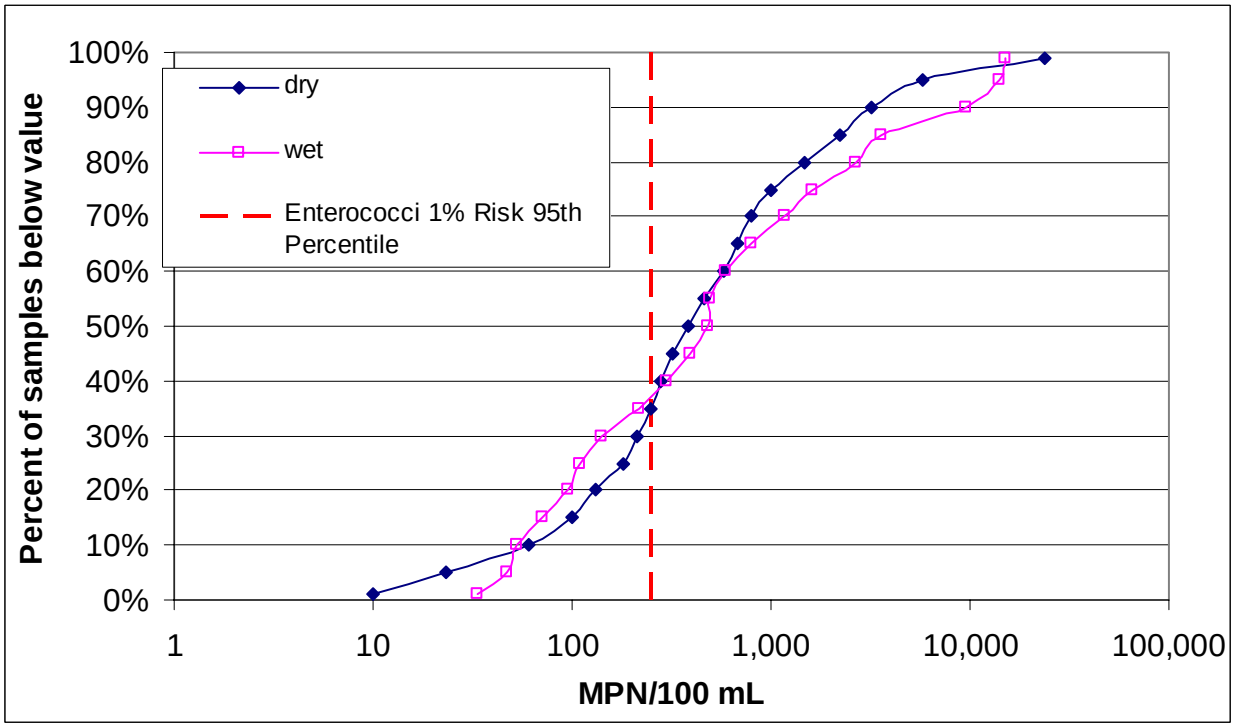
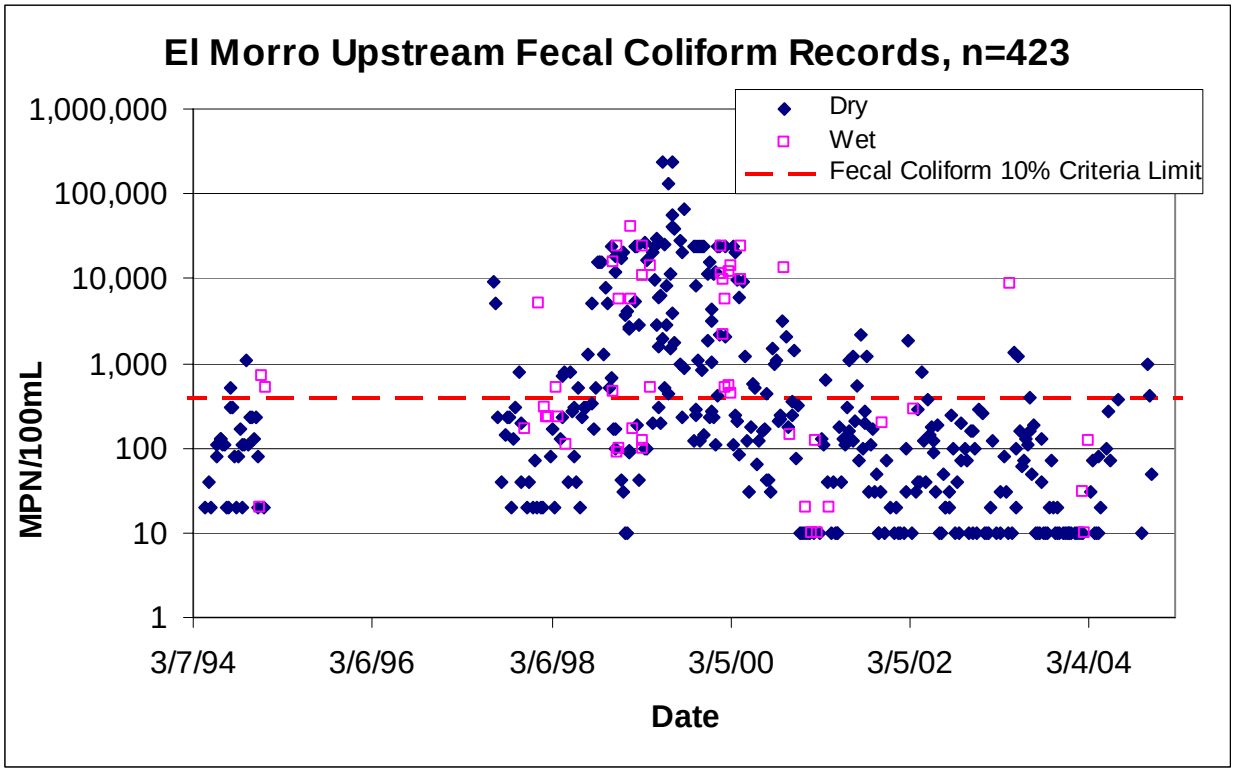


Figure A 31: El Morro Creek Upstream fecal coliform data and corresponding cumulative frequency distribution



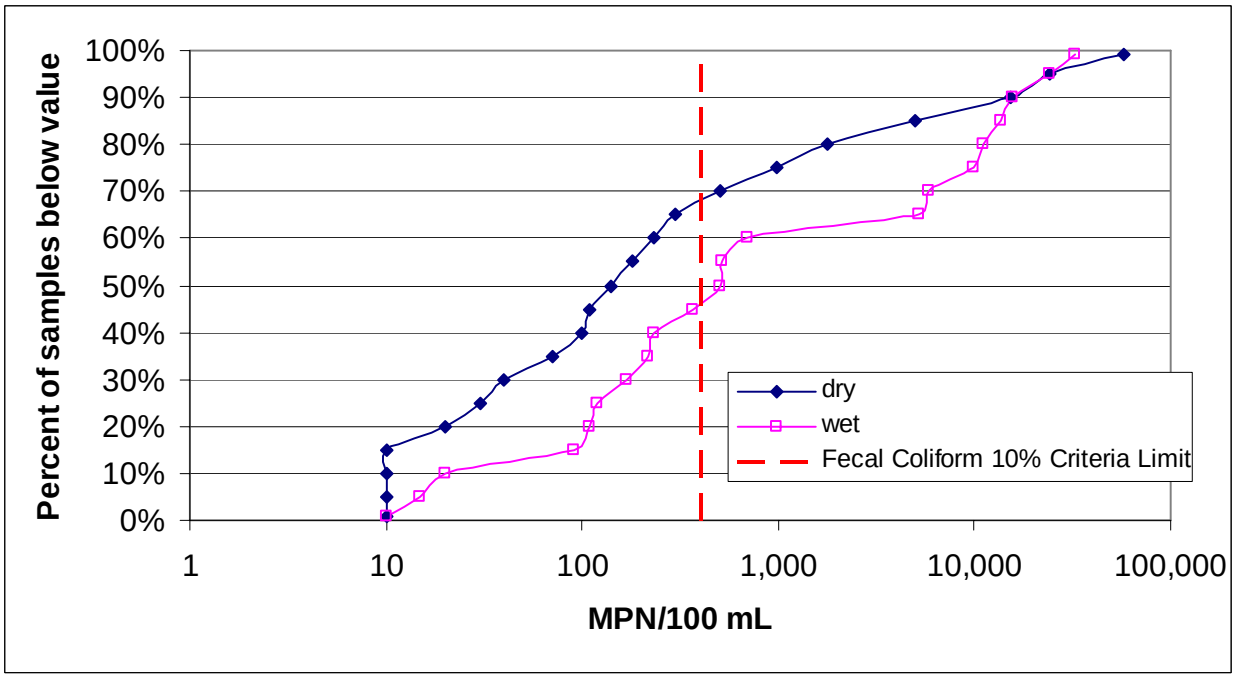
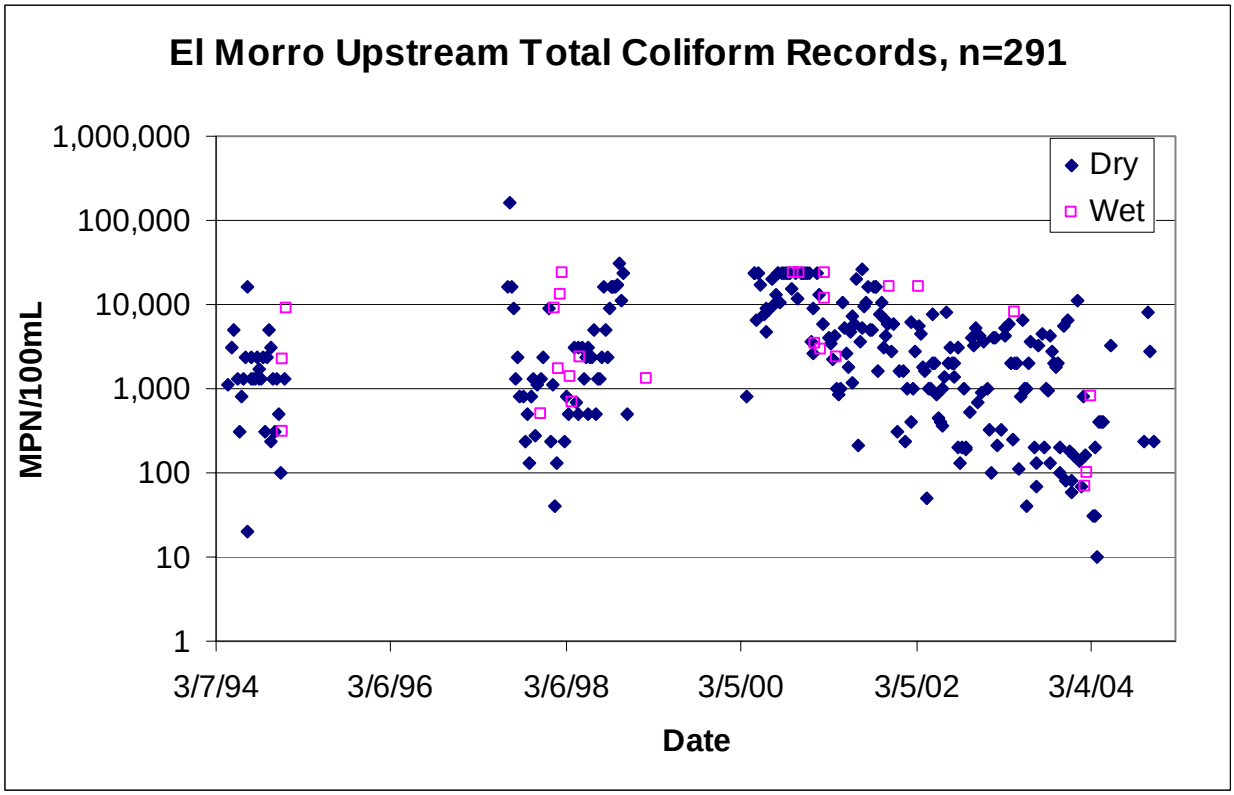


Figure A 32: El Morro Creek Upstream total coliform data and corresponding cumulative frequency distribution



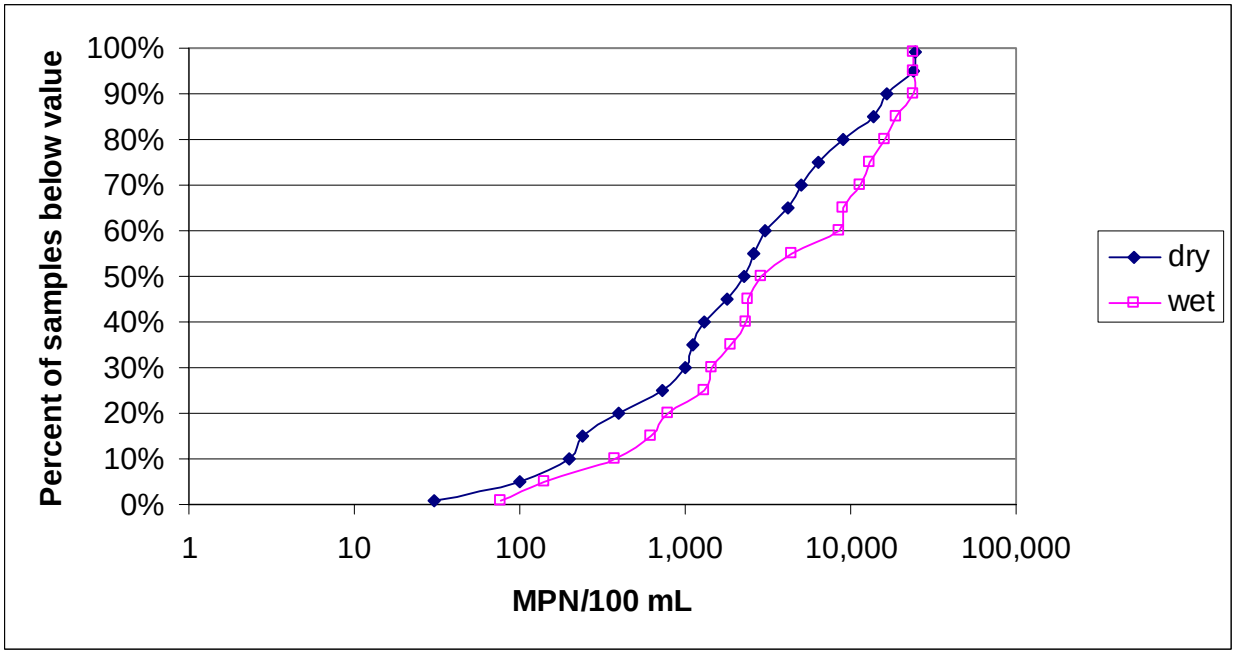


Figure A 33: Percentage of samples from El Morro Creek Upstream which exceed thresholds, by month

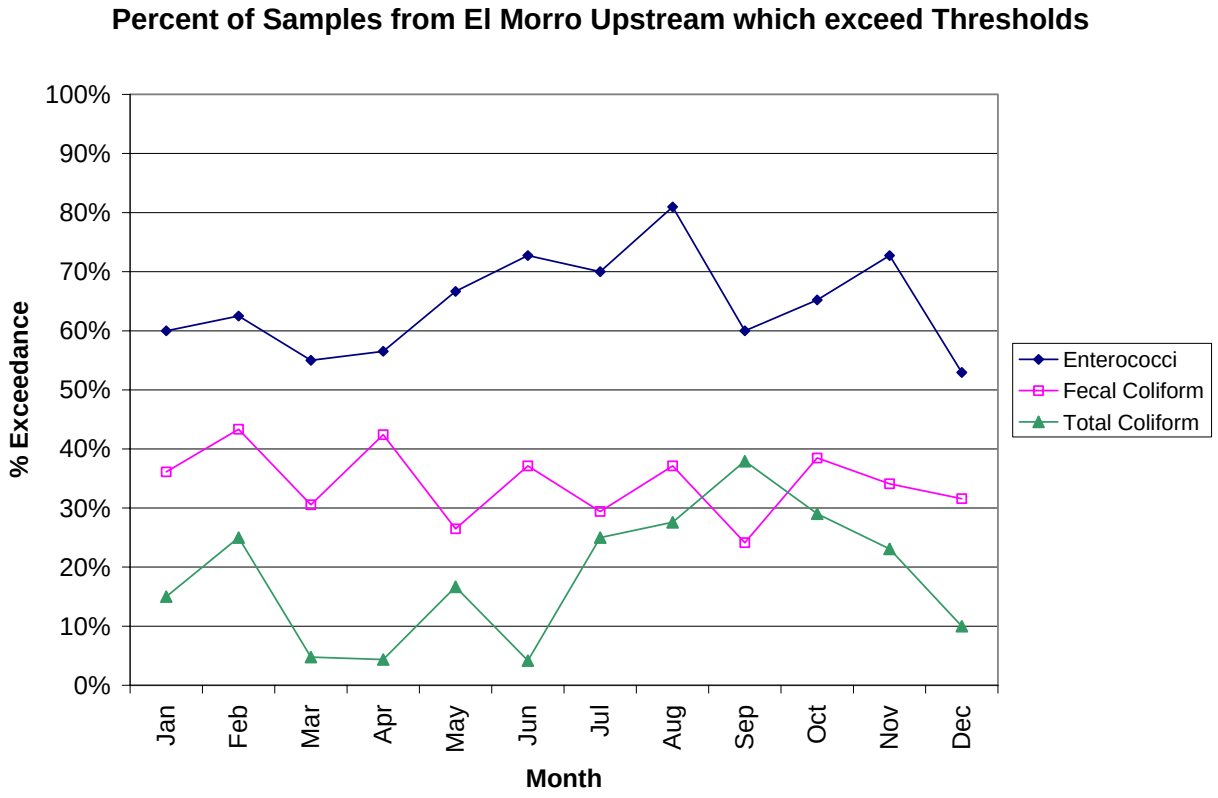
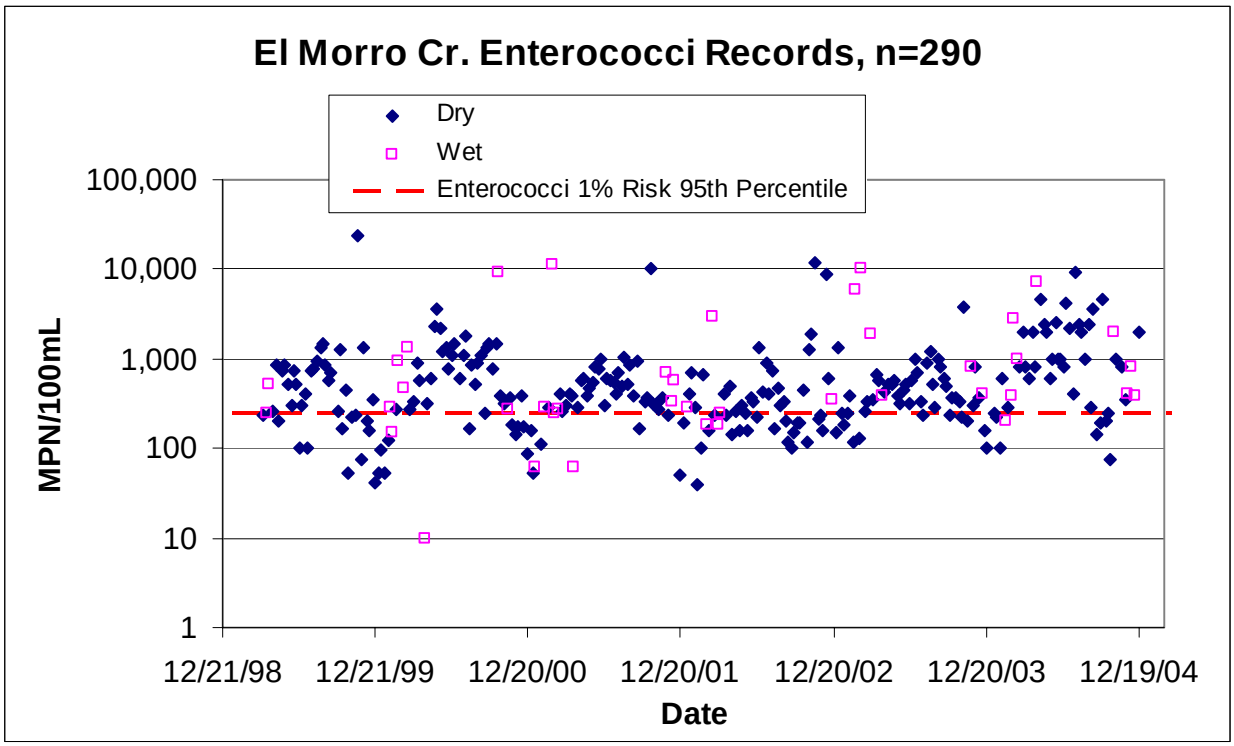


Figure A 34: El Morro Creek enterococci data and corresponding cumulative frequency distribution



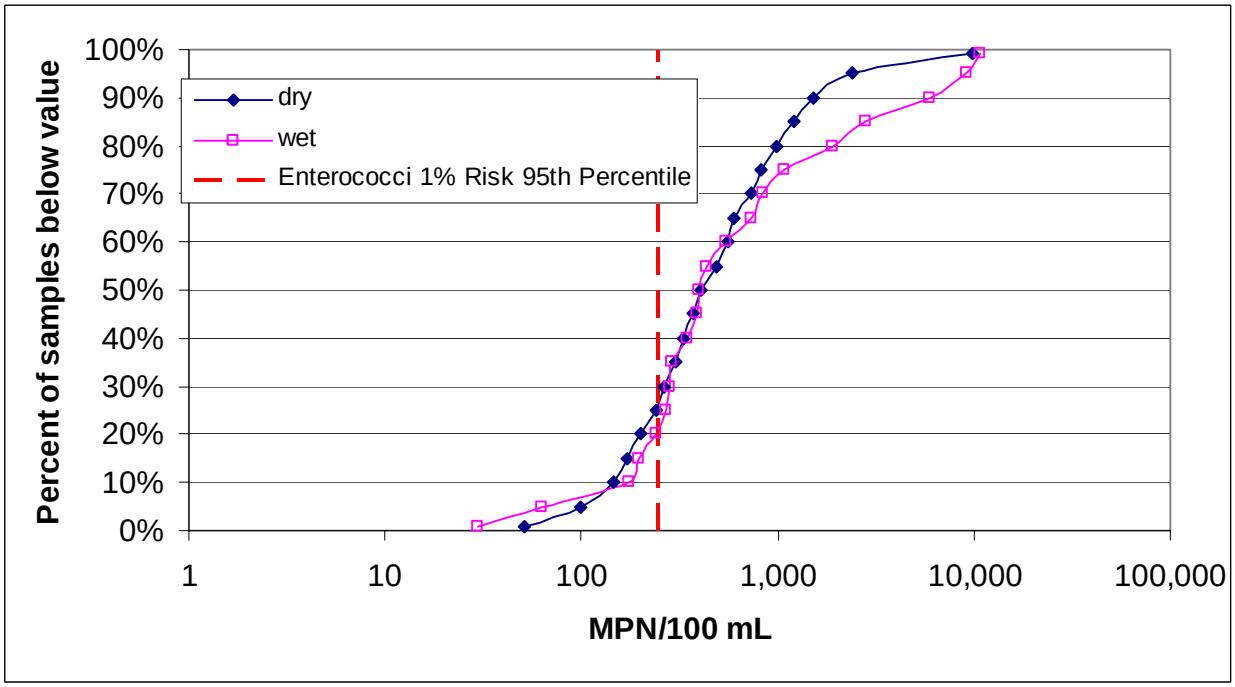
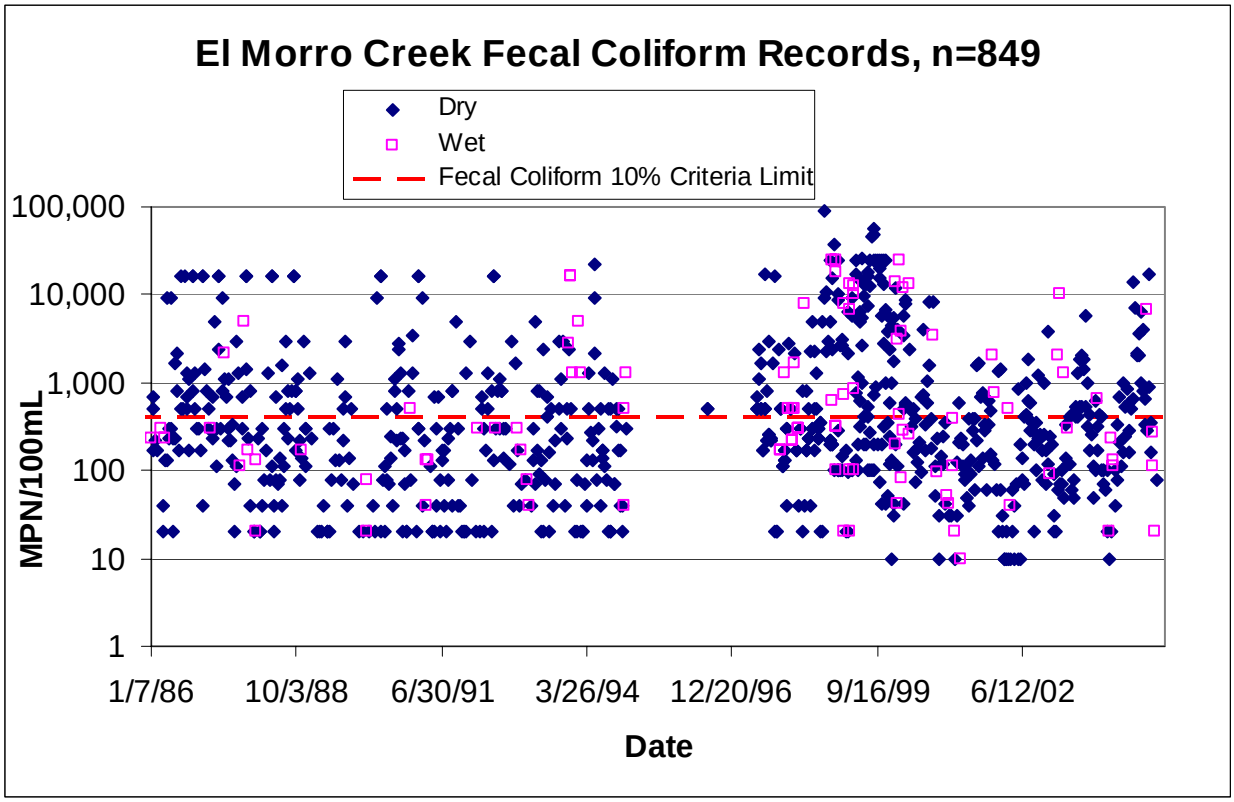


Figure A 35: El Morro Creek fecal coliform data and corresponding cumulative frequency distribution



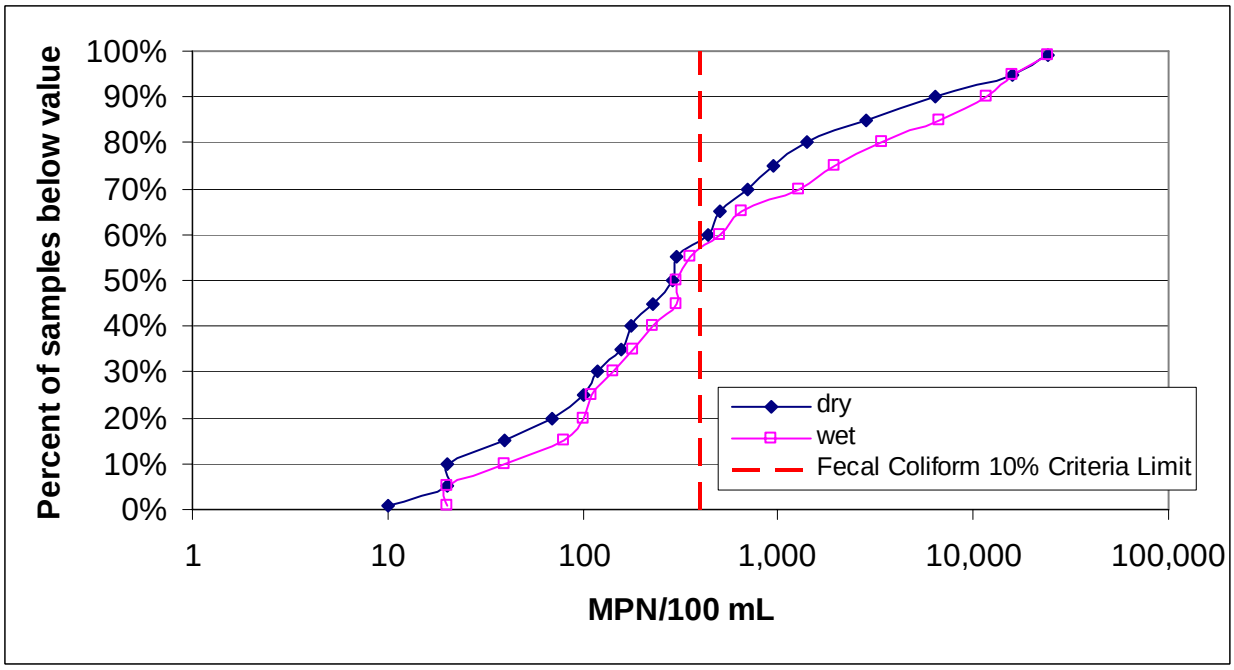
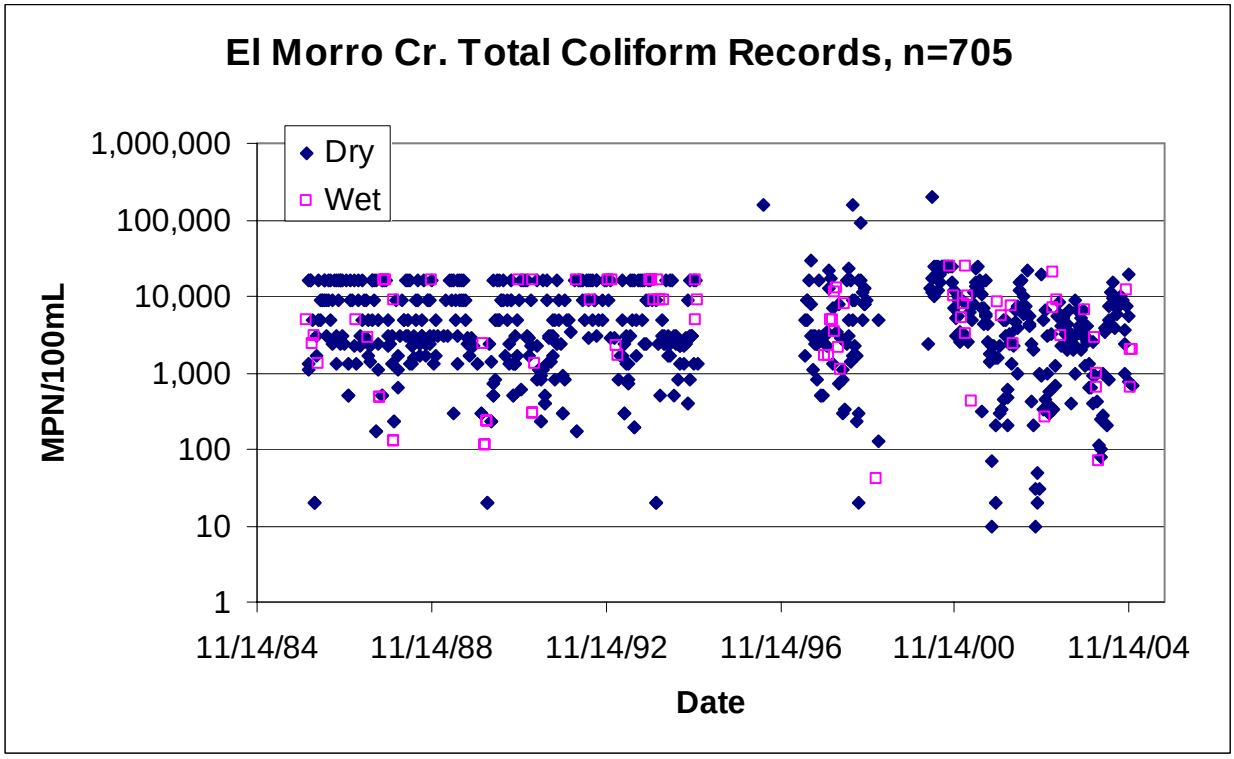


Figure A 36: El Morro Creek total coliform data and corresponding cumulative frequency distribution



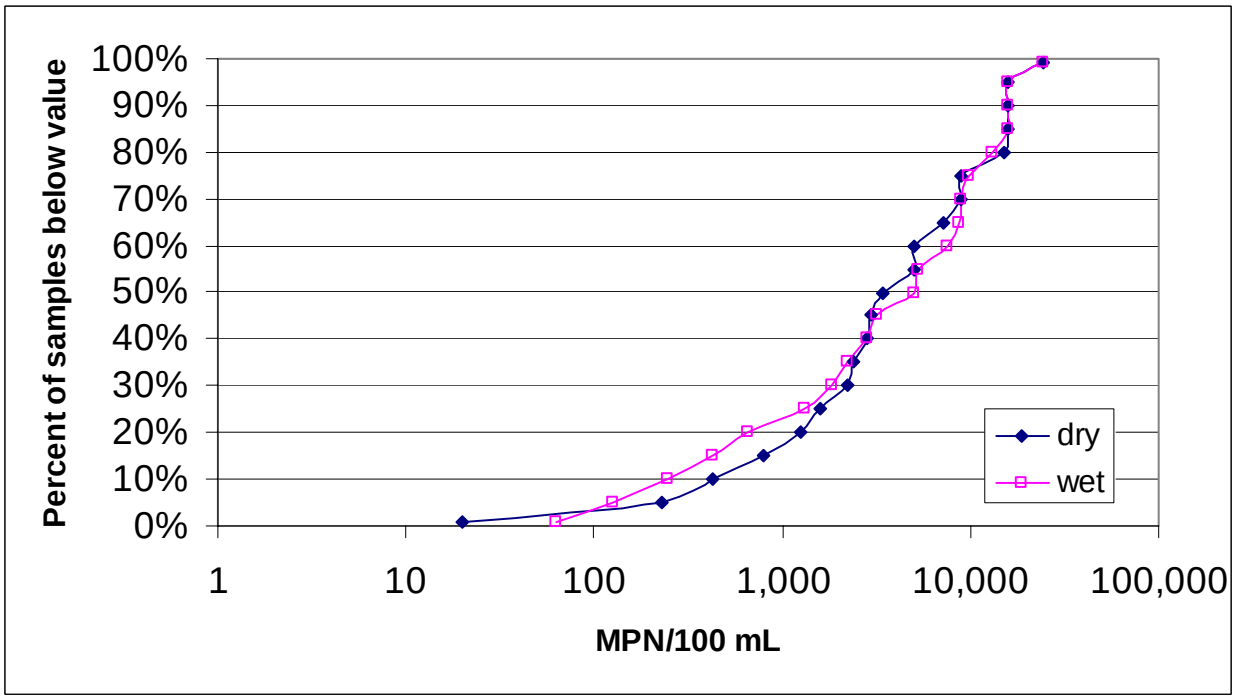


Figure A 37: Percentage of samples from El Morro Creek which exceed thresholds, by month

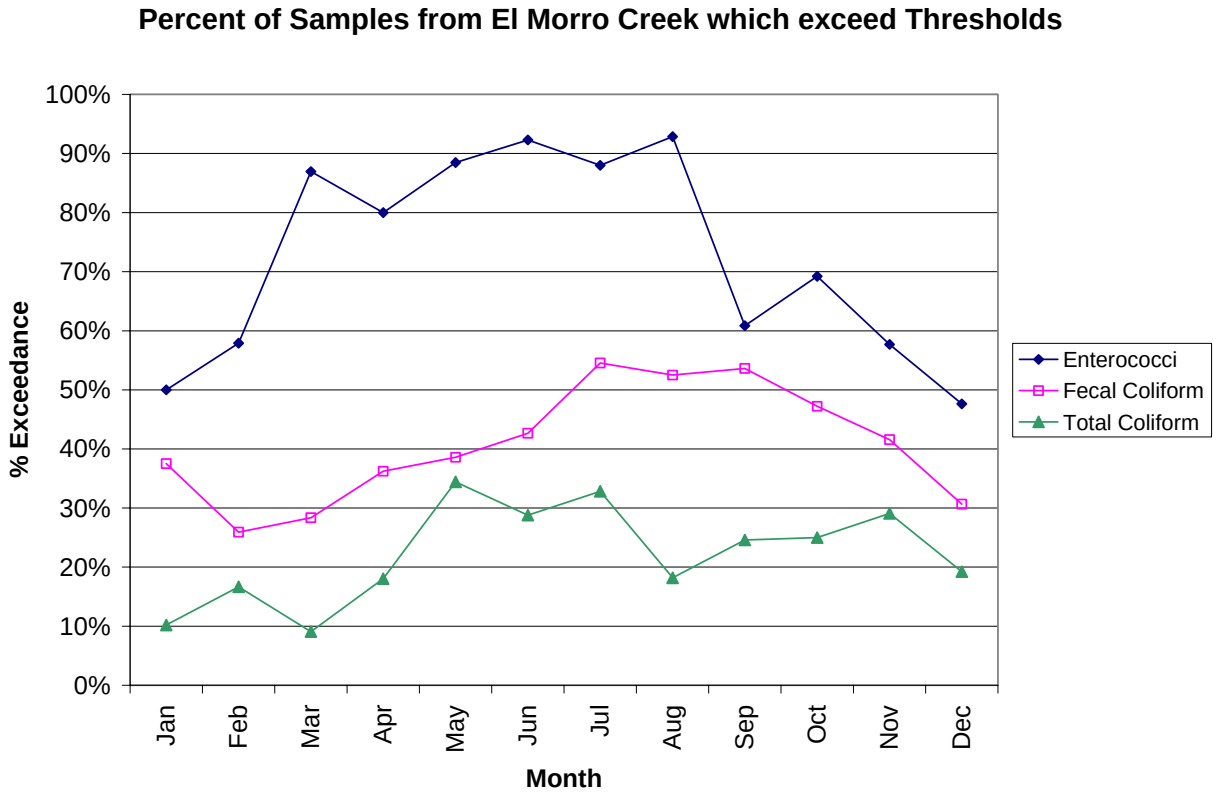
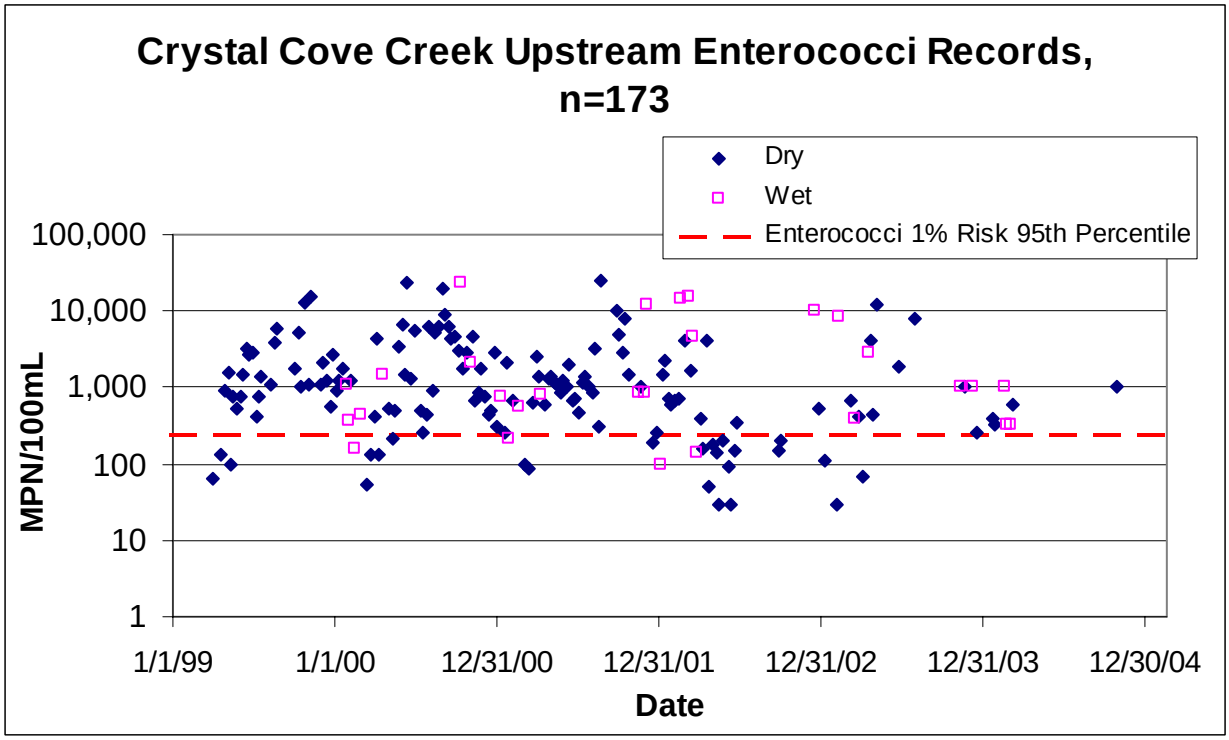


Figure A 38: Crystal Cove Creek Upstream enterococci data and corresponding cumulative frequency distribution



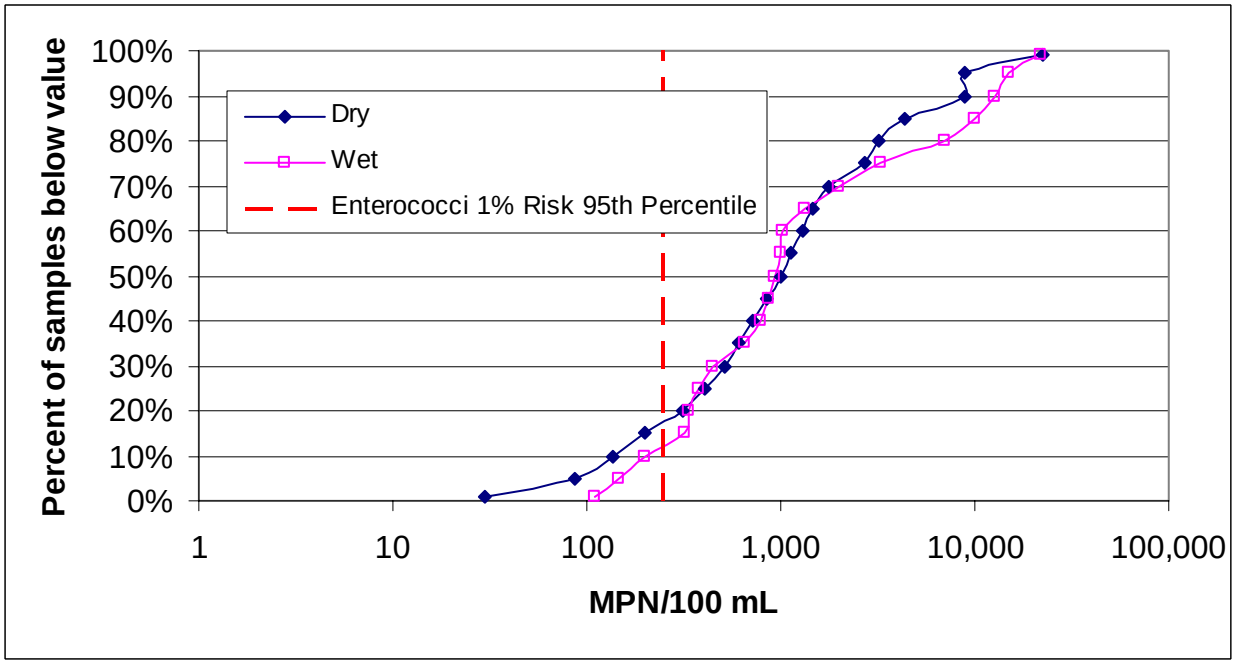
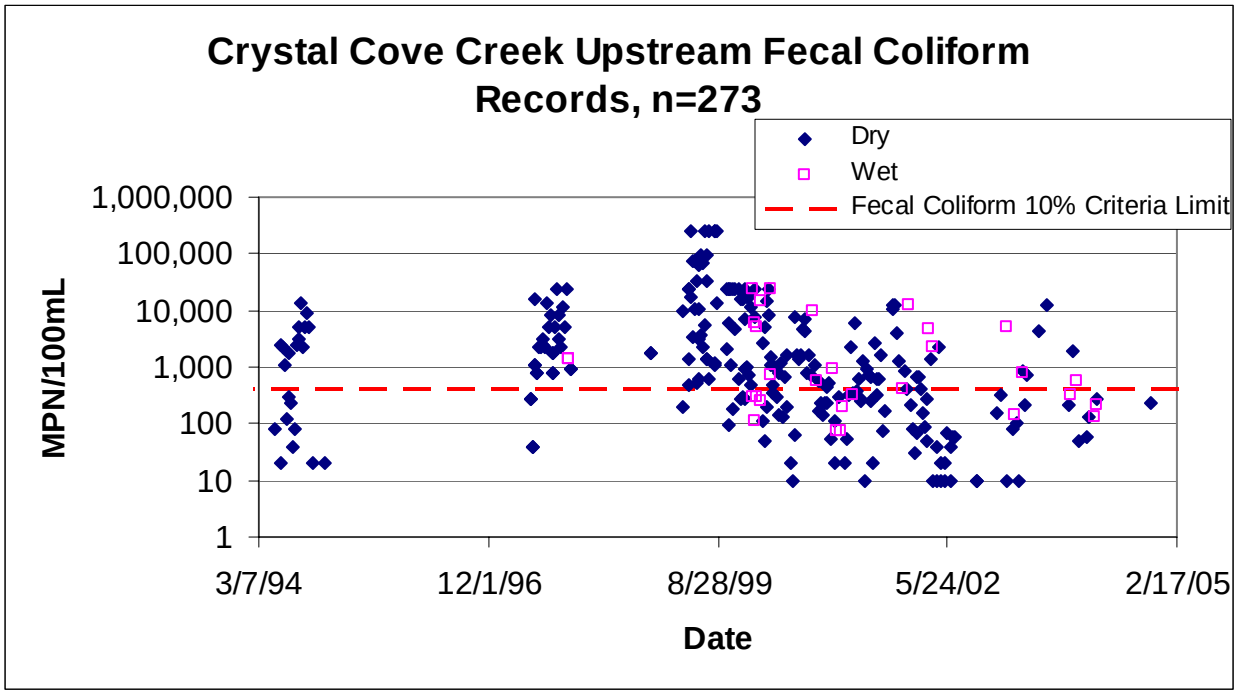


Figure A 39: Crystal Cove Creek Upstream fecal coliform data and corresponding cumulative frequency distribution



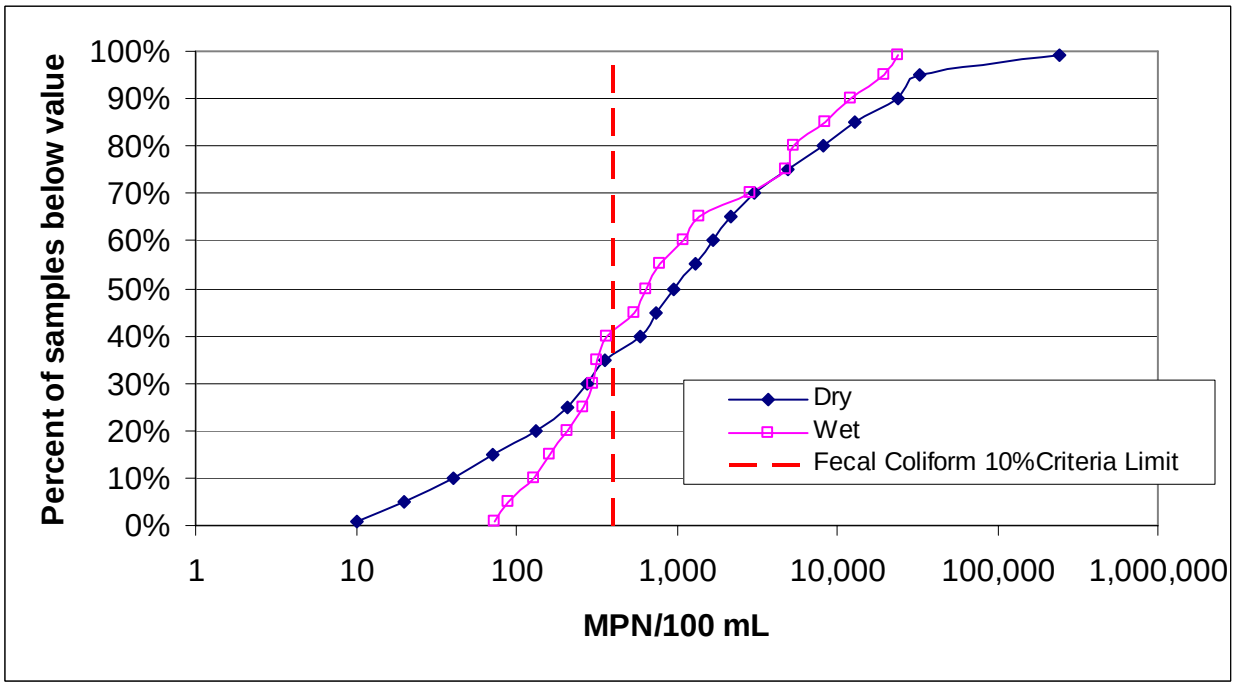
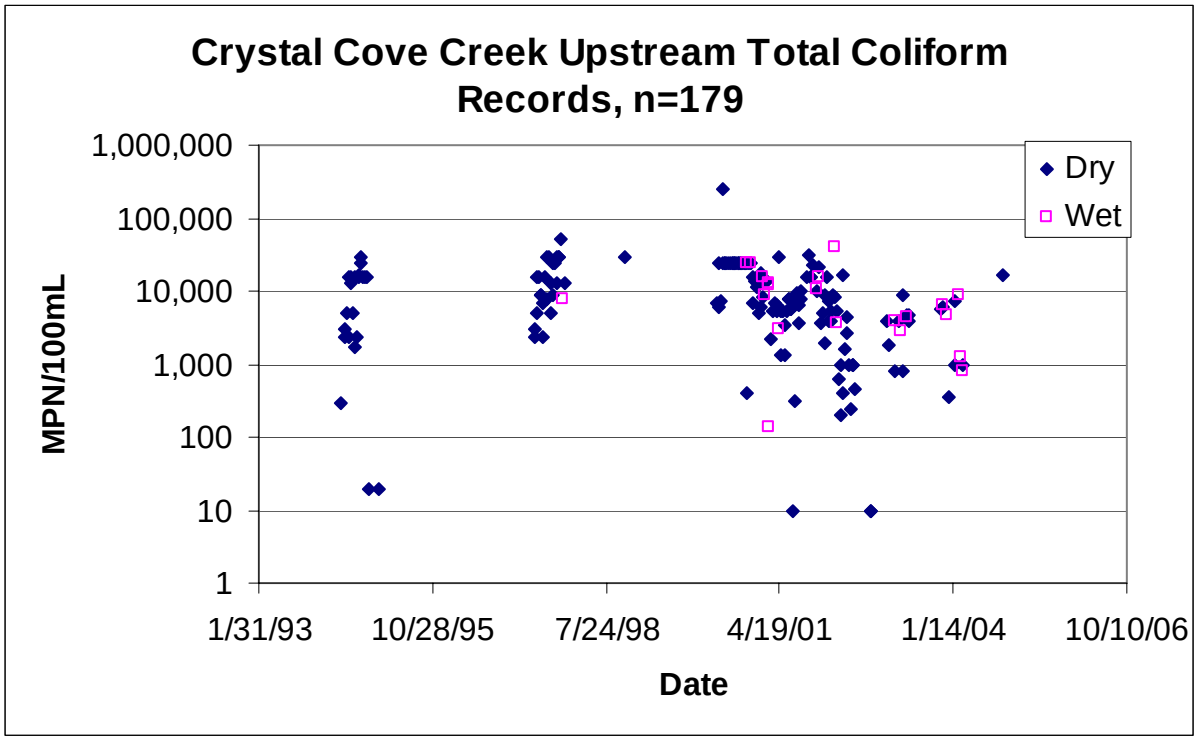


Figure A 40: Crystal Cove Creek Upstream total coliform data and corresponding cumulative frequency distribution



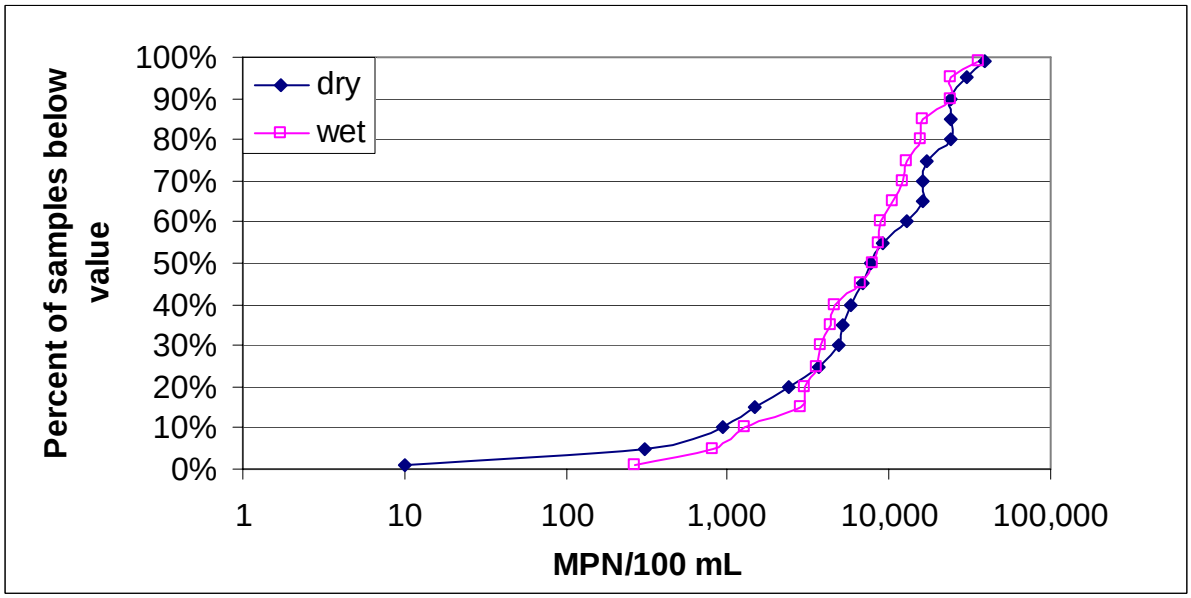


Figure A 41: Percentage of samples from Crystal Cove Creek Upstream which exceed thresholds, by month

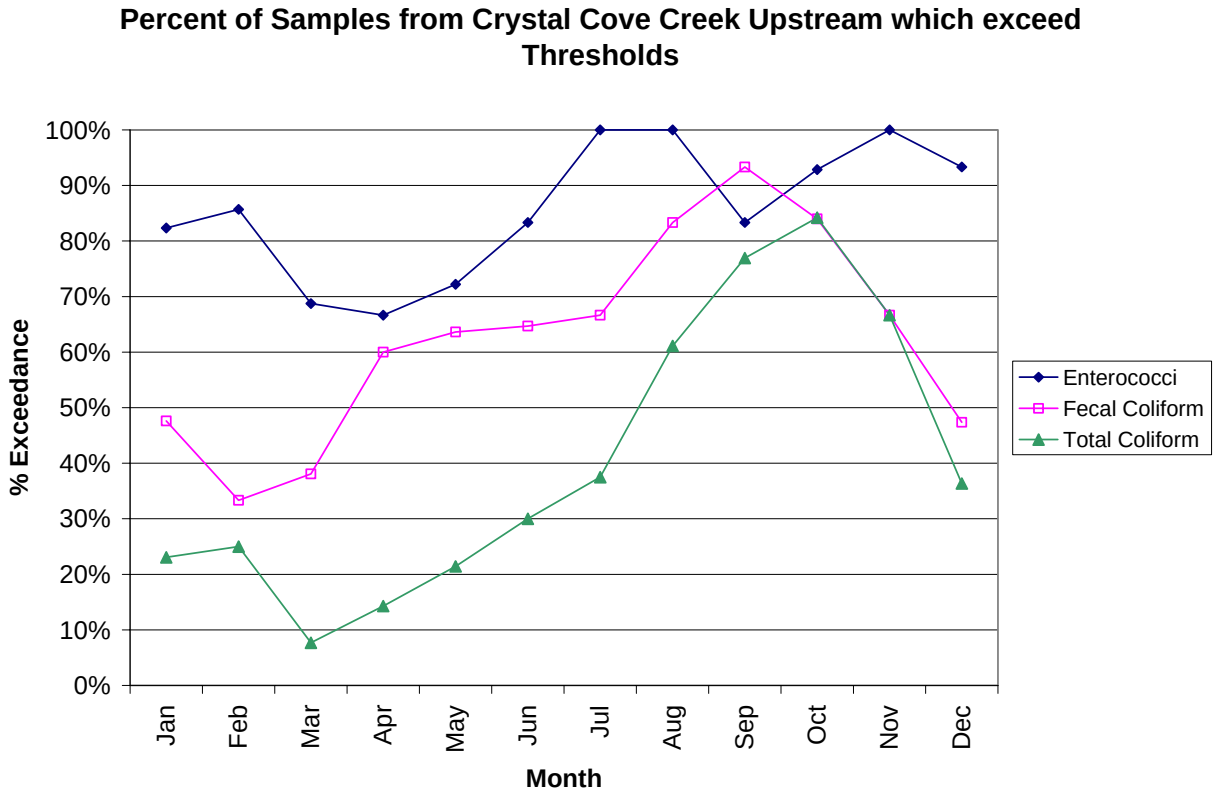
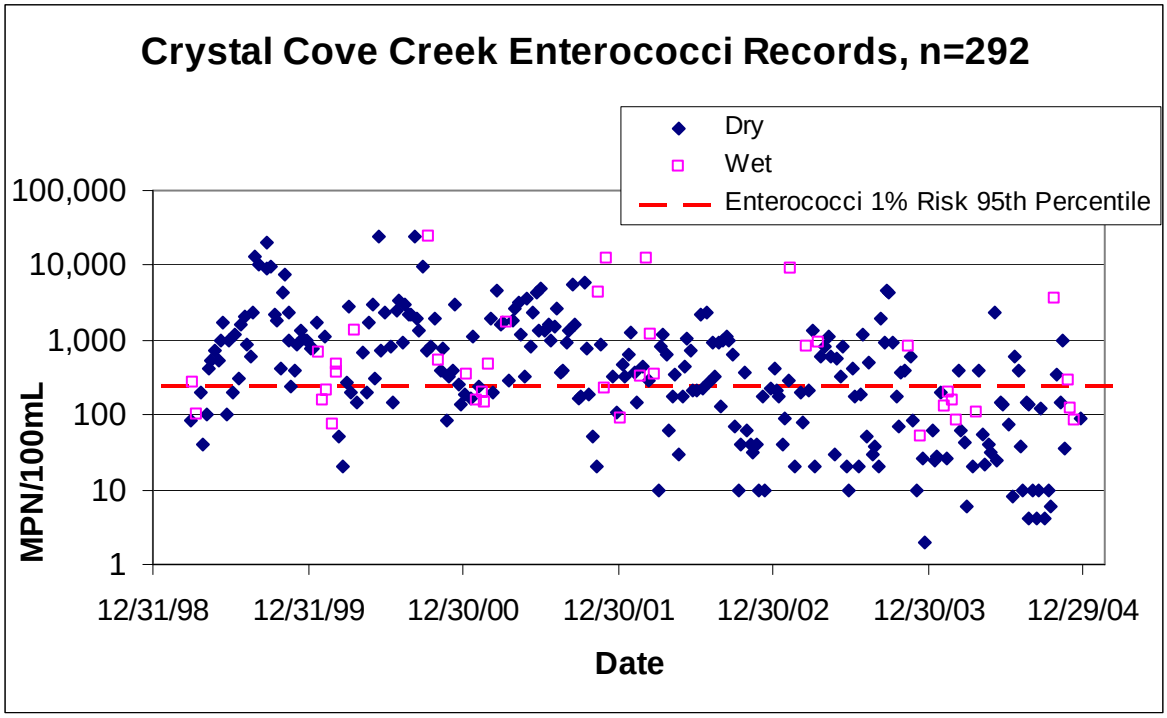


Figure A 42: Crystal Cove Creek enterococci data and corresponding cumulative frequency distribution



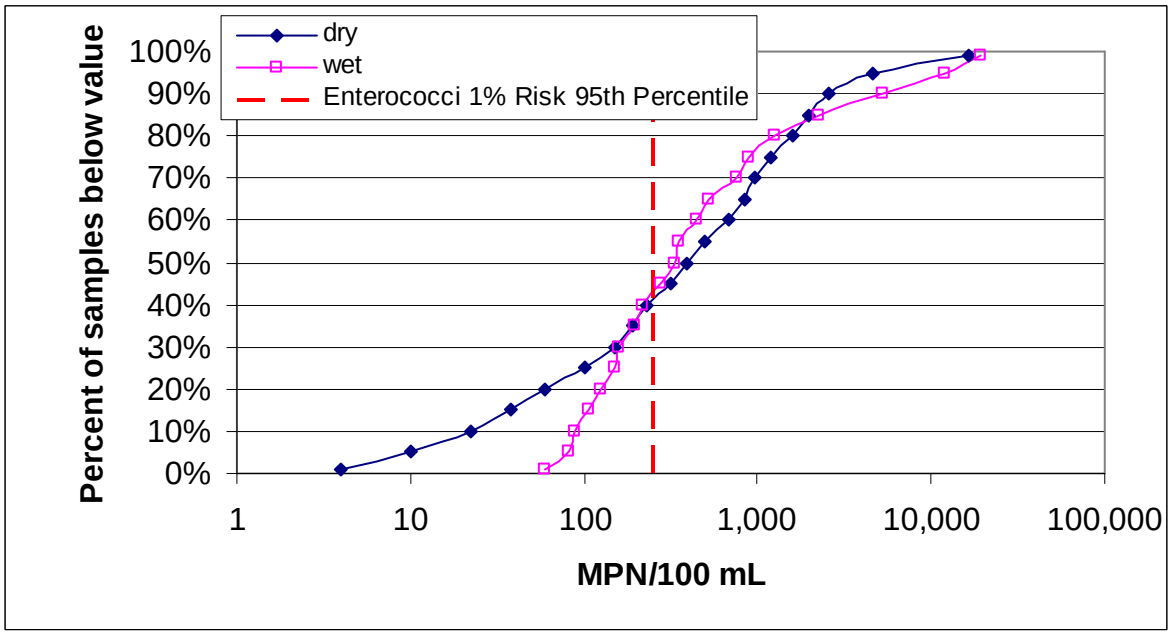
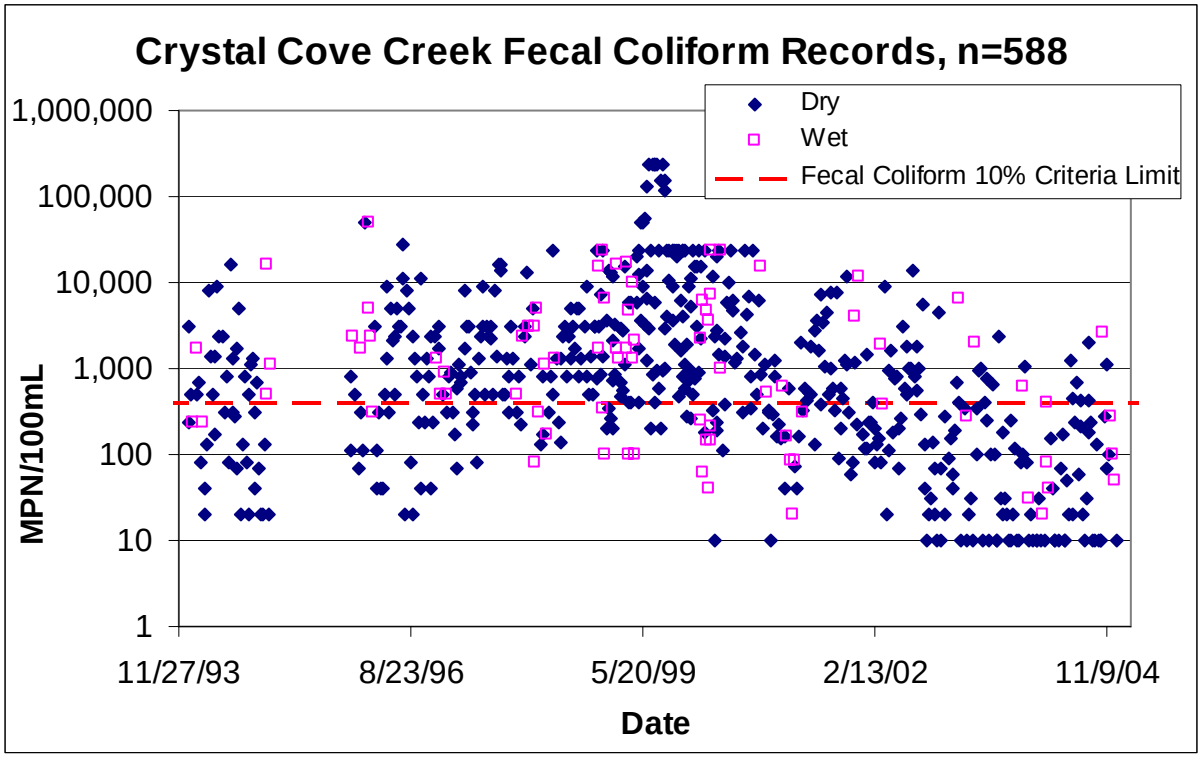


Figure A 43: Crystal Cove Creek fecal coliform data and corresponding cumulative frequency distribution



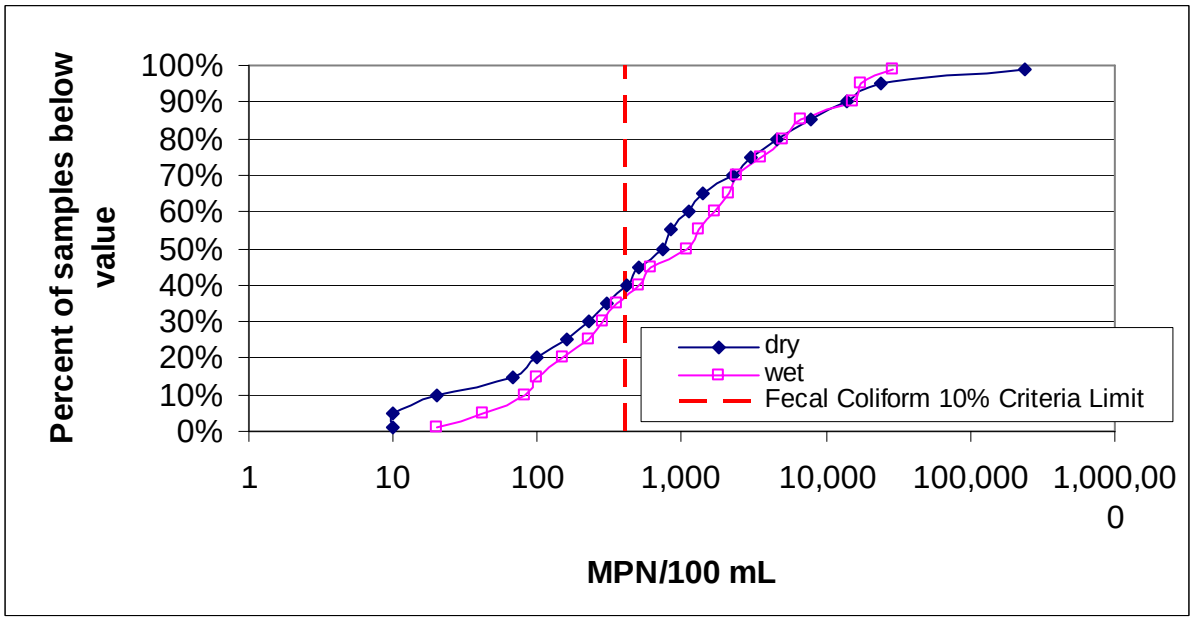
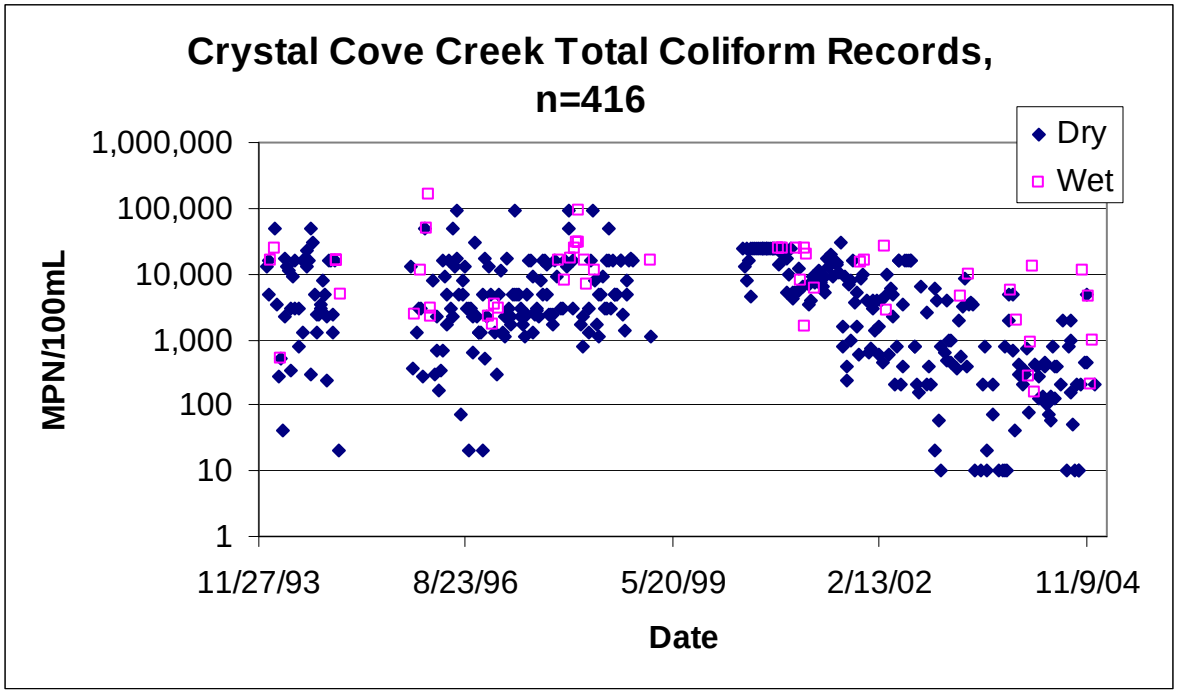


Figure A 44: Crystal Cove Creek total coliform data and corresponding cumulative frequency distribution



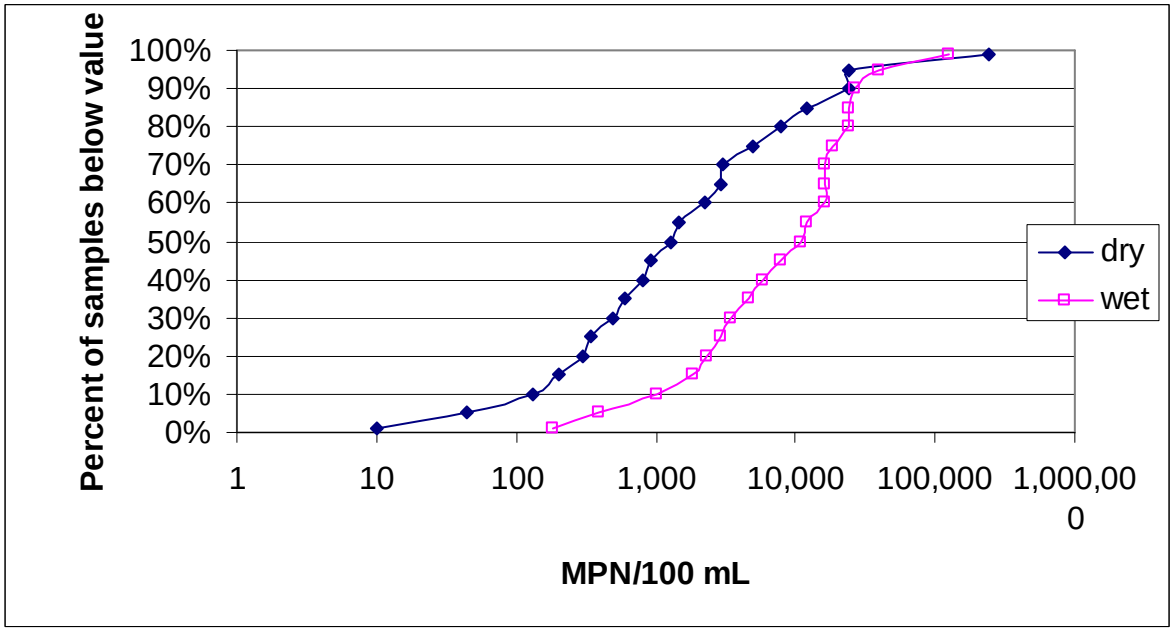


Figure A 45: Percentage of samples from Crystal Cove Creek which exceed thresholds, by month

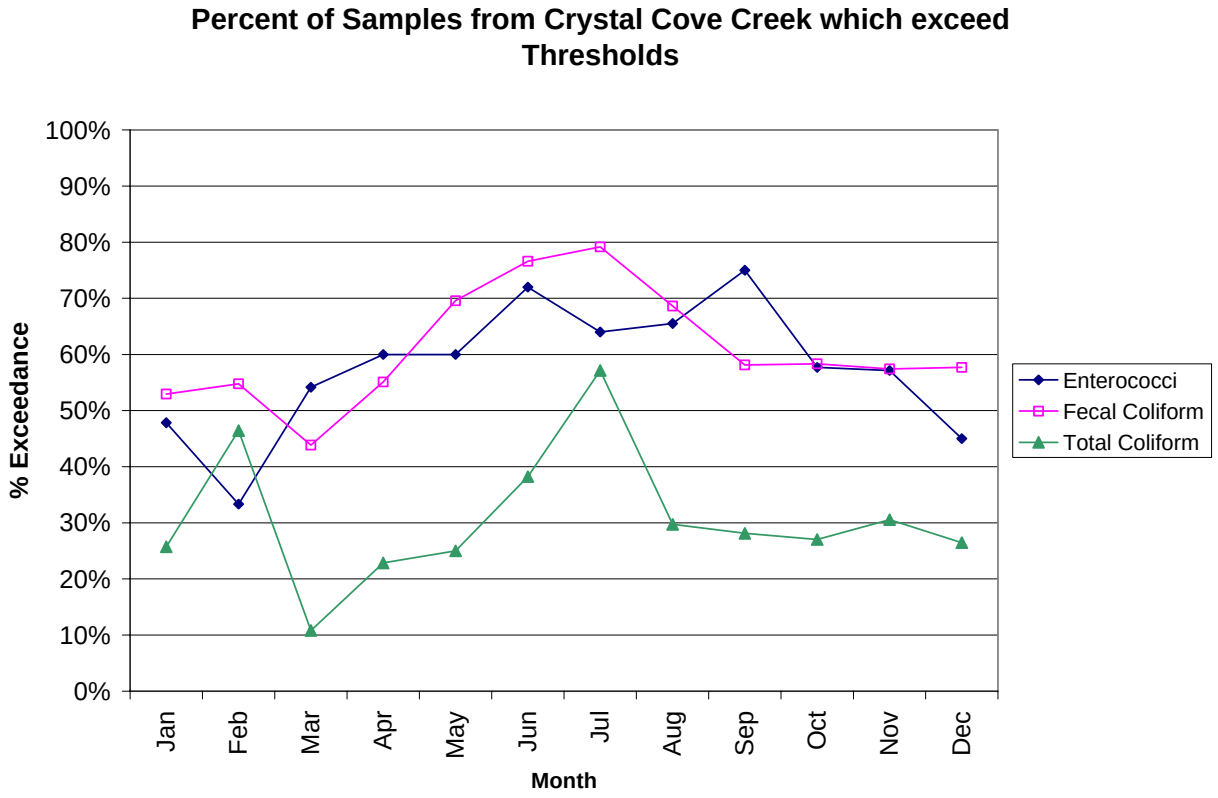
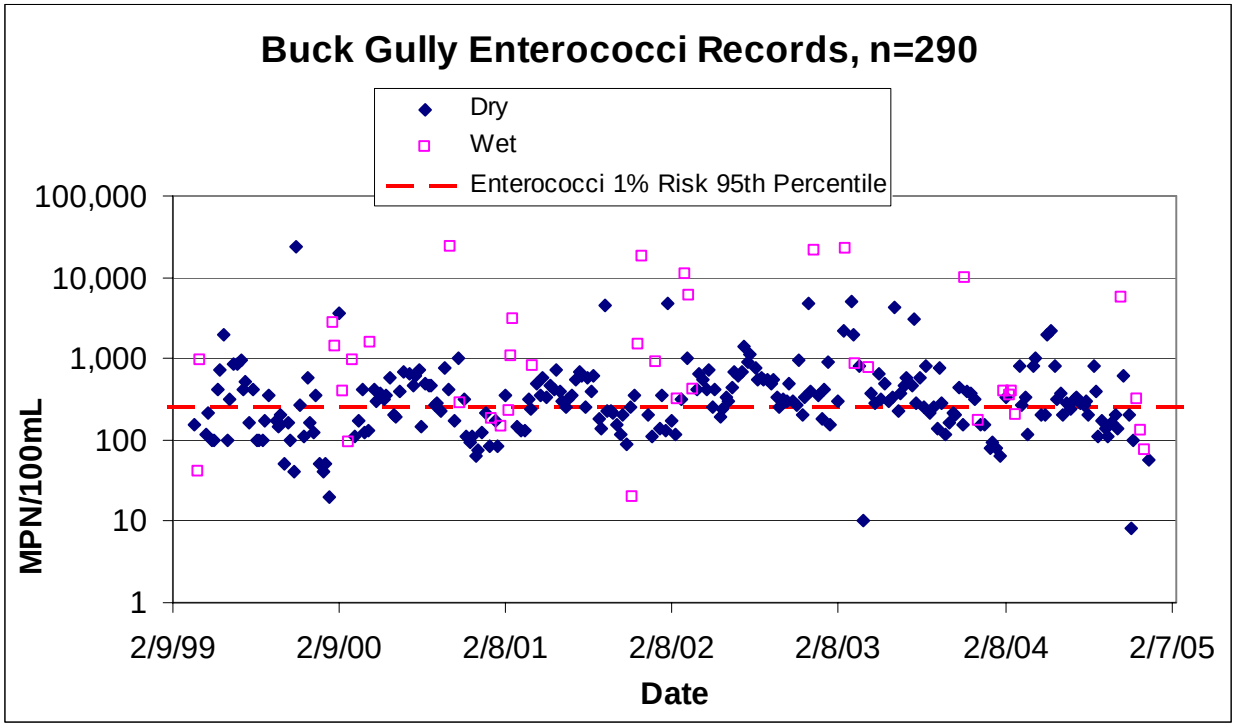


Figure A 46: Buck Gully enterococci data and corresponding cumulative frequency distribution



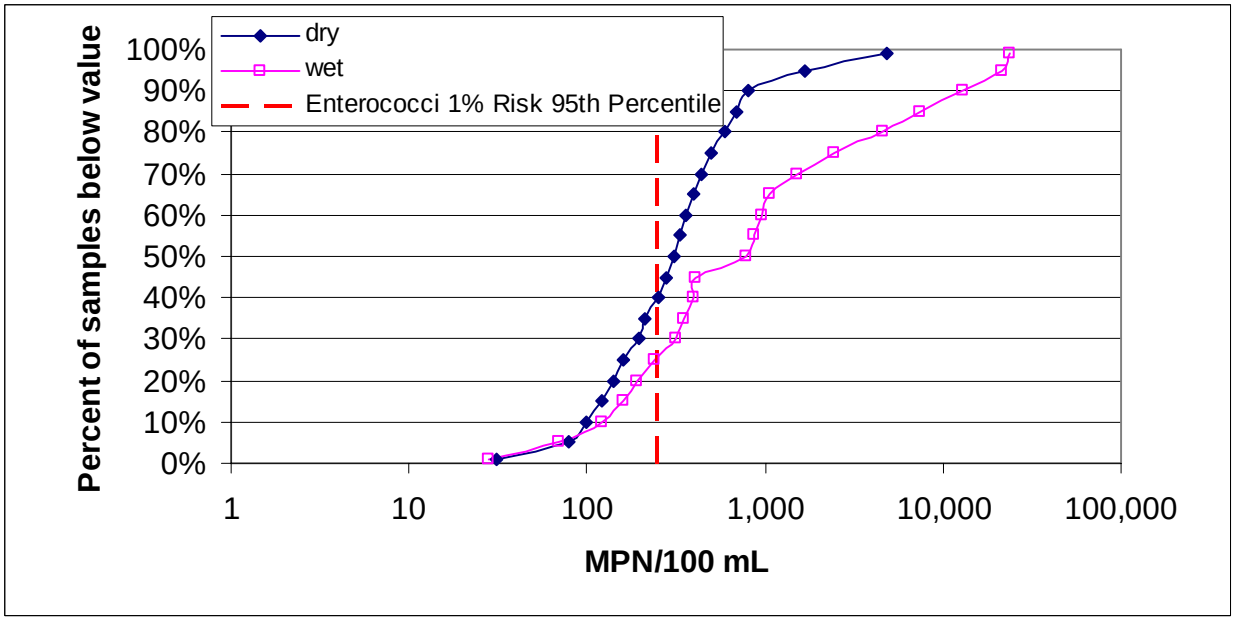
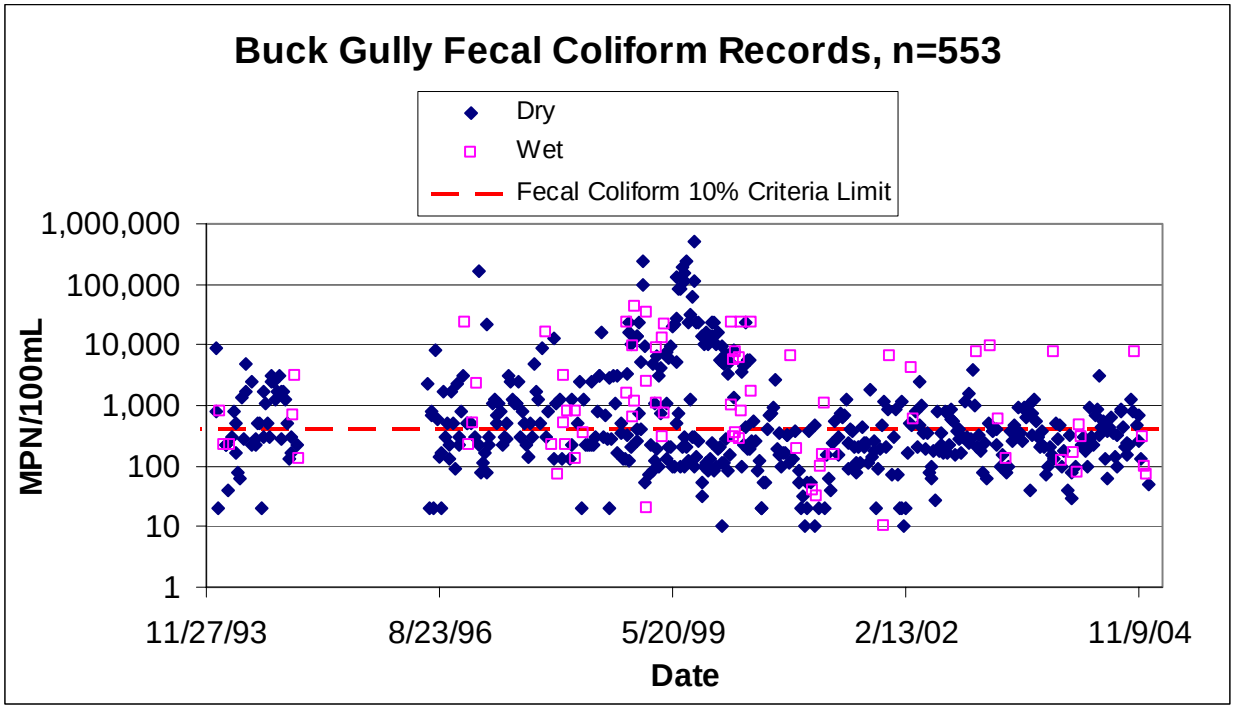


Figure A 47: Buck Gully fecal coliform data and corresponding cumulative frequency distribution



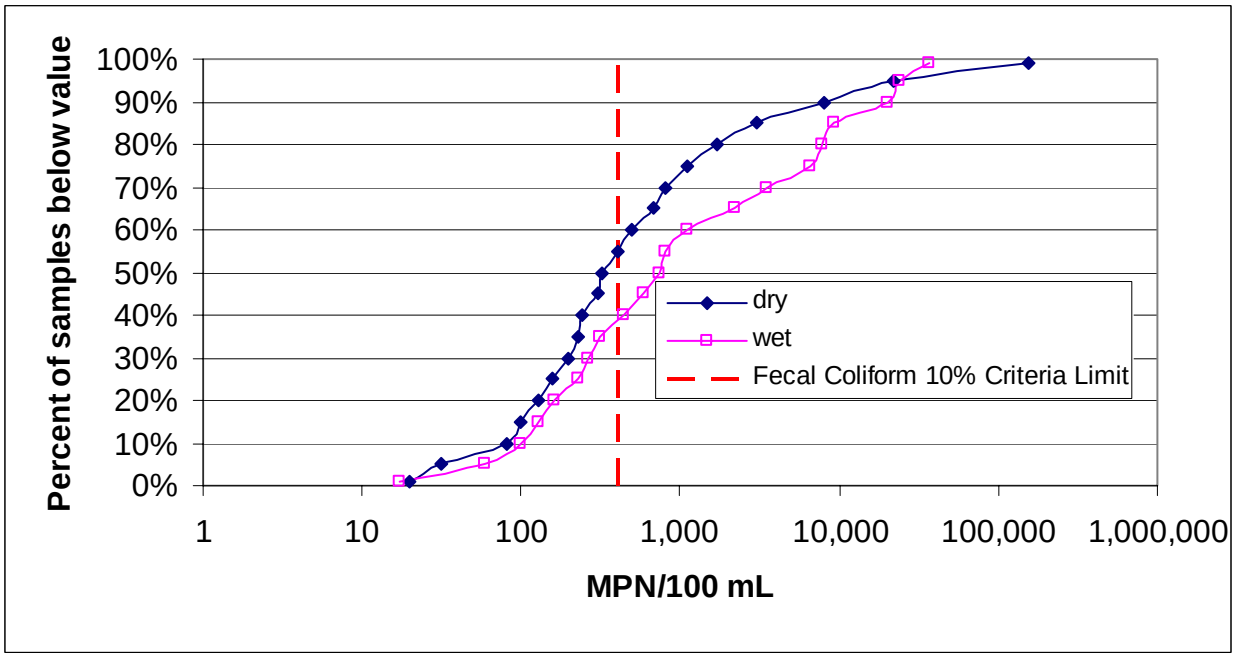
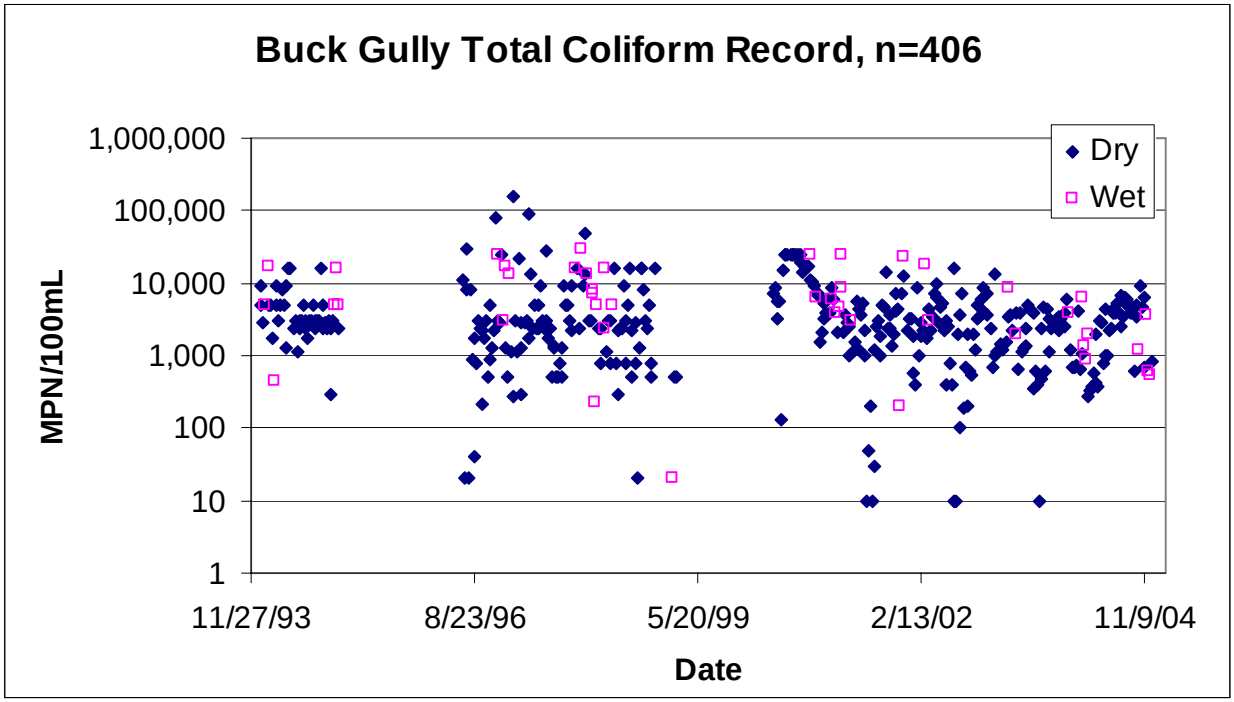


Figure A 48: Buck Gully total coliform data and corresponding cumulative frequency distribution



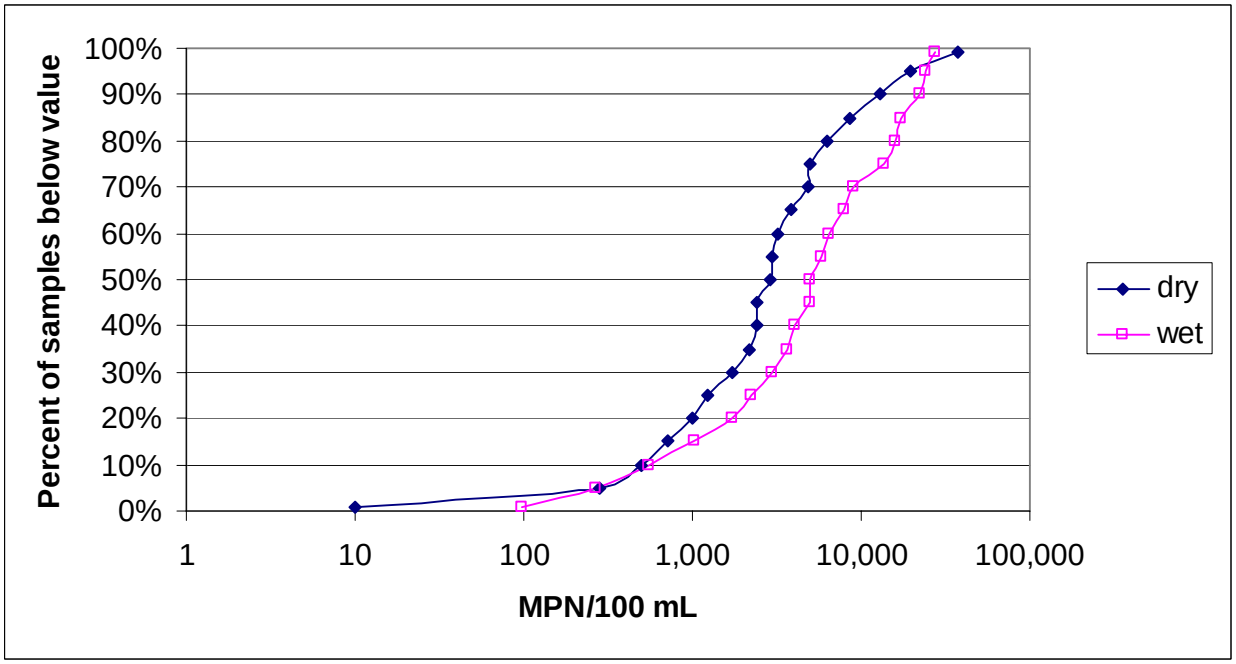


Figure A 49: Percentage of samples from Buck Gully which exceed thresholds, by month

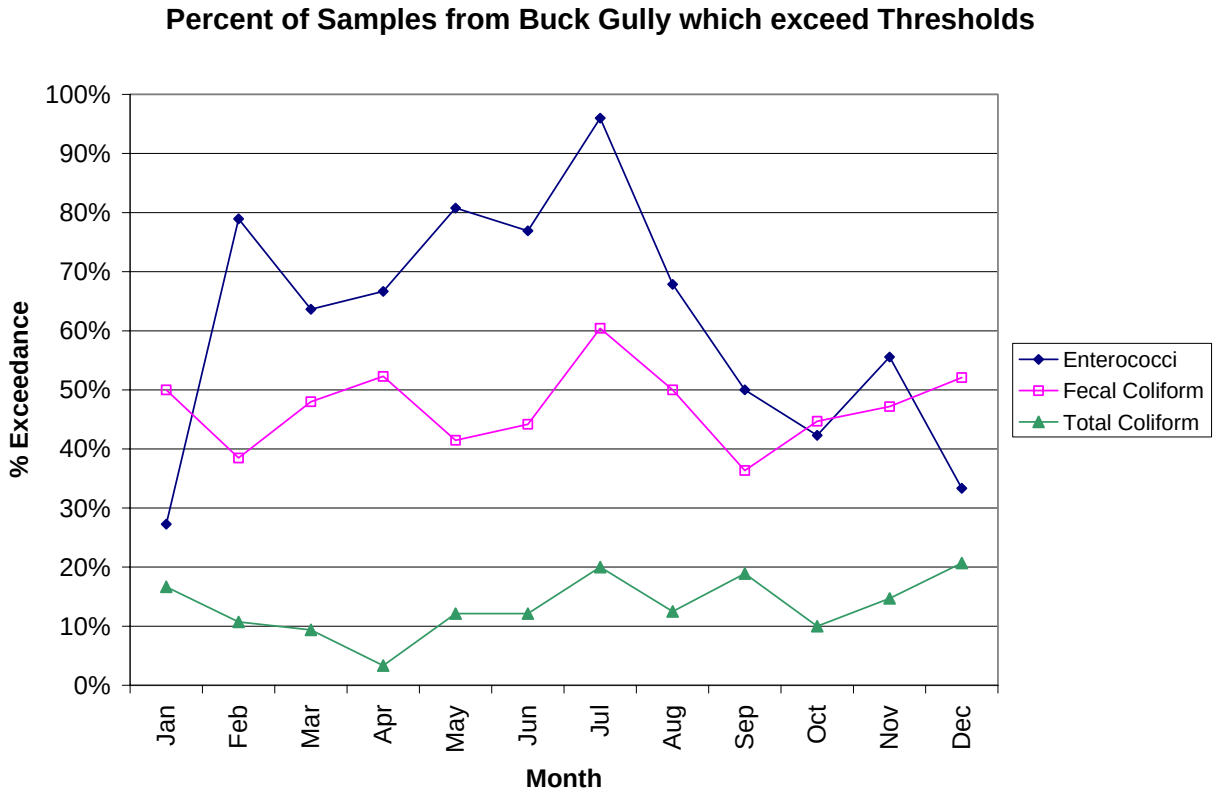
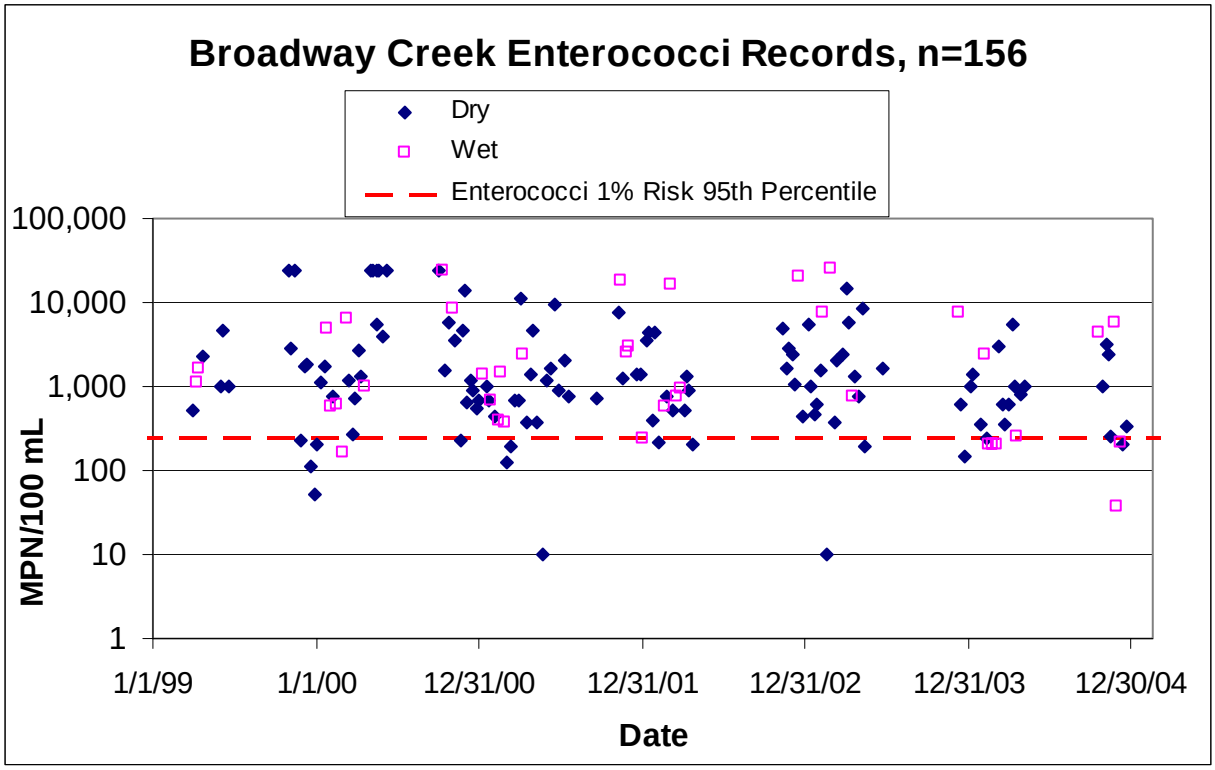


Figure A 50: Broadway Creek enterococci data and corresponding cumulative frequency distribution



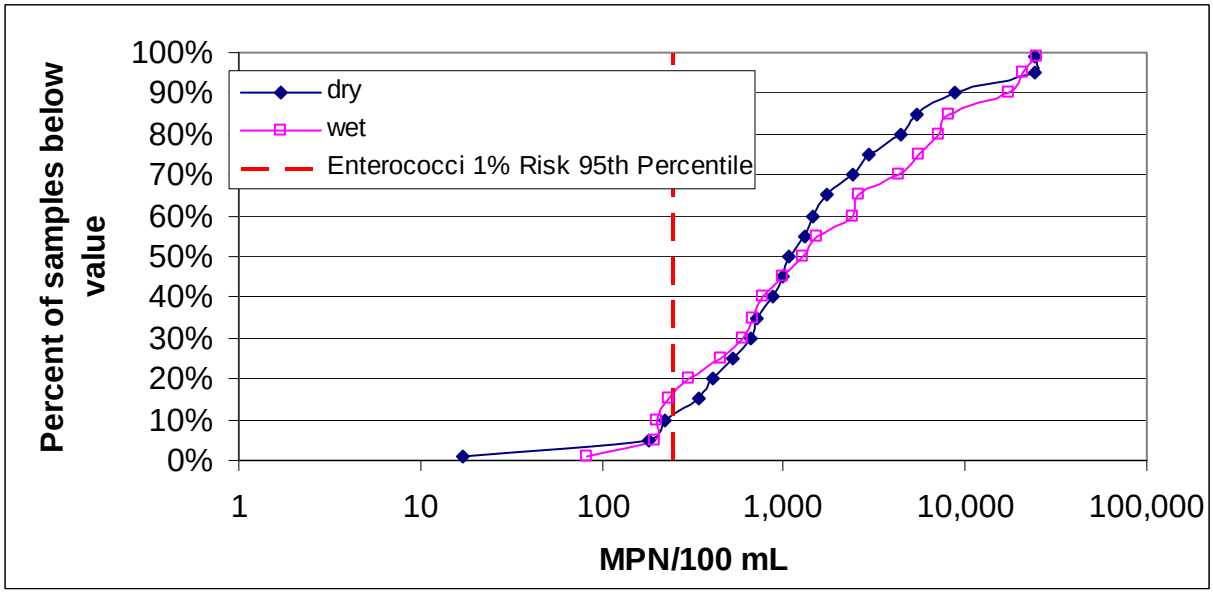
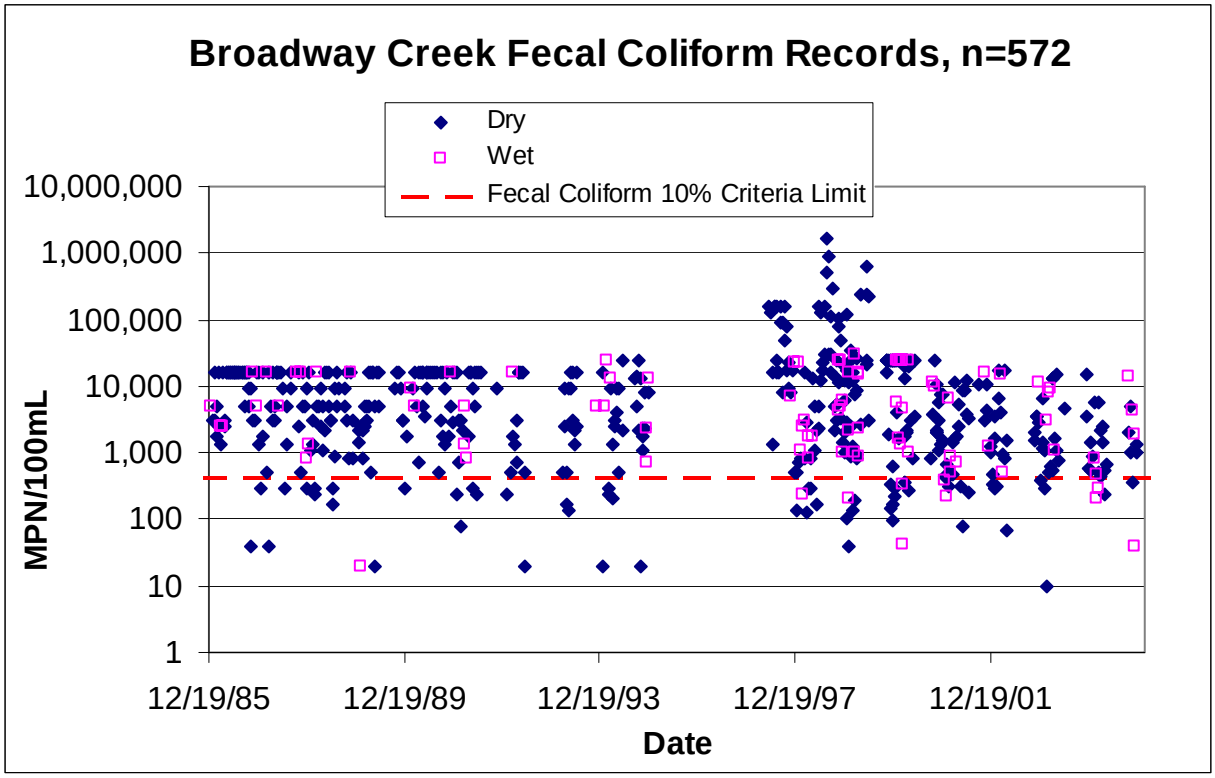


Figure A 51: Broadway Creek fecal coliform data and corresponding cumulative frequency distribution



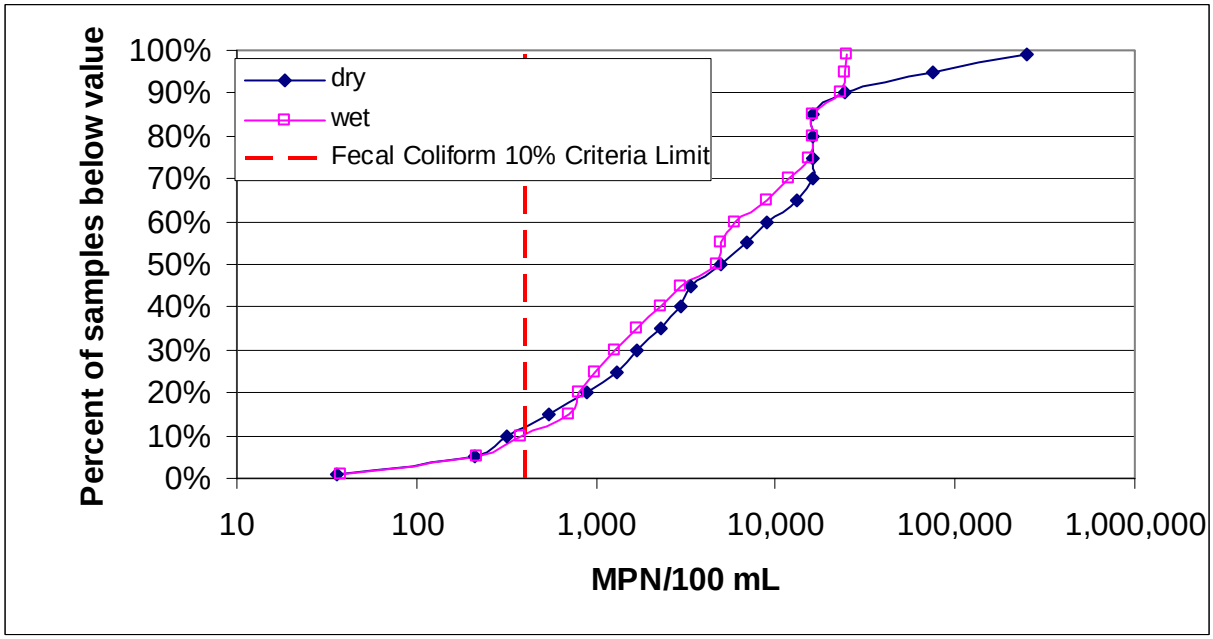
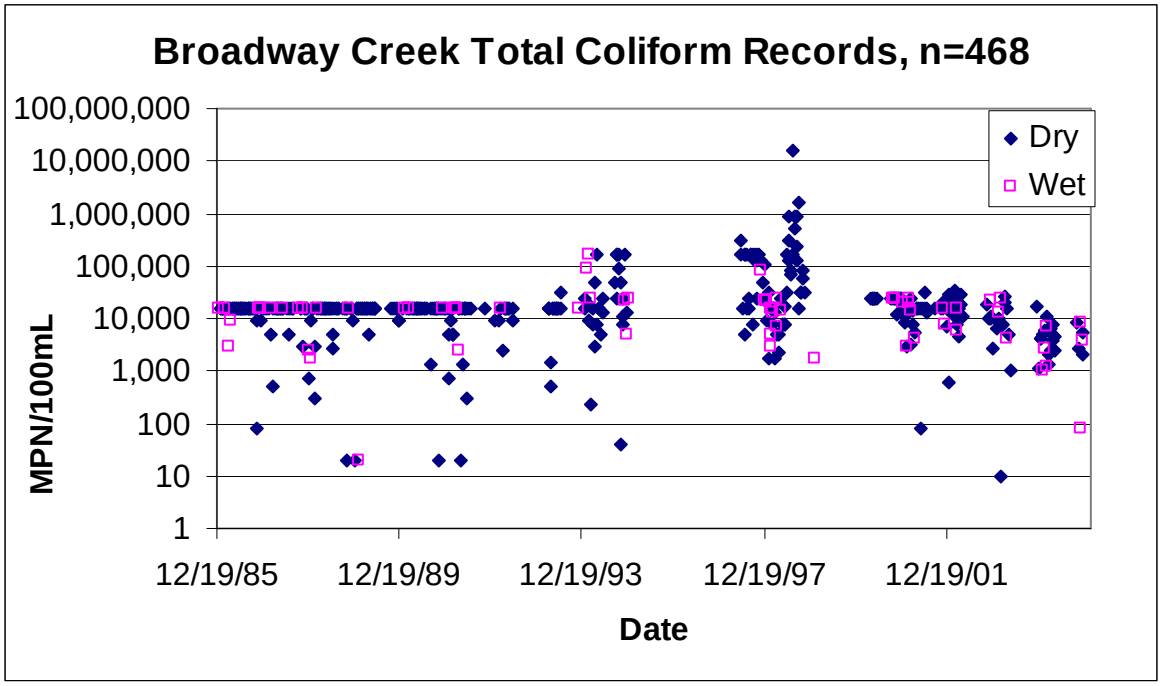


Figure A 52: Broadway Creek total coliform data and corresponding cumulative frequency distribution



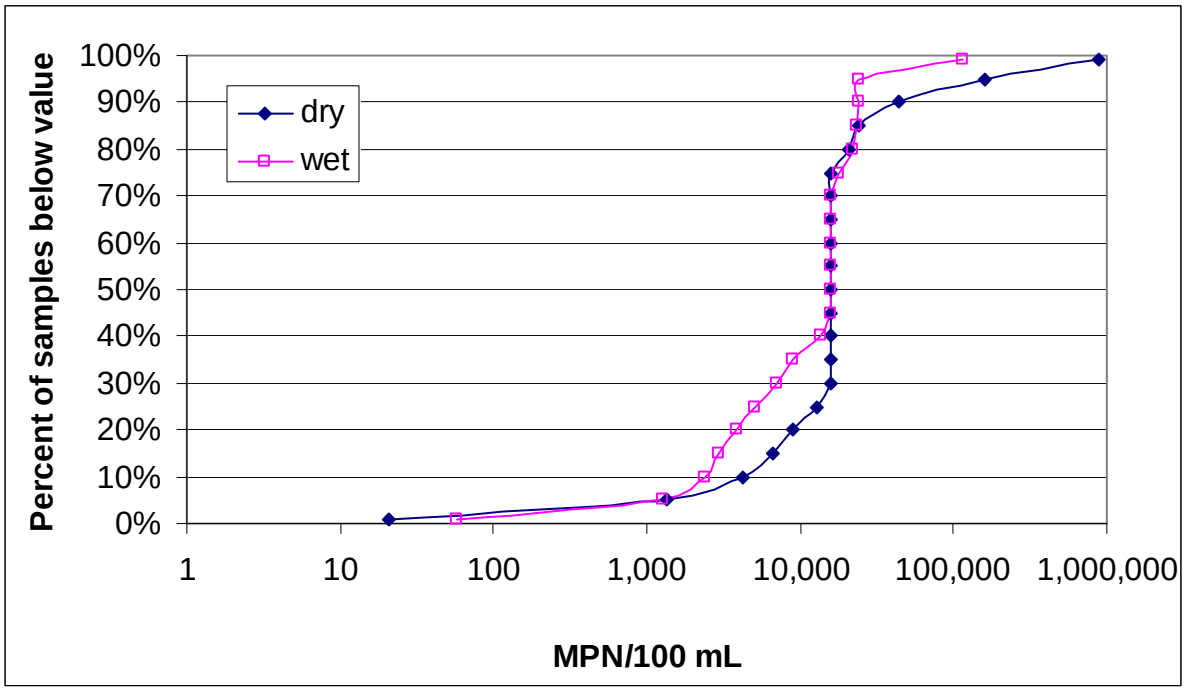
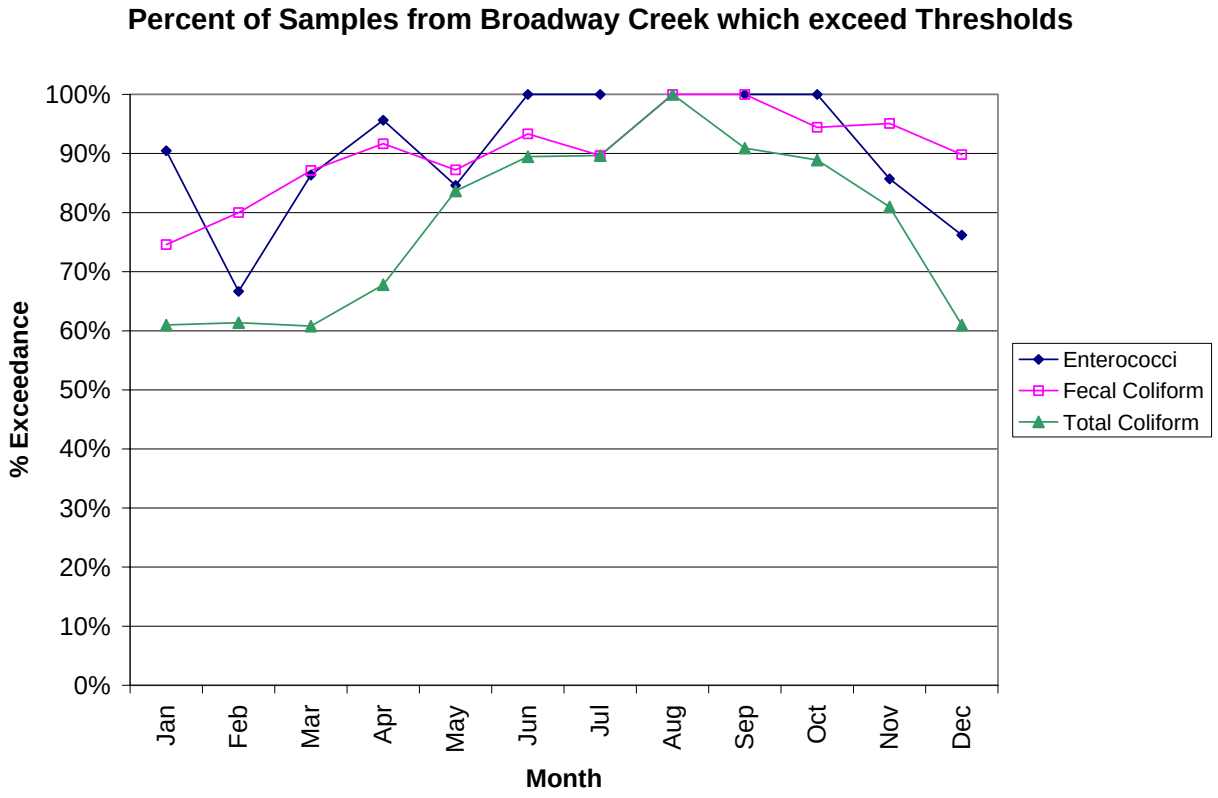


Figure A 53: Percentage of samples from Broadway Creek which exceed thresholds, by month



APPENDIX B

DATA FROM SANTA ANA REGION

FIGURES REPRODUCED FROM CDM 2005

Figure B 1: Santa Ana Watershed and sites selected by CDM for detailed bacteriological analysis (CDM 2005 Figure 19)

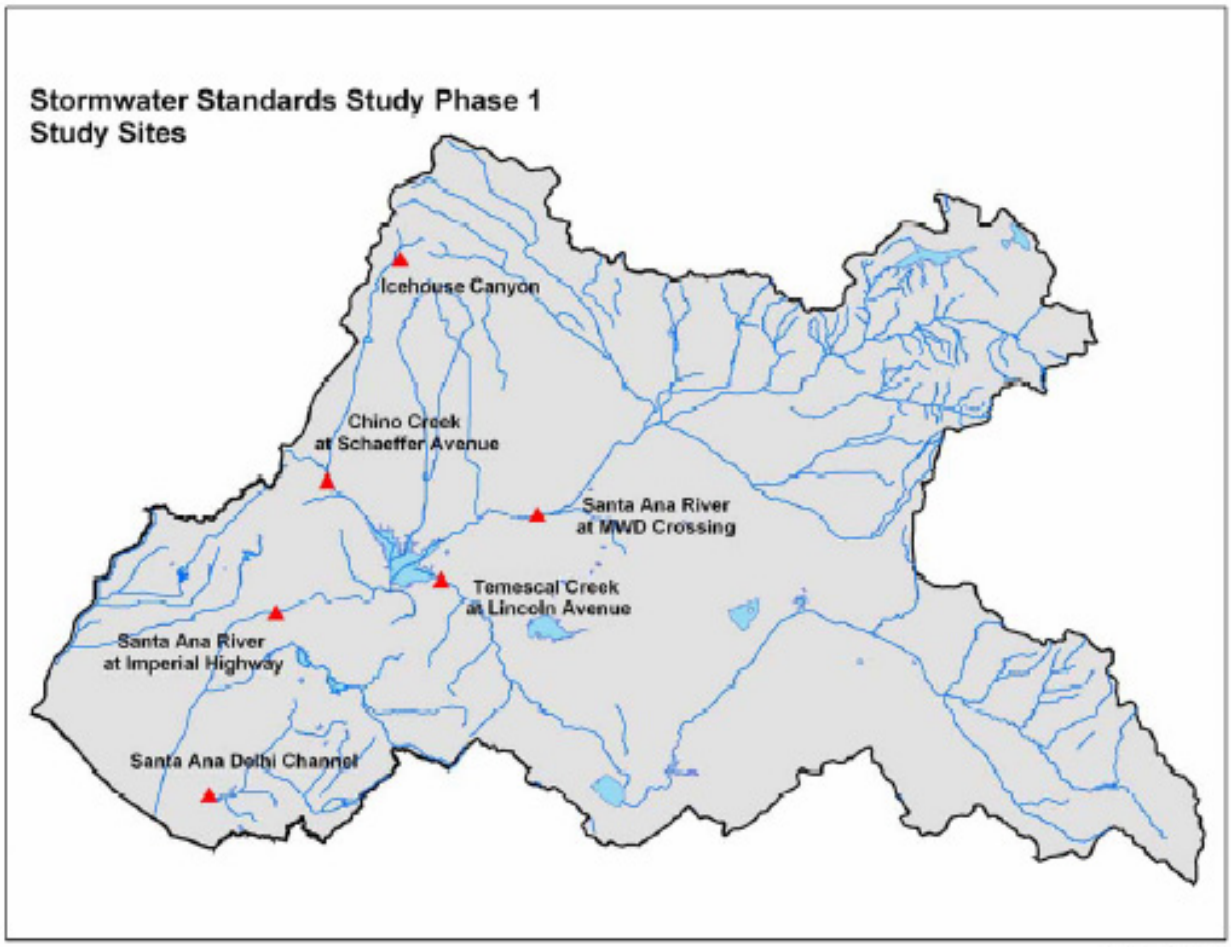


Figure 19
Study Sites Selected for Detailed Analysis

Figure B 2: Flow rate and bacteria concentration, Chino Creek (CDM 2005 Figure 35)

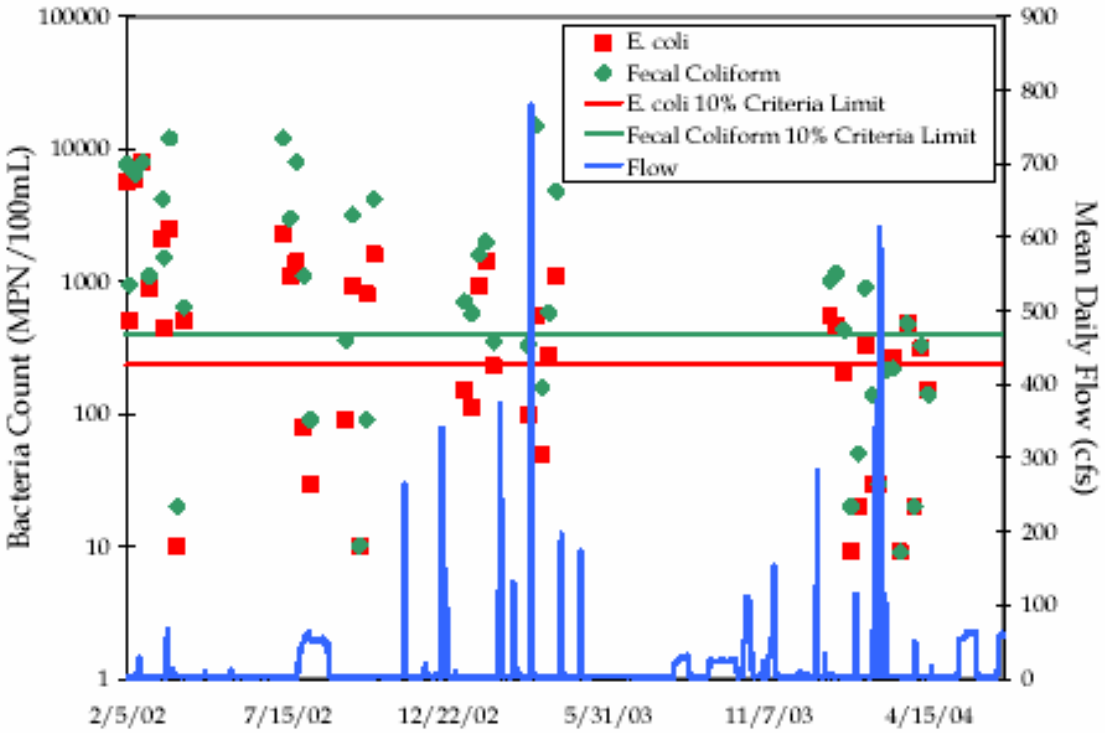


Figure 35
Time Series of Bacteria Counts and Flow at the Chino Creek at Schaeffer Avenue Study Site

Figure B 3: Flow rate and bacteria concentration, Santa Ana Delhi Channel (CDM 2005 Figure 53)

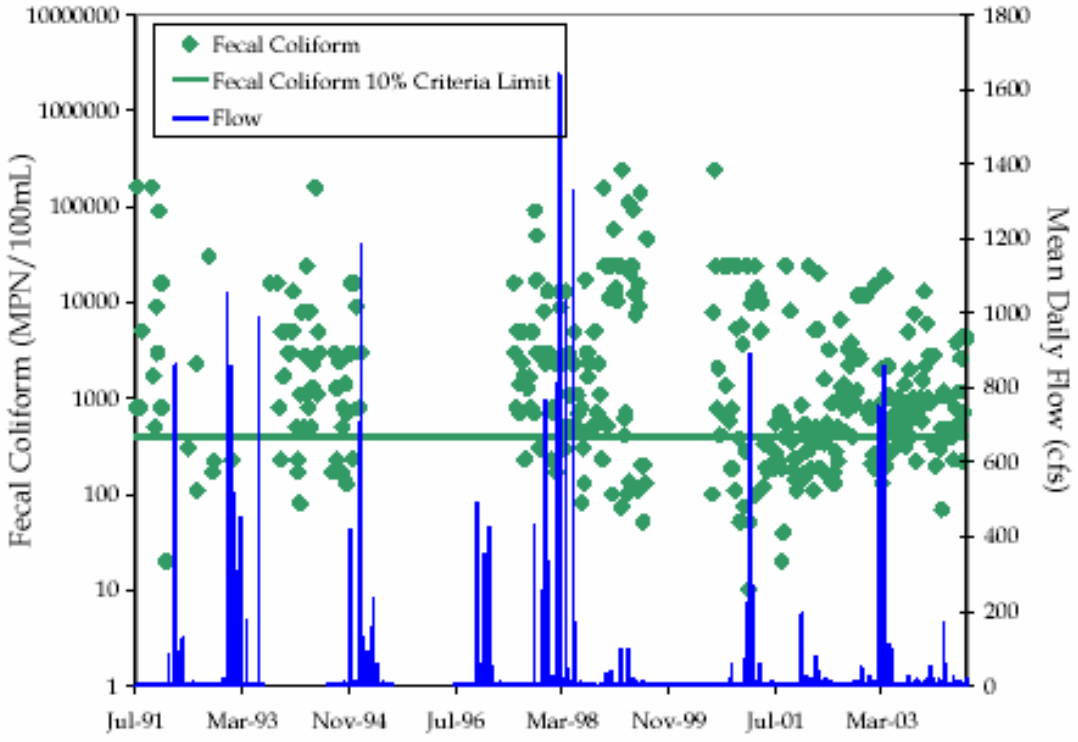


Figure 53
Time Series of Bacteria Concentrations and
Flow in the Santa Ana Delhi Channel - Backbay

Figure B 4: Flow rate and bacteria concentration, Temescal Creek (CDM 2005 Figure 72)

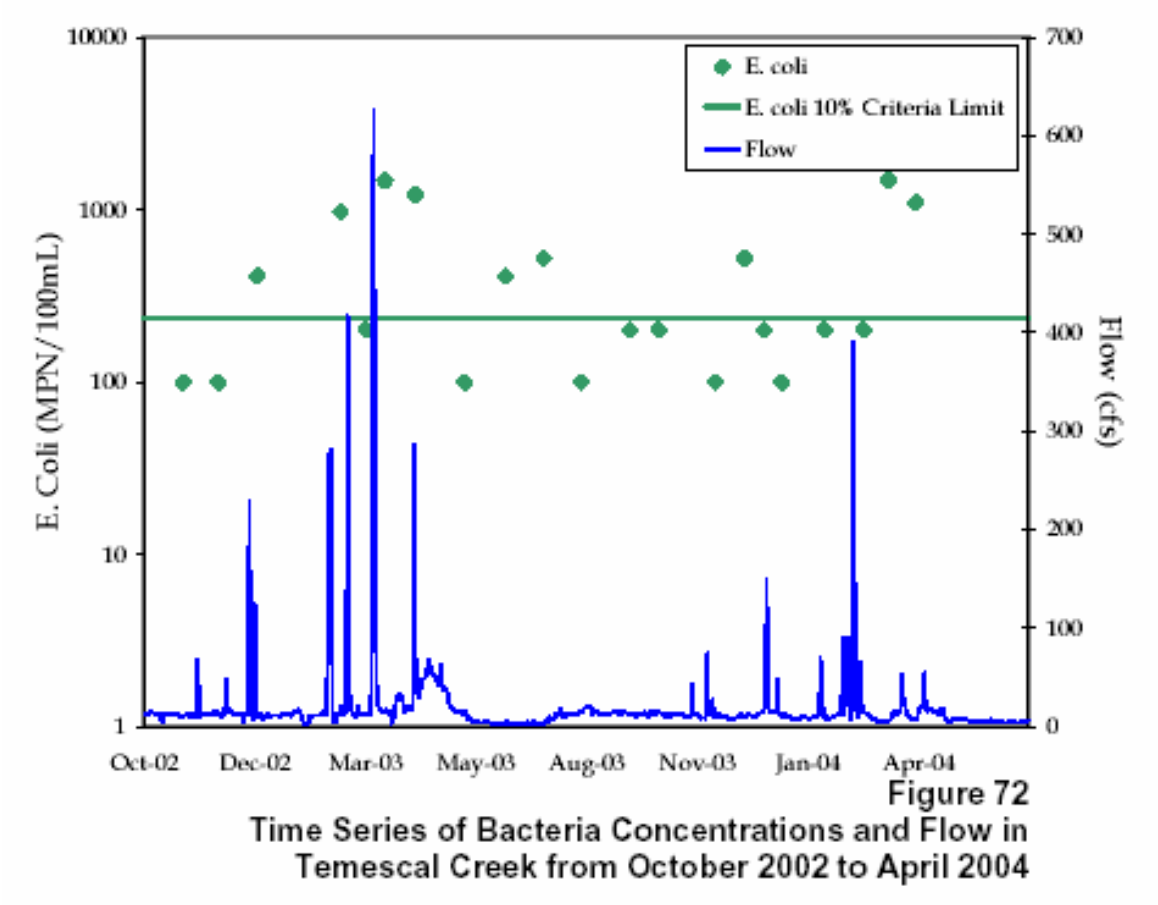


Figure B 5: Flow rate and bacteria concentration, Santa Ana River at MWD Crossing (CDM 2005 Figures 98 and 99)

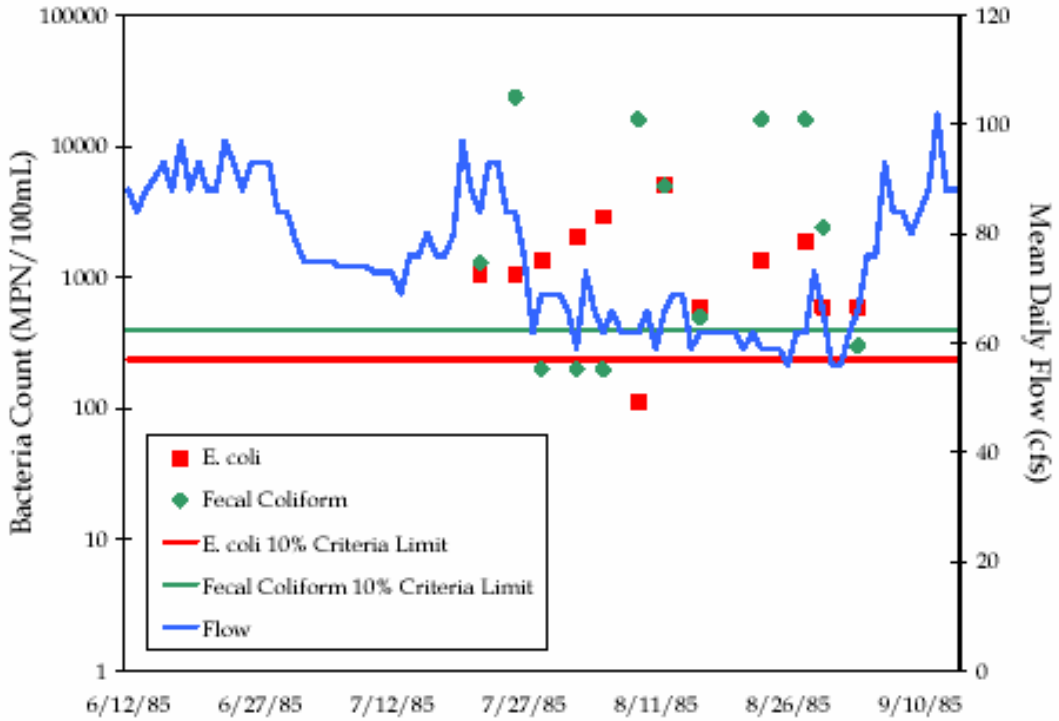


Figure 98
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the MWD Crossing Study Site

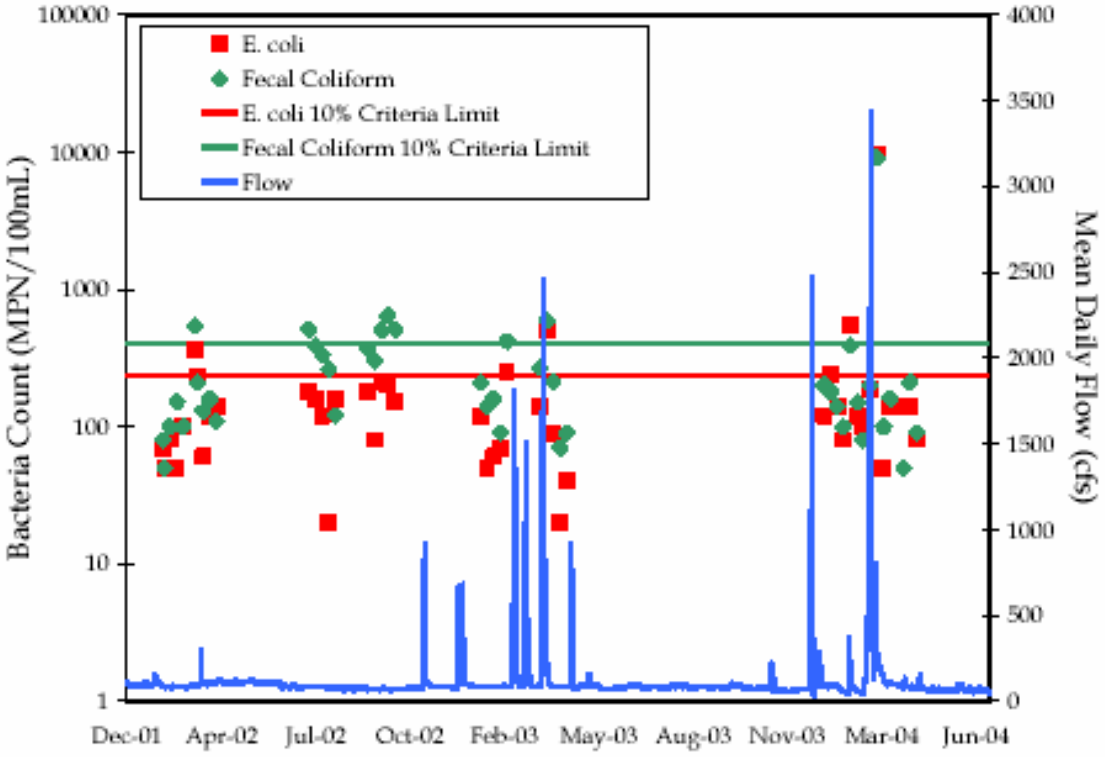


Figure 99
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the MWD Crossing Study Site

Figure B 6: Flow rate and bacteria concentration, Santa Ana River at Imperial Highway (CDM 2005 Figure 83)

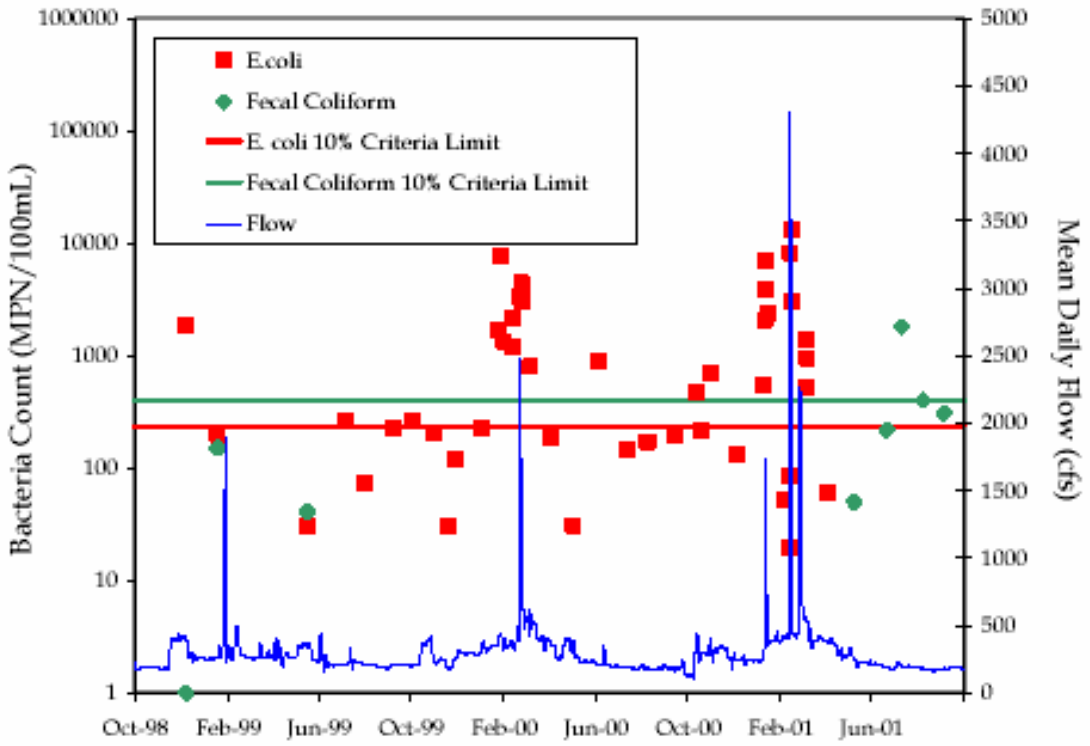


Figure 83
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the Imperial Highway Study Site

Figure B 7: Flow rate and bacteria concentration, Santa Ana River at Imperial Highway (CDM 2005 Figure s 84 and 85)

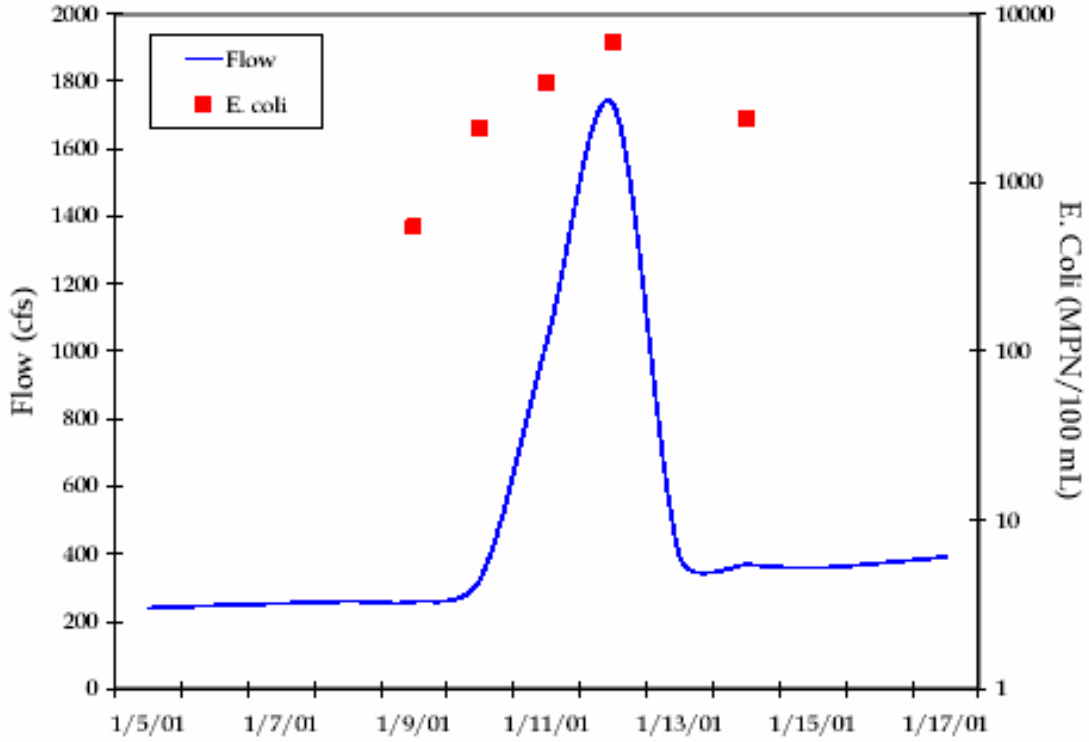


Figure 84
January 2001 Wet Weather E. coli Sampling Event

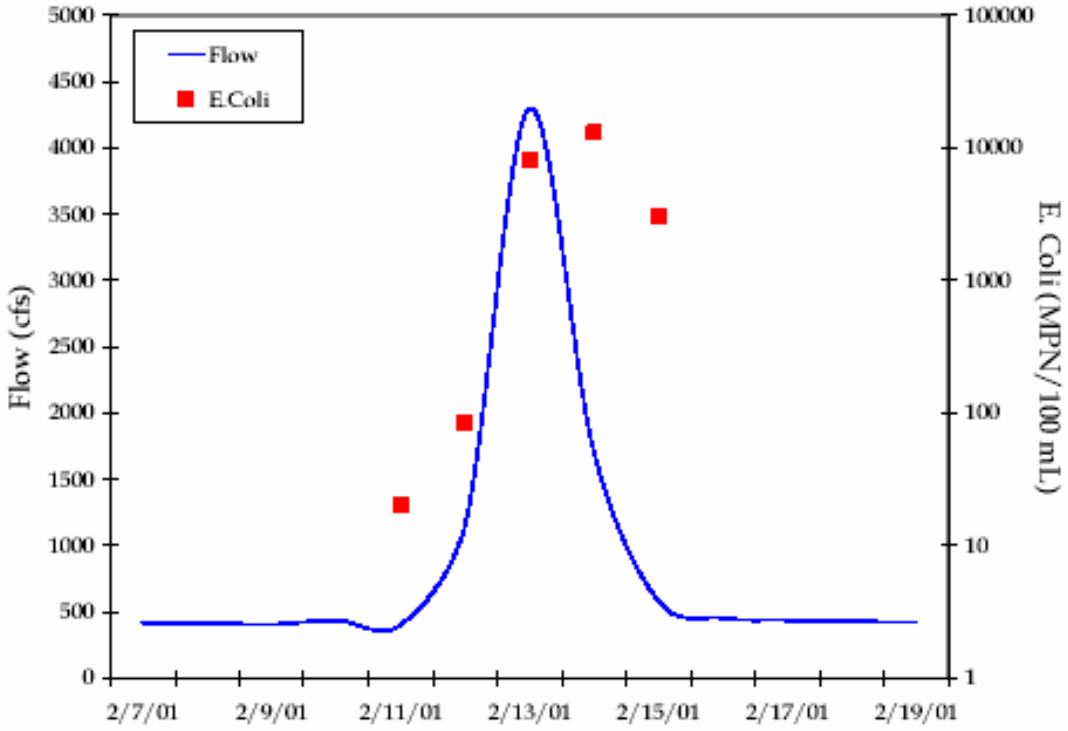


Figure 85
February 2001 Wet Weather E. coli Sampling Event

Figure B 8: Percent of months exceeding objectives (CDM 2005 Figure 102)

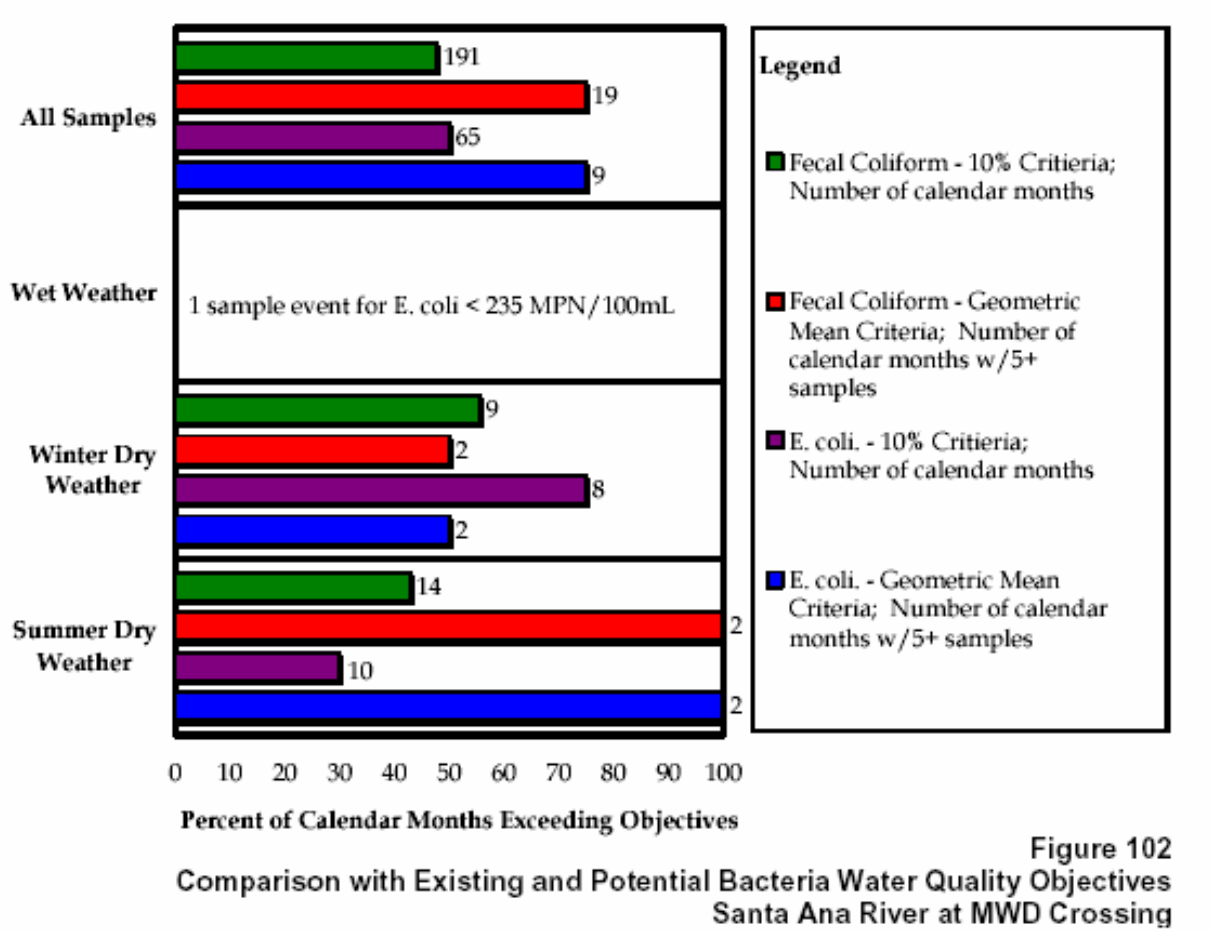


Figure 102
Comparison with Existing and Potential Bacteria Water Quality Objectives
Santa Ana River at MWD Crossing

Figure B 9: Percent of months exceeding objectives (CDM 2005 Figure 110)

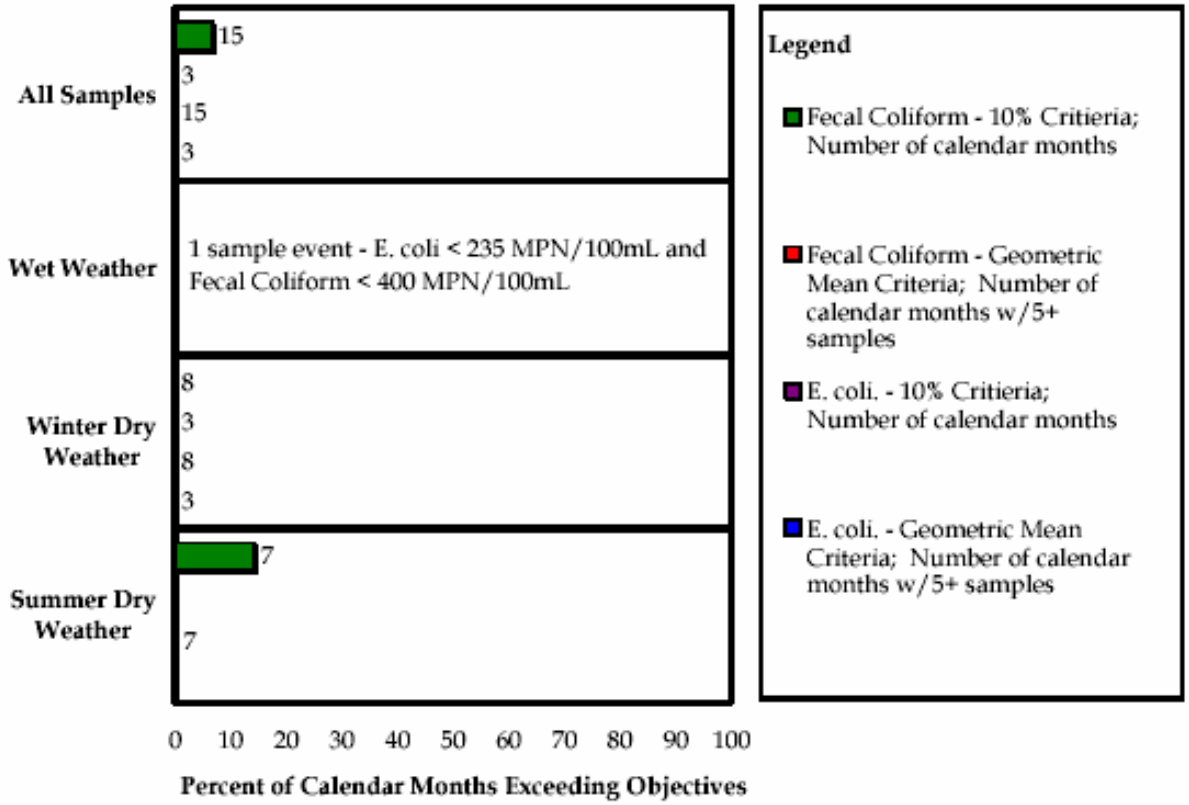


Figure 110
Comparison with Existing and Potential Bacteria Water Quality Objectives
Icehouse Canyon Creek

Figure B 10: Percent of months exceeding objectives (CDM 2005 Figure 88)

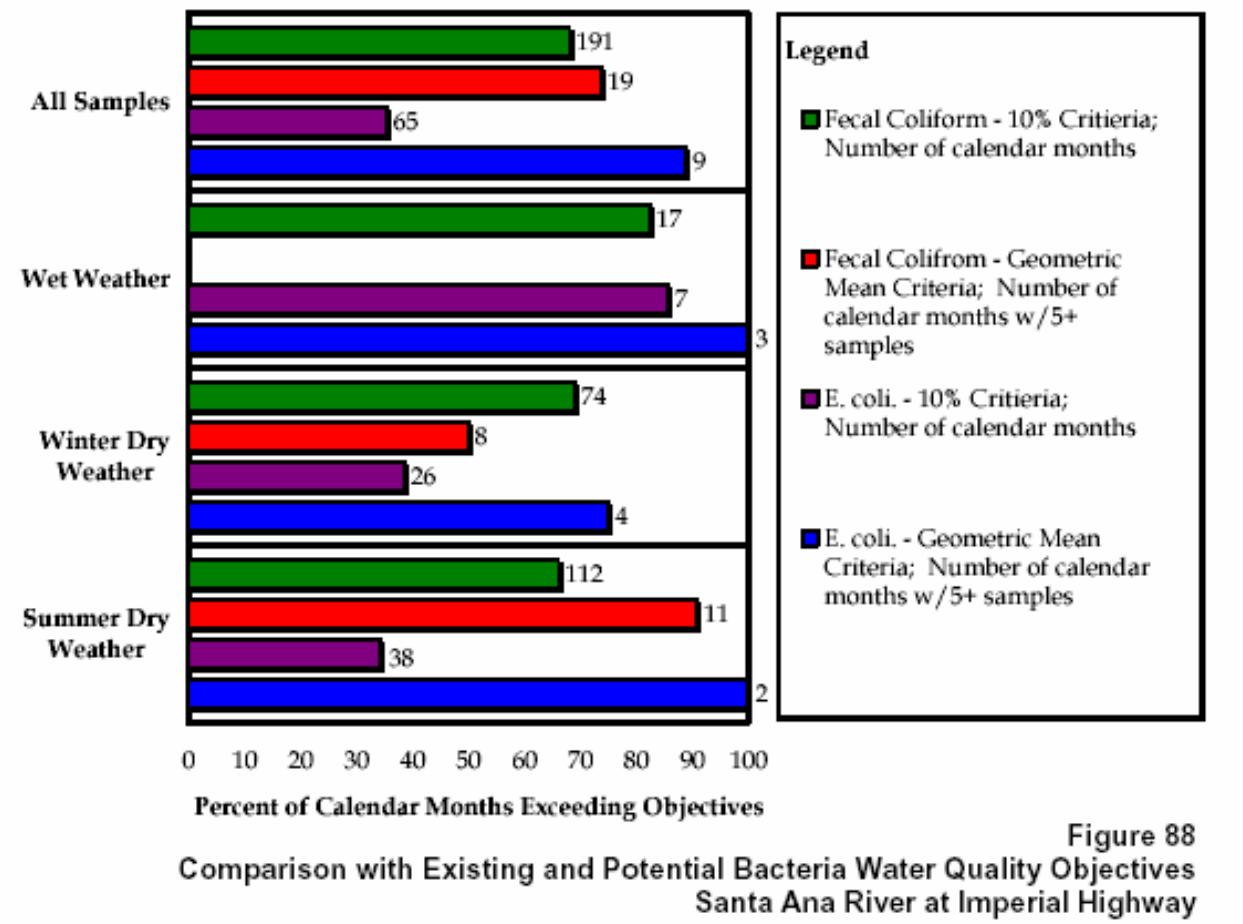


Figure 88
Comparison with Existing and Potential Bacteria Water Quality Objectives
Santa Ana River at Imperial Highway

Figure B 11: Percent of months exceeding objectives (CDM 2005 Figure 74)

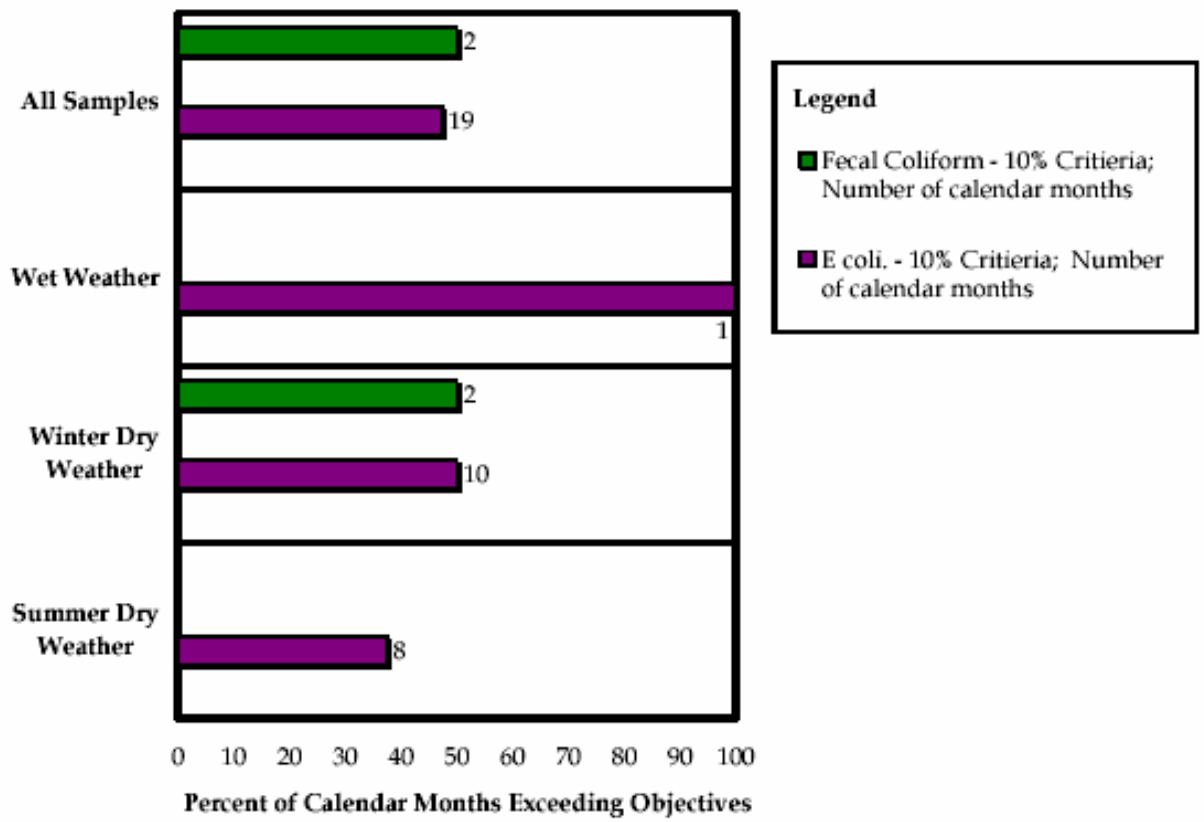


Figure 74
Comparison with Existing and Potential Bacteria Water Quality Objectives
Temescal Creek Near Lincoln Avenue

Figure B 12: Percent of months exceeding objectives (CDM 2005 Figure 38)

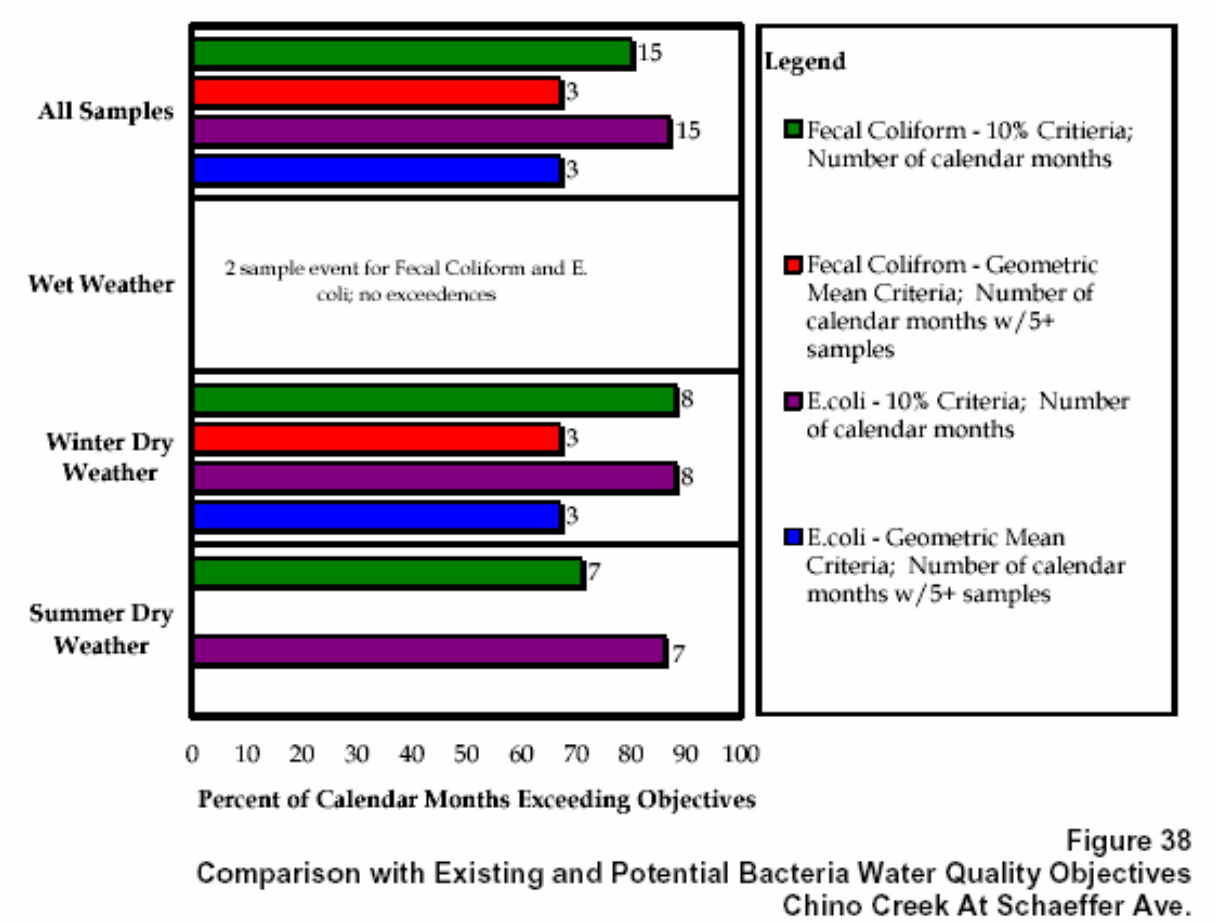


Figure 38
Comparison with Existing and Potential Bacteria Water Quality Objectives
Chino Creek At Schaeffer Ave.

Figure B 13: Percent of months exceeding objectives (CDM 2005 Figure 57)

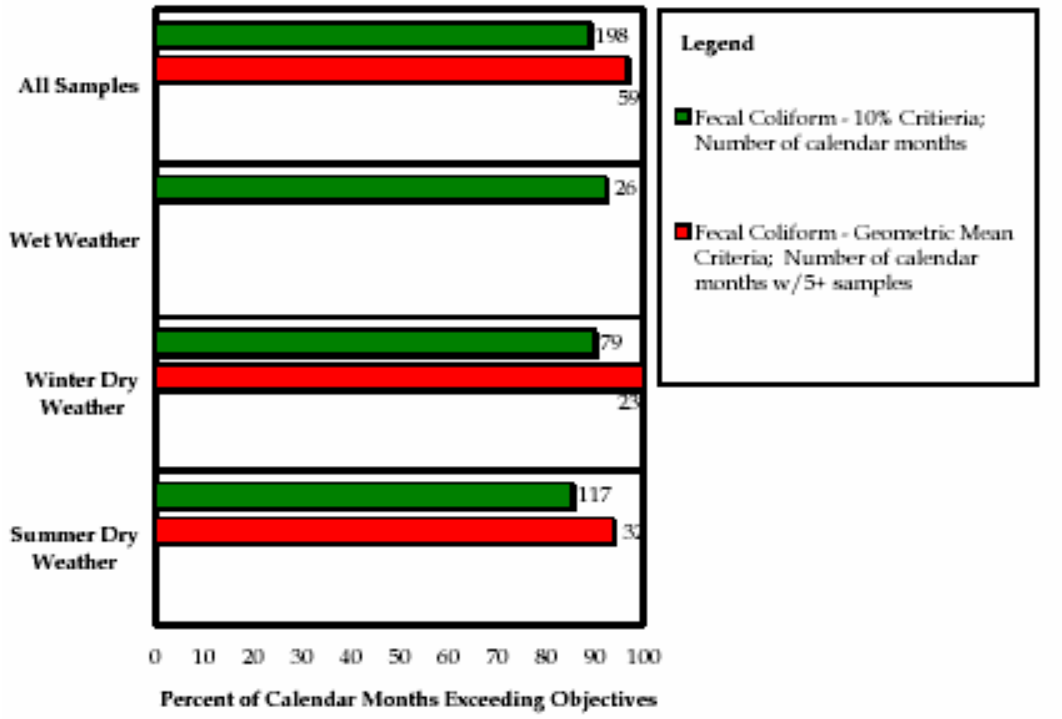


Figure 57
Comparison with Existing and Potential Bacteria Water Quality Objectives
Santa Ana Delhi Channel near Irvine Ave.

APPENDIX C

DATA FROM ALISO CREEK

G E O S Y N T E C C O N S U L T A N T S

838 SW First Avenue, Suite 530
Portland, Oregon 97204

(503) 222-9518
(503) 242-1416 Fax

MEMORANDUM

TO: SUSAN PAULSEN, FLOW SCIENCE

FROM: BRUCE WILLIAMSON, LISA AUSTIN, GEOSYNTEC CONSULTANTS

SUBJECT: ALISO CREEK BMP EFFECTIVENESS ANALYSIS

DATE: APRIL 13, 2005

CC: PETER MANGARELLA, GEOSYNTEC CONSULTANTS

Introduction

This purpose of this technical memorandum is to assess the efficacy of Best Management Practices (BMPs) installed in parts of Aliso Creek, Orange County, California (Figure 1) on the removal of pathogen indicators. Pathogen indicator data collected by Orange County Resources and Development Management Department in this watershed and on these BMPs has received increasing attention when project design features are evaluated by regulatory authorities. Therefore, it is important that we have a good understanding of these findings and their uncertainties.

The two BMPs assessed in this memo are:

1. Dry weather flows are passed through multimedia filtration/UV sterilization using a proprietary treatment unit 'Clear Creek Systems'. This treats low flow runoff from a two square mile catchment with mixed urban land use. The storm drain facility and catchment are designated as J01P28 in the watershed map and plans (Figure 1, 2B).

2. Wetland ponds to intercept watershed runoff and treat dry weather flow and first flush. These treat low flow and first flush runoff from a two square mile residential catchment. The storm drain facility and catchment are designated as J03P02 in the watershed map and plans (Figure 1, 2A).

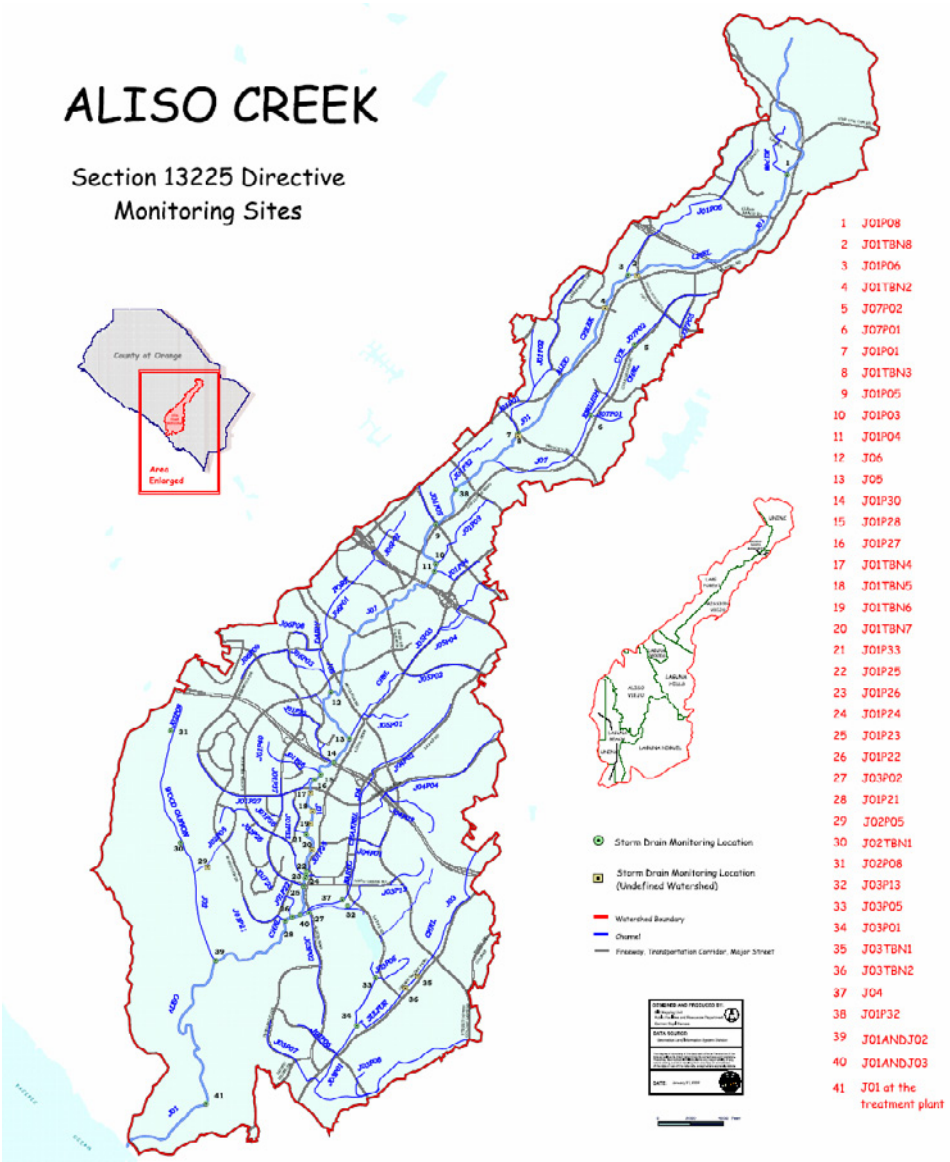
All monitoring of the BMPs and their receiving waters took place during dry weather. Consequently, low flows were mostly sampled, but during the wet season a proportion of these were probably elevated flows during storm recessions.

The data were collected by the County of Orange and its city partners and is available in reports listed at http://www.ocwatersheds.com/watersheds/Aliso_reports_studies.asp, and also in Evaluation Reports by the County of Orange.[1,2]

[1] County of Orange Resources and Development Management Department, Watershed and Coastal Resources Division. 'Aliso Creek Clean Beaches Initiative. Final Report for Agreement 01-227-550-0' submitted to Regional

Note that the Aliso Creek watershed Quarterly Progress Reports (QPR) refer to other BMPs installed in stormwater drains of urban watersheds at a number of locations in the Aliso Creek watershed. These include grassy swales for treating park runoff to Sulfur Creek in Laguna Niguel and a wetland biofilter in another branch of Sulfur Creek in Laguna Hills The status of the these BMPs is unclear, and no monitoring data for these BMPs were located in the QPR.

Figure 1



and State Boards in January 2005 and 'Wetland Capture and Treatment Final Report for Agreement No. 01-122-259-0' submitted to Regional and State Boards in March 2004.

[2] "Wetland Capture and Treatment Final Report for Agreement No. 01-122-259-0" submitted to Regional and State Boards in March 2004.

Figure 2A: Location of J03P02

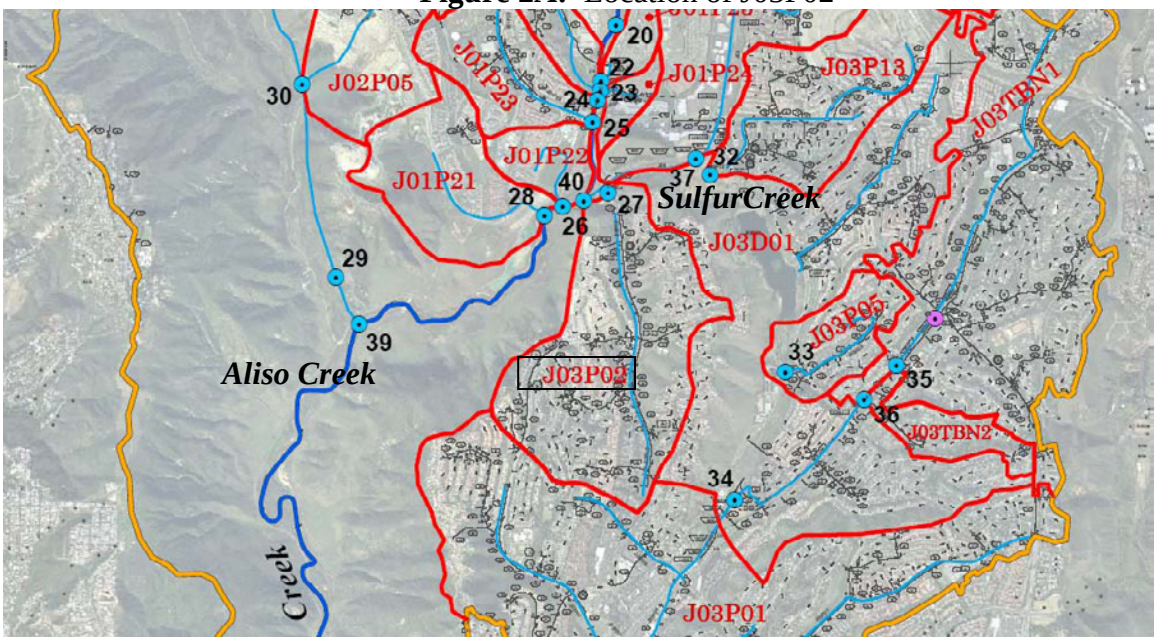
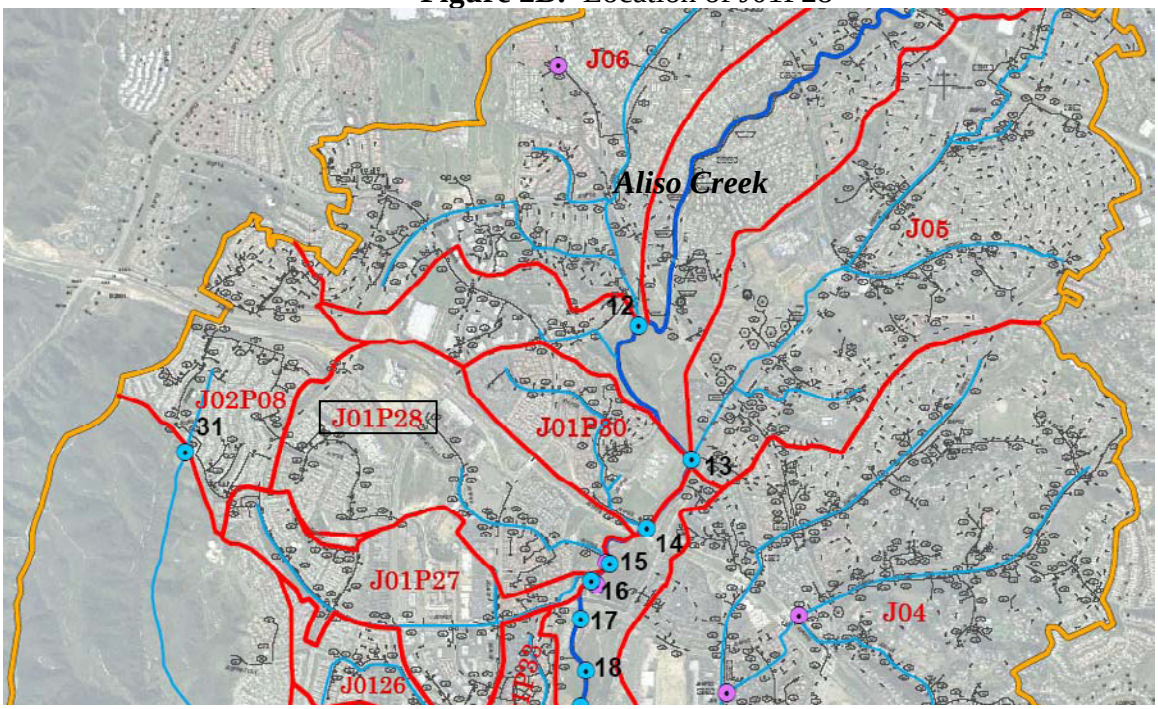


Figure 2B: Location of J01P28



Site Description

Aliso Creek Watershed

Aliso Creek watershed encompasses 30.4 square miles and includes portions of the cities of Aliso Viejo, Dana Point, Laguna Niguel, Laguna Woods, Laguna Beach, and Lake Forest. Its main tributary, Aliso Creek, originates in the Santa Ana Mountains inside the boundaries of the Cleveland National Forest. Smaller tributaries include Wood Canyon, Sulphur Creek, the Aliso Hills Channel, and English Channel (Figure 1).

Aliso Creek is the subject of a Directive issued by the San Diego Regional Water Quality Control Board (RWQCB) in 2001 for an investigation of urban runoff in the Aliso Creek watershed. The Directive found that the Permittees may be discharging waste with high bacteria levels from municipal storm drain outfalls into Aliso Creek and its tributaries. The Directive required the Permittees to begin a comprehensive monitoring program and undertake investigations within the storm drain system to identify the causes of the problem and the control actions needed to correct the problem. This has resulted in a comprehensive study involving weekly sampling of approximately 35 storm drains and their respective receiving waters, and numerous other initiatives in identifying sources and source control.

Part of the creek (J03P02) is subject to a Cleanup and Abatement Order (CAO) issued by the RWQCB in 1999. This was the result of a survey which showed that pathogen indicators (PI) in the drain were much higher than in Aliso Creek. Experience gained from the more comprehensive monitoring carried out since that time has shown that J03P02 is in the low to middle of the range of PI concentrations compared to the rest of the Aliso Creek watershed.

Sand Filtration/UV Sterilization

The J01P28 Interim Water Quality Improvement Package Plant BMP was executed in response to the San Diego RWQCB 13225 Directive to clean up Aliso Creek.

This treatment unit is located near the outlet of the J01P28 subcatchment (Figure 2). This subcatchment is a tributary to the main stem of Aliso Creek. The storm drain conveys runoff water from a fully developed area of approximately two square miles in the city of Aliso Viejo. Land uses in the catchment include residential, commercial, light industry, and parks. The BMP was installed in July 2003.

The CCS treatment system includes three multi media filters, two organo clay filters and two ultraviolet light disinfection chambers. The package plant treatment system has three main phases:

- Sediment and debris removal
- Oils, pesticides, and trace metals removal
- Disinfection

The larger debris and trash removal is performed at the inlet strainer that is located in an energy dissipation basin within the storm drain. Sediment removal is performed in the basin and in the multimedia filter. Oils, pesticides and trace metals are removed via adsorption onto the organo-clay media while the ultraviolet light chamber removes bacteria and viruses.

The package plant treatment system filters and disinfects approximately 100,000 gallons per day of urban dry weather runoff. The design capacity is 250,000 gallons per day. By October 2004, a total of 1.4 million gallons had been treated.

Monitoring results from the years 2001 through June 2003 were combined to form the "before" dataset, while results from August 2003 through December 2004 constituted the "after" dataset.

Once discharged from the unit, the water flows through a ponded area approximately 20 feet long, 6 feet wide and 1.5 feet deep, then 30 feet through a natural ditch to Aliso Creek. A monitoring site is located in the natural ditch 15 feet from Aliso Creek.

Wetlands

Wetlands have been installed near the outlet of subcatchment J03P28, which is a tributary to Sulfur Creek, itself a tributary to Aliso Creek (Figure 2A). The wetlands are positioned at the bottom of the catchment and designed to capture 100% of the low flows before they discharge to Aliso Creek. The catchment (538 acres) is entirely residential (1600 households, new to 30 years old). A number of structural BMPs have been implemented from 2000 to the present day.

1. From May 2000 to March 2001, dry weather flows were diverted to the AWMA Regional Sewage Treatment Plant.

2. From March 2001 to April 2003 (actually it is not clear when unit stopped operating), dry weather flows in the drain were treated by a mobile Clear Creek Systems filtration/UV treatment unit. The flow was diverted to the treatment plant (e.g., 15% of total flow in the July-September 2002 quarter) when the filter clogged or the UV malfunctioned.

3. The three wetlands were constructed progressively starting in about March 2001 and were completely online from April 2003[2].

J0302 has been subject to detailed studies because of the CAO. These include visual (video) inspection of sewer and storm drain pipes, field reconnaissance, resident surveys, flow monitoring, a wide range of upwatershed sampling and the identification the sources of the pathogenic indicator bacteria. Samples were examined for human enteroviruses, antibiotic resistance, and genotypes of E. coli. The researchers concluded that the primary sources of PI in J03P02 are not likely to be human, and are likely to be due to cows (soil fertilizer amendments), birds, rabbits, and some unidentified other animals. In the Aliso Creek QPRs, the Co-Permittees indicate that the following sources probably contribute to fecal coliform (FC) in J03P02:

- Organic soil amendments
- Turfgrass areas

- Wildlife
- Domestic pets
- Accumulated organic debris in the surface and subsurface storm drain system
- Street sweeping debris

The wetlands – called East, West and North, were positioned to capture 100% of catchment runoff during dry weather and first flush. Design features are summarized in Table 1. The hydrological network is outlined in Figure 3.

Wetland inflow is taken by intercepting flows in the stormwater pipes, including the 60-inch main pipe. After passing through the wetlands, some of the treated stormwater is routed back though the 60-inch pipe to an open channel just before its confluence with Sulfur Creek. Effluent from the West Wetland is discharged directly to this open channel, and does not pass through the pipe. Another untreated, unmonitored inflow also discharges to this point (Figure 2).

Table 1: Wetland design features (reference see footnote 2).

Wetland	Total Catchment Area (acres)	Planned intercepted area (acres)	Wetland Area (acres)	Depth (ft)
East	374	37	0.3	1
West	342	312	0.69	0.5
North	122	122	0.3	1

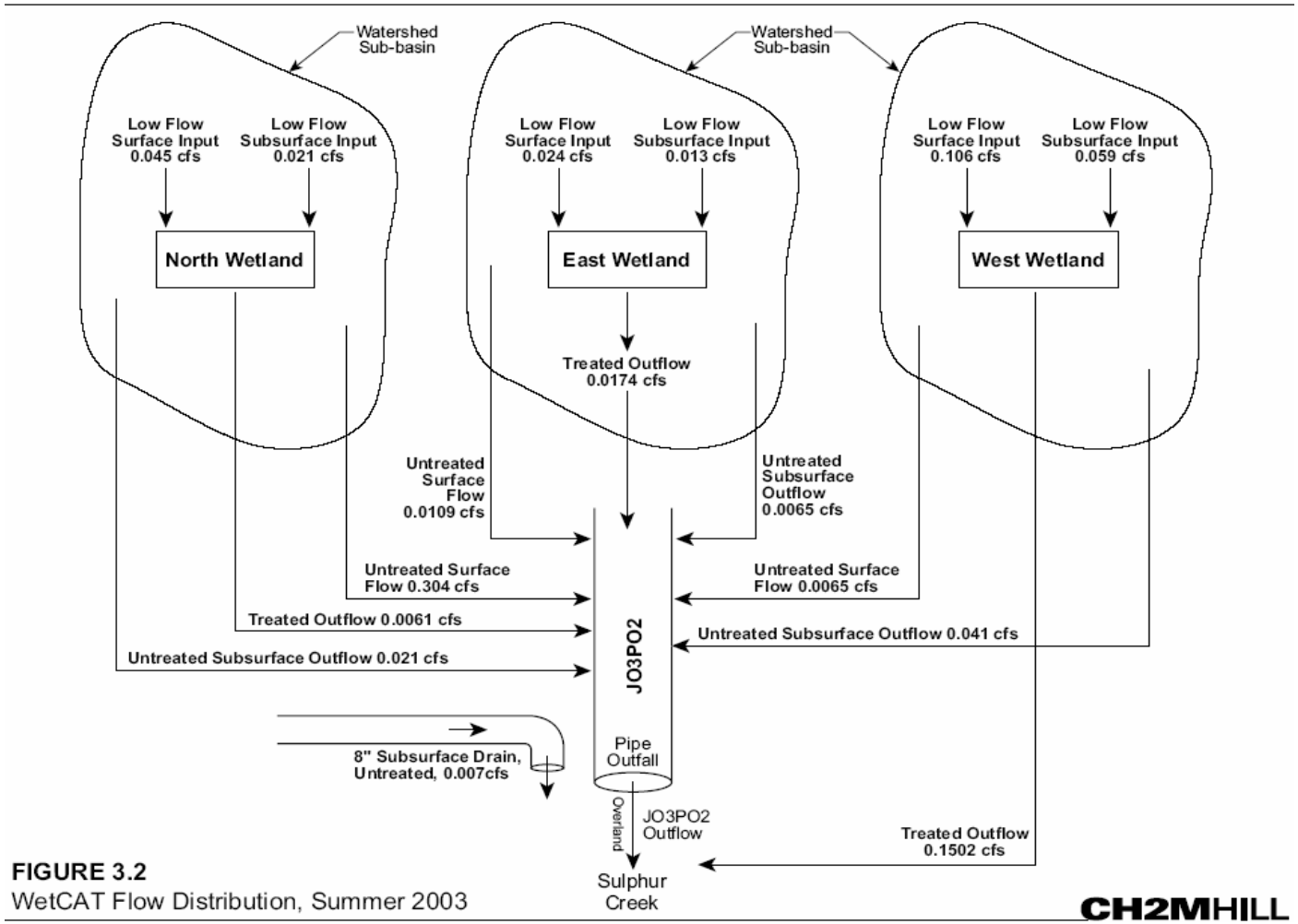
Sampling Procedures

All sampling was conducted during "dry weather," which is defined as no rain on the day of sampling. Sampling was conducted under strict protocols (see Aliso Creek 8th Quarterly Progress Report). Quality Assurance/Quality Control (QA/QC) sampling procedures were implemented that should have prevented contamination during sampling and significant changes to the sample during transport to the laboratory.

Directive Monitoring: Each location has three monitoring sites: two of these are on the main stem, 25 feet upstream and downstream of the storm drain discharge, the other is on the storm drain itself, approximately 15 feet above its confluence with the stream. These three sites were monitored weekly, so that at least five samples were collected each month, at random intervals. Some of these monitoring sites are shown in Figure 1.

BMP Monitoring: In addition to the directive sampling program, the influent and effluent to the BMPs were monitored.

Figure 2. Source: Wetland Capture and Treatment Final Report (2004)[2]. Note: untreated Surface Flow from North Wetland should probably be 0.0304 cfs.



Summary of Monitoring Results

J01P28 - Multimedia Filtration/UV Digestion

Influent/effluent. Comparison of the influent and effluent concentrations demonstrates a 99.6% reduction in fecal coliform levels. The geometric mean decreases from 77,414 CFU/100mL to 317 CFU/100mL.

Stream and drain monitoring. A statistical analysis of the levels in the receiving water (the "directive" dataset) is summarized in Table 2 and as box plots in Figure 3-4. These refer to all data collected before BMP installation. The County monitoring reports summarize data for quarterly monitoring periods. In the QPR, quarterly monitoring data are compared between years to reduce variance from seasonality, and constitute a more powerful assessment of the data. However, for our purposes here, the lumped data is sufficient to demonstrate their findings.

Table 2: Comparison of geometric means (cfu/100 ml) before and after multimedia filtration/UV sterilization. The BMP is installed about 35 feet upstream of the storm drain monitoring site.

Locations	**TC**		**FC**		**ENT**	
	before	after	before	after	before	after
u/s	5353	2851	775	773	990	662
storm drain	52267	15232*	14633	5827*	9171	1401*
d/s	17248	5142*	2722	1696*	1791	839*

* = significant change (1-way ANOVA, $\alpha<0.05$)

Regrowth. Comparison of effluent and the 'directive' storm drain monitoring site, show a large increase in FC levels in the approximately 35 feet between the unit discharge and the storm drain monitoring site. No other discharges were found, which suggest that rapid re-growth has taken place in the water column, or re-infection has occurred from sloughing or resuspension of bacteria from immersed channel-side vegetation, organic debris and/or sediments. The geometric mean increases in this short distance from 317 cfu/100mL to 2,575 cfu/100mL.

Further work is planned by the County on the re-growth issue. Permits have been requested to perform clean up work on the habitat and the storm drain outlet basin.

Figure 3: FC levels for J01P28 monitoring site.

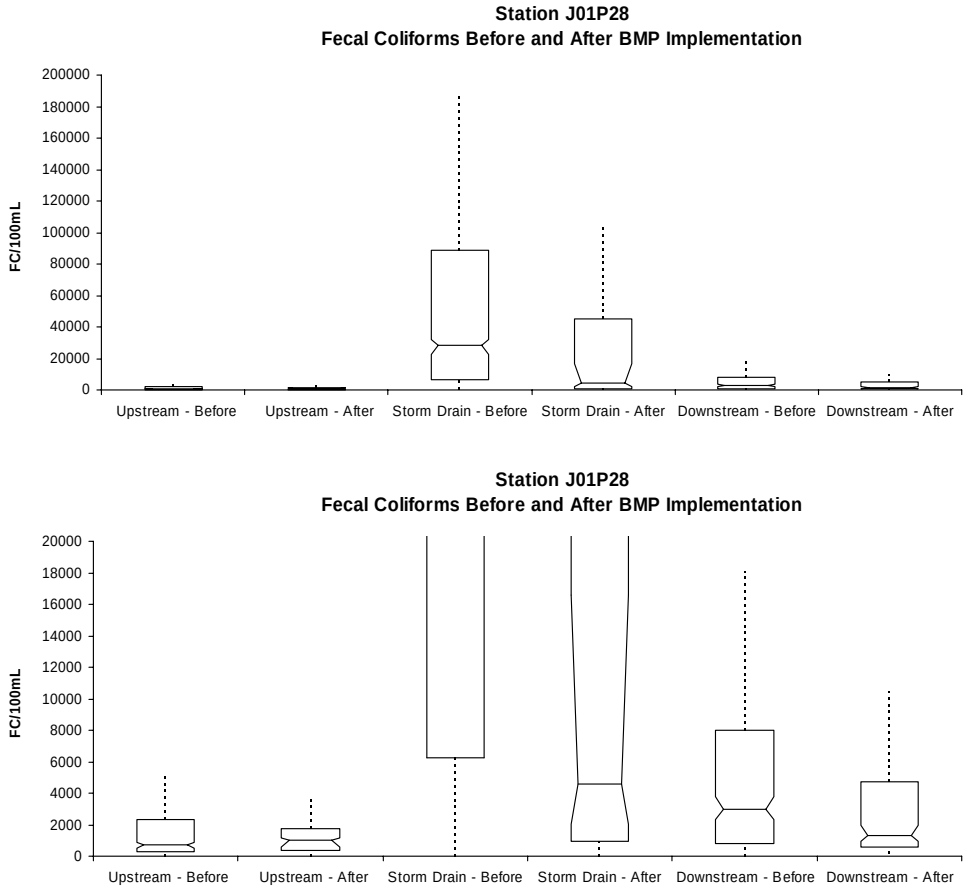


Figure 4: ENT levels for J01P28 monitoring site.

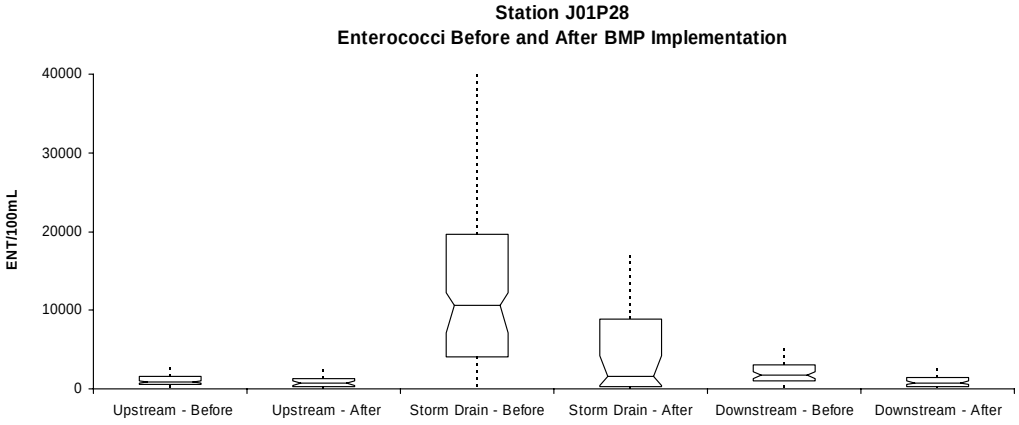
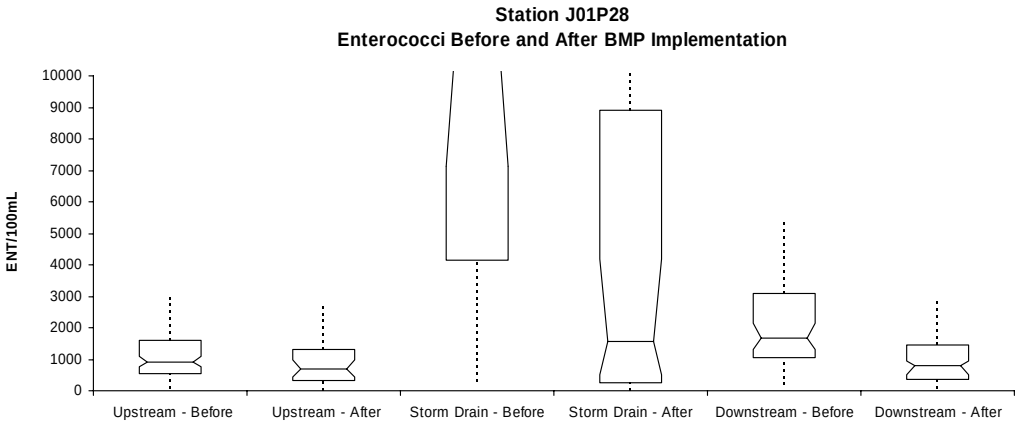


Figure 4 (continued)



J03P02 – Wetland BMPs

Influent/effluent. All monitoring took place during dry weather. Flows were measured, but only once per month and not for each sampling occasion. Most sampling took place at lows flows. The flow was typically 0.25 cfs with a range of 0.13-0.56 cfs.

Wetland monitoring in the three wetlands showed 90 to 99 percent reduction in FC levels from 2001 to present day (e.g. see Table 3). (Note that the three wetlands were installed and monitored progressively – results from 2001 were from one wetland only). Overall, 90 percent of treated effluent samples met the REC-1 objectives for FC. Although enterococci (ENT) levels dropped by 60 to 99 percent in wetlands, wetland effluent did not meet the steady state objective of 33 cfu/100ml during the period of monitoring (2001-2004). Few individual wetland samples met the single-sample objective.

Table 3: East Wetland fecal coliform (cfu/100mL) removal March 2001 – August 2002.

Parameter	Inflow	Outflow	Removal
Median	5000	50	99%
Mean	14900	150	99%
Geometric mean	2,800	35	99%

Overall there has been a progressive decline in FC and ENT since the wetlands have progressively come on line.

As well as the wetland monitoring, the effluent from the mobile UV sterilization unit was monitored when it was installed (between March 2001 to April 2003). The influent was not monitored directly. A cursory scan of the results suggests that the treatment unit effluent quality met REC-1 requirements on most months, but failed at times, which was attributed to the sand filter clogging.

Stream and drain monitoring. No "before BMP implementation" could be found because the 'directive' monitoring period encompassed either diversion to the sewage treatment plant, UV sterilization and/or wetland treatment. (However, some data is available somewhere, because it led to the CAO).

The dry weather discharge from the storm drain had little or no effect on the FC levels in Sulfur Creek. The flow from J03P02 is about 10 percent of the flow in Sulfur Creek.

The bacterial quality of the J03P02 storm drain discharge has steadily improved over the monitoring period. However, the improvement is quite complex, as described in the following section.

Re-growth. There is evidence that re-growth occurs between the wetlands and the storm drain monitoring sites. The concentrations in the open channel at the end of the pipe are about twice what is expected based on mass flow considerations.

However, there are some ambiguities in the various Quarterly Reports about the nature of the connection between the catchments, wetlands, and the J03P02 monitoring site[3]. This has been resolved in the detailed report on the BMP project for J03P02[2]. Measurements show that a high proportion of the flow is not intercepted (about 37 percent). Figure 2 also shows that the largest wetland ('West') bypasses and discharges downstream from the pipe.

Therefore, the apparent re-growth phenomenon could be wholly or partly due to the "recontamination" by the un-intercepted flows from the catchment. The project investigated this by carrying out a mass balance calculation. Unfortunately the report does not give any details on the calculations, but states that concentrations at the end of the pipe after discharge are about twice what is expected based on these mass flow considerations.

GeoSyntec confirmed that there was about this order of magnitude difference between observed and calculated mass flows using flows given in Figure 2 and using appropriate median FC numbers for the summer 2003 monitoring period. However, the proposition of re-growth, while plausible, is uncertain because:

- There is a significant input of untreated surface and subsurface flows into and at the end of the J03P02 pipe
- Most flows were estimated and not measured
- Many of the FC and ENT concentrations used in the mass flow calculations were not measured and assumed values were taken from the monthly monitoring data.
- There is a high degree of variability in monitored FC and ENT

The rates of this apparent re-growth appear to be seasonal and variable. As described above, usually observed levels at the J03P02 monitoring site are higher than the combined flows from the wetland. Fecal coliform and enterococci increase by about 100 percent in-pipe during spring, summer, and fall. However, this apparent re-growth does not occur during winter months and

[3] Most comments imply a 200 foot pipe, but 14th QPR refer to pipe outlet and 200 feet overland distance.

sometimes die-off can be observed. For example, the winter FC levels in 2004 were 1/8th of those predicted from the combined treated and untreated contributions, while ENT levels are about the same as predicted levels. The report suggests that die-off and re-growth (or re-contamination) of ENT and FC may be temperature and salinity dependent.

The overall findings of the BMP study to this particular watershed is that as the BMPs came on line, there was a steady improvement in the quality of the J03P02 discharge to Sulfur Creek during some seasons[4]. Results from monitoring the drain downstream of the BMPs show:

- Spring (Apr-Jun) geomeans for FC fell from 2001-2003. The 2004 geomean was similar to that for 2003.
- Summer (Jul-Sep) geomeans for FC have not fallen with statistical significance
- Winter (Jan-Mar) geomeans for FC fell from 2002 – 2004.

Discussion and Conclusions

Filtration coupled with UV sterilization reduced indicator bacteria to below the REC-1 standard. This was demonstrated at both sites. However, the benefits are compromised by what appears to be re-growth. At J01P28, the re-growth/re-inoculation occurred in a natural steam reach consisting of a pool and run, which was shaded with riparian vegetation dangling in the stream. It occurred within only 35 feet of the discharge point from the treatment unit.

Wetlands reduced fecal coliform (FC) levels by 90 to 99 percent to below the REC-1 guideline for 90 percent of the samples. They also reduced enterococci (ENT) levels by 60 to 99 percent, but the effluent from the three wetlands always exceeded the steady-state ENT objective, and usually exceeded the single sample objective. As with J01P28, the benefits of wetland treatment were compromised by the low-flow capture rate and what appears to be re-growth or re-contamination after discharge from the BMPs. Concentrations of FC and ENT increase between the wetland effluent and the J03P02 monitoring site 15 feet from its confluence with Sulfur Creek. The summary report proposed that most of the re-growth/re-inoculation occurred within a 200-foot pipe carrying wetland effluent to the confluence with Sulfur Creek.[2]

The study report proposed that re-growth was plausible because there was opportunity and time for re-growth to occur. The combined effluent from the East and North wetland is conveyed to Sulfur Creek through the pipe, which has a transit time during low flow of 15 minutes. As stated in the Wetland Capture and Treatment Final Report 2004[2] "Given ….. the microbiologists 'rule of thumb' that bacterial populations can double every 15 minutes under ideal conditions, rapid in-pipe propagation of FC and ENT in the dark pipe may be the main factor, or may be combined with recontamination from bioslimes or muck deposits" (Clean-Up & Abatement Order 99-211 17th QPR). Another possible reason is that the structures which divert low flow from the stormwater pipes to the wetland also trap and retain organic debris, which may act as substrates

[4] This is somewhat surprising given that the drain water was treated by multimedia filtration/UV disinfection or diverted to the sewer system while the wetlands were constructed.

for re-growth. However, re-contamination by unmonitored inflows may also be partly or wholly responsible for the observed increase between the BMPs and the confluence.

The results suggest that the benefits of BMPs may be compromised by re-growth, which occurred in both the natural channel and pipe downstream of the monitored BMPs. The various investigators have concluded that treatment systems would need to be positioned at the bottom of the watershed directly before discharge to the receiving water body – mainly to prevent regrowth during warm weather conditions.[1] Another important general conclusion in the study (see City of Laguna 6th QPR Aliso Creek 13225 Directive) states 'that "primary" bacteria concentrations (from direct deposits of bird droppings, for example) in runoff can be magnified by the "secondary" propagation of bacteria populations within the environment, so that *controlling propagation* may ultimately become as important as *source reduction* in reducing overall outfall concentrations. The research results also suggest that the presumption of a statistically valid relationship between certain concentrations of fecal coliform and an acceptable vs. unacceptable magnitude of public health risk (which is the basis for the REC-1 and REC-2 objectives) may be seriously flawed.'

The proposition that re-growth occurs after treatment has wide ranging implications for stormwater management. Given the uncertainties outlined above as to whether re-growth occurs after wetland treatment, the County study results should be confirmed by more detailed studies and sampling, such as:

- more frequent sampling of concentrations taking into account time of travel
- stormwater runoff monitoring (not just dry weather flows)
- measurement of flows where possible.

It is unknown whether the re-growth phenomenon apparent at the Aliso Creek sites would result in much higher concentrations over longer distances, but such an experiment cannot be conducted at the County-selected sites.

Finally, it is re-emphasized that monitoring was only conducted during dry weather conditions – mostly low flow and do not reflect storm runoff conditions, except for possibly occasionally during the storm regression phase. The impact of storm runoff on the treatment efficacy of the BMPs tested at Aliso Creek is unknown. Likewise, it is unknown what impact high flow may be on the mechanisms that lead to re-growth or re-inoculation; such flows may deliver organic debris and sediments and also slough off slimes and accumulations of organic detritus.

APPENDIX E

EFFECT OF URBANIZATION ON GROUNDWATER RECHARGE IN THE SANTA CLARITA VALLEY

Effect of Urbanization on Aquifer Recharge in the Santa Clarita Valley

TO: Tom Worthington/Impact Sciences, Inc.

FROM: John Porcello/CH2M HILL

DATE: February 22, 2004

Introduction

In a groundwater basin, the effect of urbanization on recharge to underlying groundwater is dependent on land uses, water uses, vegetative cover, and geologic conditions. Groundwater recharge from undeveloped lands occurs from precipitation alone, whereas areas that are developed for agricultural or urban land uses receive both precipitation and irrigation of vegetative cover. In an urban area, groundwater recharge occurs directly beneath irrigated lands and in drainages whose bottoms are not paved or cemented. This memorandum discusses the general effects of urbanization on groundwater recharge and the specific effects in the Santa Clarita Valley.

Summary of Findings

In the Santa Clarita Valley, stormwater runoff finds its way to the Santa Clara River and its tributaries, whose channels are predominantly natural and consist of vegetation and coarse-grained sediments (rather than concrete). The stormwater that flows across paved lands in the Santa Clarita Valley is routed to stormwater detention basins and to the river channels, where the porous nature of the sands and gravels forming the streambeds allow for significant infiltration to occur to the underlying groundwater.

Increased urbanization in the Valley has resulted in the irrigation of previously undeveloped lands. The effect of irrigation is to maintain higher soil moisture levels during the summer than would exist if no irrigation were occurring. Consequently, a greater percentage of the fall/winter precipitation recharges groundwater beneath irrigated land parcels than beneath undeveloped land parcels. In addition, urbanization in the Santa Clarita Valley has occurred in part because of the importation of State Water Project (SWP) water, which began in 1980. SWP water use has increased steadily, reaching nearly 44,500 acre-feet (AF) in 2003. Two-thirds of this water is used outdoors, and a portion of this water eventually infiltrates to groundwater. The other one-third is used indoors and is subsequently routed to local water reclamation plants (WRPs) and then to the Santa Clara River (after treatment). A portion of this water flows downstream out of the basin, and a portion infiltrates to groundwater.

Records show that groundwater levels and the amount of groundwater in storage were similar in both the late 1990s and the early 1980s, despite a significant increase in the

urbanized area during these two decades. This long-term stability of groundwater levels is attributed in part to the significant volume of natural recharge that occurs in the streambeds, which do not contain paved, urban land areas. On a long-term historical basis, groundwater pumping volumes have not increased due to urbanization, compared with pumping volumes during the 1950s and 1960s when water was used primarily for agriculture. Also, the importation of SWP water is another process that contributes to recharge in the Valley. In summary, urbanization has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the Valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the Valley.

Effect of Pavement on Recharge Beneath Specific Land Parcels

The amount of paved cover on the ground affects the degree to which rainfall and outdoor-applied urban water will be able to infiltrate to groundwater. In heavily industrialized areas with high percentages of paved cover, such as exist in portions of the Los Angeles Basin, less rainfall recharge will occur than if the land is in an undeveloped condition. Furthermore, if the bottoms of rivers and other drainages are paved, then the majority of stormwater generated during a rainfall event will be unable to infiltrate to groundwater. In contrast, the amount of recharge to groundwater will be greater in urbanized areas, such as the Santa Clarita Valley, that have natural soils in the bottoms of rivers and local drainages or that have lower percentages of paved cover on the developed areas lying outside the principal drainages. In these areas, the outdoor use of water for irrigation landscape vegetation or agricultural lands can notably increase the amount of groundwater recharge, particularly if the outdoor water is imported from outside the local groundwater basin. This is discussed further below.

Effect of Vegetative Cover and Water Use

From the 1930s through the 1960s, H.F. Blaney and other researchers at the U.S. Department of Agriculture performed numerous studies to measure the amount of infiltration to groundwater that occurs beneath undeveloped lands and irrigated farmlands, and the differences in recharge rates for different types of native vegetation and crops. In California, these studies included a 1933 study by Blaney in Ventura County, a 1963 study by Blaney and others in the Lompoc Uplands, studies by the U.S. Geological Survey and various consultants in the Montecito and Carpenteria groundwater basins, and a groundwater basin study by Santa Barbara County[1] that incorporated the results of these earlier studies.

Together, these studies concluded that deep percolation to groundwater from undeveloped lands occurs only during years of average or above-average precipitation. This occurs because:

1. Southern California's rainfall is highly seasonal in nature, whereupon most rainfall occurs during the relatively cool period November through March, when plant water

[1] See Santa Barbara County Water Agency, December 15, 1977. *Report on Adequacy of the Groundwater Basins of Santa Barbara County.*

requirements are low, and little, if any, rainfall occurs during the remaining (and warmer months) when plant water requirements increase.

2. During the summer, when little or no rainfall occurs, the native vegetation extracts the residual moisture that is present in the soil, which substantially decreases the soil moisture within the root zone of the vegetation. At the end of the dry season, soil moisture levels on undeveloped lands are below the soil's field capacity, which is the amount of moisture that must be present in the soil before free drainage of water can occur below the rooting zone of the native vegetation.

3. When the seasonal rains arrive, the incident rainfall that is not consumed by plants and does not become stormwater runoff must first raise the soil moisture level to the soil's field capacity before any groundwater recharge will occur. The various studies indicate that about 17 inches/year of rainfall is necessary to raise the soil moisture to the field capacity on an undeveloped parcel of land. This is similar to the average annual rainfall in the Santa Clarita Valley and in other lowland coastal and near-coastal valleys in southern California.

On irrigated lands, irrigation occurs during several months of the year, with the exact duration depending on the amount and timing of rainfall and also the crops or type of urban landscaping being irrigated. The principal effect of converting undeveloped land to land that receives agricultural or urban irrigation is to increase the amount of water that is applied to the land during the low-rainfall months. This application of water to the vegetative cover on the surface of the developed land parcel results in the maintenance of higher soil moisture levels during the warm, dry months than would occur without development. This has three effects:

1. Because irrigation will generally be performed in a manner that maintains the health of the vegetative cover, enough water will be applied to maintain the soil moisture at, or close to, the field capacity of the soil. This in turn will allow some deep percolation to occur from the irrigation water itself.

2. When the rainy season begins, because irrigation has maintained soil moisture at or near field capacity, less of the initial rainfall entering the root zone needs to be stored in the soil (to meet soil moisture deficits) beneath an irrigated parcel than in the case of an undeveloped parcel. Therefore, a greater percentage of the initial rainfall and annual rainfall will be able to infiltrate to groundwater. The southern California studies estimated that irrigated land parcels would allow rainfall infiltration to occur in years when annual rainfall is at least 10.5 inches/year. This threshold rainfall value is 6.5 inches less than the threshold rainfall value that the studies estimated to be necessary for generating groundwater recharge beneath undeveloped land parcels.

3. Because the majority of irrigation occurs during the dry (low-rainfall) months, the total annual recharge to groundwater from irrigated developed lands is the sum of: (a) the deep percolation arising from irrigation (during the low-rainfall months); and (b) rainfall (during the months when less irrigation is occurring). Therefore, groundwater recharge beneath developed lands is greater and occurs for a longer period of time each year than in the case of undeveloped lands where no irrigation is occurring.

Historical Observations of Groundwater Conditions in the Santa Clarita Valley

The findings of the studies described above for other groundwater basins in southern California are consistent with observations that have been made in the Santa Clarita Valley, which are based on long-term water level records, water budget analyses, and groundwater modeling. Based on a month-by-month calibration to a 20-year record of historical water level records (throughout the Valley) and stream gaging records (at the Los Angeles – Ventura County line), the model simulates 10 percent of the applied outdoor water as being available for recharge to groundwater in retail and residential areas, with greater percentages infiltrating beneath golf courses and agricultural lands. This is consistent with a 1980 study by DWR of the groundwater resources of the Santee and El Monte hydrologic subareas of San Diego County. In that study, which was performed to evaluate reclaimed water use plans, DWR concluded that approximately 20 percent of the applied outdoor water in municipal areas infiltrates to the water table, with the remaining 80 percent going to evapotranspiration and direct evaporation. DWR also concluded that there would likely be no significant change in these percentages as urbanization continues.[2]

In the Santa Clarita Valley, as in any urbanized area, urbanization increases the paved area and can increase the magnitude and intensity of stormwater runoff from paved land areas. In the Santa Clarita Valley, this stormwater runoff will find its way to the Santa Clara River and its tributaries, whose channels are predominantly natural and consist of vegetation and coarse-grained sediments (rather than concrete). The stormwater that flows across paved lands in the Santa Clarita Valley is routed to stormwater detention basins and to the river channels, where the porous nature of the sands and gravels forming the streambeds allow for significant infiltration to occur to the underlying groundwater. Consequently, for a developed land parcel, the water that runs off of the paved portion of the land parcel will infiltrate to groundwater from a detention basin or a riverbed, rather than infiltrating onsite.

Riverbed infiltration is a significant percentage of total recharge in the Santa Clarita Valley in any given year. Streamflow records and the model calibration process together demonstrate that year-to-year fluctuations in total recharge in the Valley arise not just from year-to-year variations in incident rainfall within the Valley, but also from year-to-year variations in streamflows in the Santa Clara River and its tributaries. Because the areas contributing flow to the rivers are located both within and outside of the Valley, the recharge that occurs from riverbeds is a significant source of groundwater recharge within the Valley.

Evidence that stormwater infiltration to groundwater is not significantly decreased by urbanization comes from long-term water level records at wells completed in the Alluvial aquifer. These records show that groundwater levels and the amount of groundwater in storage were similar in both the late 1990s and the early 1980s, despite a significant increase in the urbanized area during these two decades. This long-term stability is attributed in part to the significant volume of natural recharge that occurs in the streambeds, which do not contain paved, urban land areas. Also, groundwater pumping volumes have not increased

[2] See State of California, Department of Water Resources, Southern District. August 1984, *San Diego County Cooperative Ground Water Studies: Reclaimed Water Use, Phase II*. Pages 40-41.

due to urbanization, compared with pumping volumes during the 1950s and 1960s when water was used primarily for agriculture. Additionally, beginning in 1980, water was imported into the Santa Clarita Valley from the State Water Project (SWP) for urban use, with SWP water use reaching nearly 30,000 acre-feet per year (AF/yr) by the end of the 1990s, and progressively increasing from about 32,500 AF in 2000 to nearly 44,500 AF in 2003. Because two-thirds of the total urban water demand is used outdoors, a substantial portion of the imported SWP water has been and continues to be applied to urban landscaping, thereby increasing the amount of recharge to groundwater. The remaining urban water is used indoors, and is subsequently routed to local water reclamation plants (WRPs) and then to the Santa Clara River (after treatment). A portion of this water flows downstream out of the basin, and a portion infiltrates to groundwater.

In summary, urbanization has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the Valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the Valley.

APPENDIX F

ASSESSMENT OF POTENTIAL IMPACTS RESULTING FROM CUMULATIVE HYDROMODIFICATION EFFECTS, SELECTED REACHES OF THE SANTA CLARA RIVER, LOS ANGELES COUNTY, CALIFORNIA

Assessment of potential impacts resulting from cumulative hydromodification effects, selected reaches of the Santa Clara River, Los Angeles County, California

Report prepared for:

GeoSyntec Consultants

Prepared by:

Scott Brown

Barry Hecht

Balance Hydrologics, Inc.

October 2005

A report prepared for:

GeoSyntec Consultants
55 SW Yamhill Street
Suite 200
Portland, OR 97204
(503) 242-1416
Attn: Lisa Austin

Assessment of potential impacts resulting from cumulative hydromodification effects, selected reaches of the Santa Clara River, Los Angeles County, California

Balance Project Assignment 205018

by

Scott Brown
Hydrologist, Geomorphologist

Barry Hecht, CEG 1245, CHg 50
Principal

©2005 Balance Hydrologics, Inc.

841 Folger Avenue
Berkeley, California 94710-2800
(510) 704-1000
sbrown@balancehydro.com
bhecht@balancehydro.com

October 27, 2005

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 BACKGROUND AND PURPOSE 1
1.2 TECHNICAL APPROACH 2
1.3 REPORT ORGANIZATION 2

2. GEOMORPHIC SETTING 3

2.1 CHANNEL PATTERN INFLUENCES 3
2.1.1 Physiography 3
2.1.2 Climate 4
2.1.3 Flows 4
2.1.4 Ground-water supported riparian vegetation 5

3. PERTURBATIONS 6

3.1 STREAMFLOW CYCLES AND EVENTS 6
3.2 DAM CONSTRUCTION 6
3.3 URBANIZATION 7
3.4 TREATED EFFLUENT DISCHARGE 7
3.5 SAINT FRANCIS DAM BREACH 7

4. METHODS 9

4.1 DESCRIPTIONS OF ANALYSIS CRITERIA 9
4.1.1 Width of active braiding corridor 9
4.1.2 Relict channel corridor 9
4.1.3 Channel width 10
4.1.4 Vegetation 10
4.1.5 Number of vegetated islands 10

5. RESULTS 11

5.1 QUALITATIVE DESCRIPTIONS 11
5.2 QUANTITATIVE RESULTS 12

6. DISCUSSION 14

7. CONCLUSIONS 16

8. LIMITATIONS 18

9. REFERENCES 19

LIST OF TABLES

Table 1. Results of quantitative analysis of channel change at designated cross sections.

LIST OF FIGURES

Figure 1. Timeline of selected major events in the upper Santa Clara River watershed, California.

Figure 2. Mean annual flow of the Santa Clara River at the L.A./Ventura County line, 1953-1996.

Figure 3. Location of channel cross sections on the Santa Clara River, measured on aerial photographs.

Figure 4. Comparison of 2004 and 2005 conditions on the Santa Clara River, just downstream of the L.A./Ventura County line.

.

Figure 5. Active braiding corridor width measurements for cross sections on the Santa Clara River.

Figure 6. Progression of aerial photographs downstream of Castaic Canyon, showing channel change between 1993 and 2005.

APPENDICES

Appendix A. List of aerial photographs analyzed

1. INTRODUCTION

1.1 Background and purpose

The Newhall Ranch Specific Plan projects will urbanize a portion of the Santa Clarita Valley in Los Angeles County during the coming decades. The project is an extension of prior community growth, which commenced in earnest during the 1960s, in accordance with the adopted General Plan and adopted growth projections. Concern has been expressed that future urbanization may result in changes in the Santa Clara River, a stream of regional scale draining westward from northern Los Angeles County through Ventura County, flowing into the Pacific Ocean near Oxnard. Prior analysis by Geosyntec Consultants (2005) indicates that cumulative future urbanization in the upper watershed of the Santa Clara River, of which Newhall ranch will contribute a portion, will reach approximately 9 percent at "built-out" conditions. A survey of the literature (reviewed in GeoSyntec, 2002) shows that many western-state streams begin to exhibit effects when impervious areas exceed a threshold of about 10 percent, with some considerable site-by-site variability. Additional studies by GeoSyntec in the San Francisco Bay area (2004) and a recent Southern California regional study (Coleman and others, 2005) indicate that, for watersheds smaller than about 25 square miles, channels in granular, non-cohesive sediments may become unstable downstream from urbanizing areas when impervious coverage reaches as little as 2 to 3 percent.

This report uses an empirical approach to assess the potential effects of urbanization on channel morphology associated with the implementation of the Newhall Ranch Specific Plan, combined with other existing and future development in the upper watershed of the Santa Clara River as described in the adopted General Plan. We use historical changes in the Santa Clara River channel pattern to help bracket potential morphological effects on the river of hydromodification due to accumulated urban development. We note that historical changes (both natural and human-induced) in the three factors most likely to affect the Santa Clara River stability (magnitude and frequency of stormflow events, sediment supply and caliber, and channel vegetation) are very large relative to the effects, if any, of the Newhall Ranch project and other planned future urban development. We hypothesize that it will prove useful to learn from history, and to assess the nature and general degree of change that may result from future urbanization by applying these insights.

Much of what is learned from this analysis may be applicable in other aspects of planning and managing the Santa Clara River in the Newhall Ranch reach and reaches downstream. It is not, however, an immediate objective of this report to develop management plans, to assess

potential changes in tributary channels, or to explore how habitat conditions might be changed by potential hydromodification, beyond that which is related to the physical channel form and dynamics.

1.2 Technical approach

The history of the Santa Clara River in the Santa Clarita Valley and eastern Ventura County allows us to explore the three factors most likely to affect the stability and morphology of the river downstream from existing and future development in the Santa Clarita Valley (including Newhall Ranch):

- High streamflows, including increased peak flows, volumes, and/or durations of stormflows,
- Coarse-sediment supply, including sharp curtailment of sediment entering the river following completion of Castaic (1974) and Santa Felicia-Piru (1958) Dams.
- Mature riparian vegetation, with interpenetrating roots, which can stabilize the banks and maintain the channel pattern.

We consider the 'pre-urban' condition to be the form and functions of the river during the 1950s and 1960s, prior to significant urban growth and modification of the flow and sediment regimes due to the construction of the Castaic and Santa Felicia-Piru Dams. Historic deviations from the pre-urban condition can be evaluated using the geomorphic evidence left by a period of floods and high flows from 1938 to about 1945. The effects of sediment supply can be evaluated by quantifying effects of eliminating coarse-sediment delivery from Castaic Creek (with a drainage area of 155 square miles, approximately 25 percent of the Santa Clara watershed at the L.A./Ventura County line. Supporting evidence can also be obtained similarly at Piru Creek (approximately 40 percent of the watershed at its confluence with the Santa Clara River at Piru).

1.3 Report organization

The analysis begins with an overview of the factors affecting the form and geomorphic history of the Santa Clara River (Chapter 2). The larger events and fluctuations, and manner in which they may have affected the river, are considered in Chapter 3. The fourth chapter explains the source materials and methods used to quantify the river's response to these perturbations, which are summarized in Chapter 5. Chapter 6 is a discussion of what we have learned from this study, and Chapter 7 draws conclusions as to how these findings relate to potential hydromodification effects in response to anticipated future watershed urbanization.

2. GEOMORPHIC SETTING

2.1 Channel pattern influences

Several previous reports have described the overall and geomorphic histories of the Santa Clara River (c.f., Schwarzberg and Moore, 1995; SCREMP 2005). In each case, authors have noted that the forms and functions of the river have varied with climatic cycles and with episodes such as floods and fires. It is this variability that is characteristic of the river. In the this report, we utilize the study of historic influences of some of the more pronounced events and cycles to better understand the impacts of drainage changes, if any, that can be expected to result from the anticipated future development in the Santa Clarita Valley, including Newhall Ranch.

2.1.1 Physiography

The Santa Clara River flows through a complex, tectonically-active trough generally bounded by reverse faults on the San Cayetano Mountain and South Mountain fronts. Some of the most rapid rates of geologically-current uplift in the world are reported from the Ventura anticline and San Gabriel Mountains, just to the northwest and southeast, respectively, of the river. Slopes are very steep, with local relief of 3000 to 4000 feet being common. These faults bring harder, more resistant sedimentary rocks over softer and younger sedimentary formations, but all formations are fundamentally soft and erodible. On either side of the faults, sandstone (generally multi-cyclic and fine-grained) and mudstones prevail. The northeastern and southeastern corners of the watershed are underlain by deeply-weathered granitic and schistose rocks, which produce sands that are coarser than those of other rock units when they weather and erode. The San Gabriel fault crosses the valley near the county line, bringing slightly more resistant rock to the surface and creating a local base level reflected as a slight rise or 'bump' on the river's longitudinal profile.

Most geologic materials in the watershed decompose mainly to silts and clays and to sand, with some coarser materials. Rhea Williams and his colleagues at the U. S. Geological Survey found that most sediment moved by the Santa Clara River and its main tributaries are quite fine, with less than 5 percent bedload-sized material (>0.25 mm, or about 0.01 inches in diameter). Some gravels and cobbles do occur within the beds of the streams and in their alluvium. Nonetheless, both the bed and the sediment transported by the river tend to be finer than in most Southern California watersheds (c.f., Knudsen and others, 1992).

The Santa Clara River watershed drains a watershed of 1,600 square miles, of which 625 square miles are within Los Angeles County, upstream of the "county-line gage" (USGS No. 11108500), near the western edge of the Newhall Ranch Specific Plan area.

2.1.2 Climate

Much of the watershed upstream of the Newhall Ranch Specific Plan area receives rainfall averaging about 18 to 25 inches per year (NOAA). As throughout Southern California, rainfall in the Santa Clara watershed alternates between wet and dry periods, a variation that is central to understanding the cultural and geomorphic histories of the upper watershed (Schwarzberg and Moore, 1995; Lynch, 1931; Reichard, 1981). Wet cycles tend to persist for several years, sometimes for periods of 6 or 8 years, during which rainfall, although variable, may average about 140 to 150 percent of the long-term average. For the woody riparian vegetation along the banks and on islands in the braided channels, these are crucial periods for establishment and growth. During dry cycles, the roots of the riparian vegetation must grow downward to the water table or perched zones, and where it cannot do so, this band of vegetation will die back.

2.1.3 Flows

Flows in the Santa Clara River, as in most southern California streams, are highly episodic. For the gaged period between 1953 and 1996 annual flow at the Los Angeles/Ventura County line gage ranged between 253,000 acre-feet (1969) and 561 acre-feet (1961). In general, however, streamflow, and especially dry-season streamflow, has increased over the past few decades primarily due to discharges from two wastewater treatment plants. Mean annual flow at the County Line increased from 25,700 acre-feet in 1972 (averaged over a 20-year record) to 35,360 acre-feet in 1988 (36-year record), with a significant decrease in the number of very low years over that period (UWCD and CLWA, 1996). Downstream of the County line, however, the Santa Clara River flows through the Piru groundwater basin, which represents a "Dry Gap" where dry-season streamflow is lost to groundwater.

Annual peak flows at the County line between 1953 and 1996 ranged from 68,800 cfs (1969) to 109 cfs (1960). Of note is that the second highest annual peak, 32,000 cfs in 1966, was less than half of the highest peak (68,800 in 1969). Both of these events occurred in the late pre-urban to early-urbanization stages within the Santa Clarita Basin and no consistent increase in peak flow is evidence since this time. Flow data for the 2005 flood event are not yet available, however the peak flow at the County line may have approached the flow observed in 1969. As discussed below these large episodic events have a significant impact on the geomorphic characteristics of the Santa Clara River mainstem.

2.1.4 Ground-water supported riparian vegetation

The Santa Clara River is underlain by several distinct alluvial ground-water basins—the Piru, Fillmore, and Santa Paula Basins (Reichard and others, 1999; SCREMP 2005). These basins are divided longitudinally by sills or ridges of bedrock that support areas of locally-high ground water, including the area upstream from the County line (above the Piru Basin), and upstream from the mouth Sespe Creek (the transition between the Piru and Fillmore Basins). This locally-high ground water sustains summer baseflow and riparian vegetation within the Santa Clara River corridor even through relatively dry climatic cycles.

3. PERTURBATIONS

This section describes several major perturbations (those with the potential to affect channel- and floodplain-form) that occurred in the Santa Clara River watershed since the early 1900s (summarized in Figure 1). Aerial photographs were selected to bracket these events and analyzed, both qualitatively and quantitatively, to try to discern and quantify responses of the Santa Clara River channel to:

(1) changes in flow regime during wet and dry multi-year cycles,

(2) sediment supply, notably describing the channel's adjustments to construction of large dams, and

(3) development of mature riparian vegetation with interpenetrating roots.

3.1 Streamflow cycles and events

As described above, streamflow within the Santa Clara watershed is highly episodic, and can vary drastically from year to year. However, decade-scale patterns of wet and dry periods have been identified in the historic record—as early as the 1700s. Previous wet periods (with associated high flows) are reported from 1810 to 1817, 1831 to 1840, 1883 and 1893, and 1903 to 1916, during each of which periods the area received a total of an additional 60 to 80 inches above the mean annual rainfall over the duration of the wet cycle. Prolonged static or drying periods similar to that observed between 1945 and 1977 also occurred from 1780 to 1810, 1842 to 1882, and 1919 to 1935 (with associated reductions in streamflow). The river is likely to have remained most stable during the latter periods, with the notable exceptions of a few major storms of record, such as 1862 (c.f., Lynch, 1931; Reichard, 1981; Schwartzberg and Moore, 1995). The primary wet periods in this study occurred between 1938 and 1946, and 1978 to 1983 (Figures 1 and 2). Other large storm events occurred in 1966, 1969, 1972, 1983, 1998, and 2005. Notable dry periods occurred between 1946 and the late 1960s, and 1983 and 1991.

3.2 Dam construction

Castaic Dam was completed on Castaic Creek (a tributary of the Santa Clara River just upstream of the Newhall project) in 1974. The watershed area above the dam is approximately one-quarter of the watershed area of the Santa Clara River at the L.A./Ventura County line, downstream of the Castaic confluence, and therefore the dam effectively reduced the sediment contributing area by about 25 percent. For comparison purposes, we also considered the effects

of the construction of the Santa Felicia Dam (Lake Piru), which resulted in an approximate 38 percent decrease in sediment contribution area below the confluence of Piru Creek and the Santa Clara River[1].

3.3 Urbanization

Settlement of the Los Angeles County portion of the watershed transitioned from rural to mixed-use suburban during the mid- to late-1960s. This change initiated a period of ongoing urban expansion, with associated increases in the area of impervious or compacted surfaces as homes, commercial and industrial centers, highways and diverse infrastructure have developed throughout the Santa Clarita Valley. Future General Plan urbanization within the upper watershed, inclusive of Newhall Ranch, will bring the percent of urban area west of the County line to about nine percent (GeoSyntec, 2005).

3.4 Treated effluent discharge

Since the 1960's, treated effluent from two water reclamation plants (Saugas and Valencia) has been released directly to the Santa Clara River. This, combined with an increase in applied, imported agricultural water, has led to increased summer baseflows in the Santa Clara River at the County line, which had only rarely occurred under pre-urban conditions. This led to an increase in available water to support woody riparian vegetation. The increase in baseflow is evident in the USGS gaging record at the county line (Figure 2). In some stream corridors, vegetation growth in response to increased baseflow can provide additional bank cohesiveness and reduce erosion; though in others heavy in-channel vegetation growth (riparian encroachment) can serve to destabilize the stream and induce lateral erosion by directing flows toward the banks.

Newhall Ranch has proposed an additional plant that would ultimately treat approximately 5.8 million gallons per day at project build-out. However discharge from the plant in the summer is not expected, as this water will be re-used for irrigation purposes, and we therefore do not expect further change in riparian vegetation growth as a result.

3.5 Saint Francis Dam Breach

On March 12, 1928 the Saint Francis Dam, located in San Francisquito Canyon upstream of the Newhall project, failed and released approximately 30,000 acre-feet of water over the course of a few hours, with an estimated peak discharge of up to 800,000 cubic feet per second (Newhall,

[1] Drainage area calculations were based on USGS gaging station watershed data at Piru and Castaic Dams, and gages on the Santa Clara River at the L.A./Ventura County line and near Piru.

1928; and SCREMP, 2005). This event had drastic effects on the stream reaches downstream, as the resulting flows were much higher than anticipated from any natural event. Aerial photograph coverage during this time period is limited, however, and therefore an assessment of this event was not feasible. In addition, because of the extreme size of the event, it is unlikely that an assessment would be beneficial for assessing hydromodification impacts.

4. METHODS

We analyzed aerial photographs from 1927, 1947, 1957, 1966/67, 1989, 2002, and 2005 to describe channel change in response to the major episodes described above. The main criteria described were the width of the active braiding area (or meander belt width if there was no braiding), bank vegetation, number of channels, and width of the active channel. Also described, where they could be identified, were the width and length of "islands" (vegetated mid-channel bars) within the stream. Islands were typically easier to identify where vegetation was heavy, as the color of the vegetation highlighted the differences between channel and meta-stable islands.

The aerial photographs were analyzed in two different ways. First, a qualitative comparison of the alluvial corridor shown in the different years' photos was made, describing general differences in channel pattern and vegetation on a reach-wide scale. Second, specific cross sections were defined and the above parameters measured for each year with photo coverage in that area to provide a quantitative comparison of channel change at these standard locations along the Santa Clara River (Figure 3).

4.1 Descriptions of analysis criteria

4.1.1 Width of active braiding corridor

For braided reaches, the active channel width was identified primarily by noting the extent of active channels or recent sediment deposition. In many cases the active corridor was bounded by a significant change in vegetation or sediment deposition characteristics.

4.1.2 Relict channel corridor

The relict channel corridor is the portion of the flood plain that does not appear to have been active in the recent past (within the last 5 years or so). Typically the relict corridor is identified by areas of heavy or scattered vegetation containing no or few distinct channels, or areas that do not appear to have experienced recent sediment deposition. Alternatively, identification was based on the width between farmed fields[2]. Measurements of this feature were made from outside bank to outside bank, and include the active corridor.

[2] The total width of the former channel migration corridor is difficult to identify in aerial photographs due to past and present agricultural field reclamation following major perturbations. Where necessary, we used the width between agricultural fields as a estimate of the relict corridor.

4.1.3 Channel width

Where a distinct channel or channels could be identified, the widths of the individual channels were measured. The number of individual channel threads was also recorded, where threads could be distinguished. In some cases, measurement of these features was complicated by poor photo resolution or contrast, and difficulty in distinguishing major channels from minor ones (where a full spectrum was present).

4.1.4 Vegetation

Vegetation was described qualitatively as bare, scattered, moderate, and heavy. The location of specific areas of vegetation, such as vegetated islands, vegetation within the relict corridor, or vegetation along banks, was also described. Where the resolution was adequate, the growth form of vegetation, or state of maturity, was also described (trees or shrubs).

4.1.5 Number of vegetated islands

The number of distinct vegetated islands (mid-channel bars) was also recorded at each cross-section, where the resolution of the photographs was adequate. Where islands could be identified, measurements of width and length were recorded.

5. RESULTS

5.1 Qualitative descriptions

Initial inspection of the series of aerial photographs showed that significant changes in channel planform have occurred throughout the 1900s, as would be expected in a large, braided stream in southern California. Vegetation within the relict corridor (see definition above) near the Newhall Ranch planning area appears to become progressively heavier through time, likely due to the increase in agricultural water and discharge of treated effluent to the channel through the summer months.

The photos show many areas of net deposition, and corresponding channel shifts in major depositional areas. Single-thread, dominant channel segments are rarely present, especially in years following large events. Even when there is one main channel, secondary channels are often present within the active channel corridor.

Portions of the stream have been altered for flood control purposes, including stabilization of banks bounded by orchards and fields, or construction of levees within the active corridor. These levees are most prominent in the 1989 photographs (upstream of the L.A./Ventura County line), where the substantial segments of the main channel are confined in a flood control channel approximately 225 feet wide. By 2002, however, little evidence can be discerned in the aerial photographs of these levees.

The 2005 flood events caused significant changes within the Santa Clara River. Vegetation within the channel was almost all completely washed out (compared to 2002 conditions), and many areas of significant bank-widening were identified, even in areas of heavy bank vegetation (Figure 4).

There appears to be little change in agricultural constriction of the Santa Clara River over the span of photographs reviewed. Through the Newhall reach, the agricultural areas appear to be well buffered by the relict channel and the vegetation supported there. There were only a few places identified where the active channel cut into agricultural areas rather than staying within the relict corridor. In contrast, within the Piru Basin (downstream of the Newhall reach), significant agricultural constriction and subsequent channel widening occurred over the time span of the photos reviewed.

Areas of shallow ground water between Piru and Sespe Canyon[3], which support denser riparian vegetation than typical for the river between Valencia and Fillmore, show little if any significant change for all years in the studied photo-sets. Both the density and extent of vegetation in these areas does not appear to change over time (despite significant differences in climate and other watershed factors) nor does the amount of vegetation appear to significantly affect channel planform, compared to upstream and downstream reaches (the braided channel does not shift to a single-threaded channel through the wetted reach).

5.2 Quantitative results

For the quantitative portion of the aerial photograph analysis we looked at four different types of criteria to identify physical changes to the Santa Clara River channel (Table 1; see also section 4.1.1 for descriptions of criteria). Because of difficulties in identifying and measuring the width/number of channels and number/dimensions of vegetated islands, because of the varying resolutions and contrasts of the photographs, we concluded that analysis of these two criteria were less meaningful for this study. In other words, there was more variation due to the ability to identify the features for the varying quality of the photos than there was actual variation in the system. While we believe that these criteria may be a valid indicator of channel change, more study would be needed to adequately quantify these features so they were used a supplementary qualitative metric.

For this study we found that measurement of the "active corridor" (see section 4.1.1) was the most useful and easiest to work with to identify channel changes. In most cases there is enough vegetation along the banks that the active braiding corridor is easily identified, and changes in the width of the corridor can be tracked from year-to-year.

Figure 5 summarizes the changes in active corridor width over the time span of the reviewed photos. Within the Newhall reach, the width of the "active corridor" at the four measured cross-sections varies from year-to-year by as much as 500 feet, though most of the variation is considerably less. One station, in the narrows above the Piru Basin, has a very consistent channel width, varying by less than about 50 feet from year to year.

To provide additional analysis, we looked at a series of recent photos (1994, 2000, and 2002-2005) at one cross section downstream of the Castaic confluence. For this photo set, the channel widened significantly between 1994 and 2000 (probably in response to the 1995 or 1998 large

[3] See Reichard and others (1999) for a discussion of the hydrogeology of these shallow ground water areas; although downstream from the Los Angeles County line, results are applicable to the upstream as well, as discussed later in this report.

storms), but showed almost no change between 2000 and 2004 (Figure 6). The channel then widened considerably again in response to the high-flow events in 2005.

As a secondary check of the numbers derived for the measured standardized cross sections, we also measured active channel widths at approximately twenty different locations through the Newhall Reach on three different photo sets—1967, 2004, and 2005. From these measurements an average active braiding corridor width was calculated and compared with the other years. In 1967, the average channel width was approximately 580 feet, which was significantly wider than the average width in 2002 (392 feet). However, after the 2005 storms, the active width was approximately 560 feet, similar to the 1967 conditions.

The "relict corridor" (see section 4.1.2 for definition) also proved useful as a secondary criterion, providing a measurement of potential changes due to agricultural encroachment or constriction of the flood corridor. Measurement of the "relict corridor" at the standard cross sections showed that while there was some variation between photos, there is no consistent trend of agricultural constriction to the Santa Clara River flood corridor. These measurements, along with qualitative observations that within the Newhall reach agricultural activities were generally restricted to outside the active corridor, suggest that agricultural encroachment has not historically affected the geomorphology of the Santa Clara River within the Newhall Reach.

6. DISCUSSION

The Santa Clara River is a dynamic, episodic system. The above analyses highlight the magnitude of geomorphic change over the course of recent history, in response to natural and human disturbances in the watershed. Understanding the magnitude of past response is a key factor in assessing the potential response to future urbanization within the watershed.

The construction of Castaic Dam in 1974, regulating approximately 25 percent of the watershed at the L.A./Ventura County line, cut off a significant supply of sediment to the Santa Clara River. This change, however, does not appear to have had an effect on the channel dimensions of the Santa Clara River mainstem. The width of the active corridor, as well as the general form of the channel, are generally consistent both before and after construction of the dam. It appears that the Santa Clara River adjusted without morphological expression to absorb this change. One factor contributing to the lack of change is the seemingly large volume of sediment stored in the tectonic basin above the county line—a result of bedrock control associated with movement along the San Gabriel fault, which supports the large extent of semi-consolidated and alluvial deposits adjoining the drainage net.

The amount of vegetation within the Santa Clara River corridor appears to have increased since the 1960s, likely due to the increased summer return flows from agricultural water and to year-round augmentation of baseflows due to treated effluent discharge to the river. However, this vegetation does not seem to provide enough erosion resistance to maintain a "stable" channel capable of withstanding regular 're-sets', which occur at intervals averaging about a decade – or much less than the expected lifetime of the riparian woodlands which do get established. Despite heavy vegetation on the active channel banks near Newhall ranch and in areas of shallow ground-water, the stream still responds to large events by a general widening and/or shift of the channel. The role of vegetation in large-channel stability and morphology in Southern and Central California does fundamentally differ from that of smaller streams and streams elsewhere in the country. The geomorophic and historical record shows that resets have been occurring throughout the recent geologic past in basins exceeding a certain size. One partial explanation may be that 're-set' flood events in these larger channels exert stresses beneath or around the riparian vegetation exceeding the vegetation's threshold of stability[4].

[4] Sedimentologists note that crossbeds in the alluvium of the Santa Clara River are often 8 to 12 feet high, equal or greater than the depth to which roots can interpenetrate in most riparian settings in the region.

As stated above, the Santa Clara River, as with many streams in semi-arid southern California, is highly episodic. Concepts of "normal" or "average" sediment-supply and flow conditions have limited value in this "flashy" environment where episodic storm and wildfire events have enormous influence on sediment and stormflow conditions. Many of these channels are actively adjusting to lower flows than the last major event, which may have occurred some years before[5] (Hecht, 1993). In these streams, a large portion of the sediment movement events can occur in a matter of hours or days. In many of these channels most sediment is moved—and most bed changes occur—during the large flow events resulting from storms that may be expected approximately every 5 to 15 years (c.f., Capelli and Keller, 1993; Hecht,1993; Inman and Jenkins, 1999; Knudsen and others, 1992; Kroll and Porterfield, 1969).

Evidence of episodic channel changes can be seen in the Newhall reach of the Santa Clara River. Based on aerial-photograph interpretation of a near-yearly sequence of aerial photographs from within the last decade, the channel appears to maintain a consistent planform during average or dry rainfall years (such as between 2000 and 2004). Large events, however, (such as that which occurred in February 1998 and January 2005) can significantly modify this channel form. This widened and/or shifted channel (like that which was present after the 1998 or 2005 stormflow events) then sets the geomorphic template for subsequent normal to dry years. This model, similar to that described for the Ventura River by Capelli and Keller (1993), suggests that the geomorphology of the Santa Clara River is primarily driven by these large events.

Other perturbations which potentially affect channel geometry appear to have transitory or minor manifestations. For example, effects on the channel width due to 1980s levee construction are barely discernible by the first few years of the 21st century, probably mostly due to morphologic compensation associated with the mid- to late-1990s storm events.

[5] Actively adjusting channels may be aggrading, incising, expanding or otherwise changing channel dimensions, depending on the magnitude, type, and various effects of the episodic event.

7. CONCLUSIONS

Based on the study of historic aerial photographs described above we conclude that:

- Major perturbations within the Santa Clara River watershed (dam construction, levee construction, changes in flows in response to decadal-scale climatic patterns, and increases in woody vegetation) do not appear to have had a significant impact on the geomorphic expression of the Santa Clara River, as quantified from measurements made from a series of historical aerial photographs flown during the years 1927 through 2005.

- Large events (those which are typically not as affected by increases in impervious area and associated increases in stormwater peaks and runoff volume) can completely alter the form of the Santa Clara River channel. We call these events "re-set" events. These events, perhaps occurring on average once every ten years, are a dominant force in defining channel characteristics.

- The geomorphic dominance of "re-set" events overwhelms geomorphic effects of hydromodification on smaller events. Due to these episodic "re-sets" we do not expect hydromodification feedback "unraveling" of the Santa Clara River mainstem, as is seen in many smaller southern California watersheds[6]. The "re-set" events appear to adequately buffer changes that may occur in short-term sediment transport.

- While there is no expected increase in summer flows due to additional treated effluent discharge to the Santa Clara River, even if summer baseflow do increase we would not expect a significant change within the channel. Additional growth in the extent or density of vegetation is not anticipated, as the reach near Newhall already appears to have enough flow to support summer vegetation, and the existing vegetation does not appear to affect channel form for durations longer than the "re-set" interval. Further, re-sets occur at intervals significantly shorter than the period required for maturation of riparian vegetation, such that full development of bank-holding properties is frequently interrupted.

- Given that the channel morphology of the Santa Clara River mainstem has not adjusted significantly to much larger perturbations in flow, sediment yield, and riparian

[6] In many smaller streams, hydromodification of moderate events can induce incision of the stream bed, which reduces the connection of the stream to the floodplain. This disconnect, in turn, increases the erosive forces of the flows (concentrating more flow in the channel) and causing further erosion, and thus a positive feedback response.

vegetation growth factors, within the Newhall reach, we do not expect a significant geomorphic impact to the Santa Clara River mainstem due to the anticipated increase in 'urban area' from four to nine percent.

8. LIMITATIONS

The analyses in this report were designed to help bracket the range of likely effects on the geomorphology of the Santa Clara River due to proposed urban expansion under the General Plan, inclusive of the Newhall Ranch Specific Plan projects. It does not consider specific elements of the project or of evolving mitigation measures; rather, it focuses upon the susceptibility to perturbation of the Santa Clara River corridor as a whole. We believe that it conforms with the standard of care applicable to reconnaissance studies of this nature; no other warranty, expressed or implied, is made.

The above analyses and discussion were intended to assess the potential cumulative impacts to the Santa Clara River *mainstem* (not tributaries) due to the anticipated urban expansion in the watershed. While we conclude that urban expansion from approximately four- to nine-percent urbanized (not 'impervious') will not significantly affect the channel geomorphology of the Santa Clara River, we do expect that there might be a response to urbanization on a larger scale. However, further study would be required to define what the likely threshold and magnitude of response might be.

We ask readers to note that this is a reconnaissance report. It is intended to bracket likely future conditions, to identify factors which must be better known, and to help guide initial planning. This report should *not* be used to site or design individual facilities without further site-specific investigations. Similarly, it is *not* intended to serve as basis for flood management or detailed floodplain planning, both of which should be conducted by well-defined and site-specific procedures, and which frequently require multiple lines of evidence.

The application of geomorphic history to inferring future channel and corridor change has a long and respected record in the earth sciences. As with all history or archival analysis, the better the record is known and understood, the more relevant and predictive the analysis can be. We do encourage readers who have knowledge of other events or processes which may have affected the river to let the authors know at the first available opportunity. The authors and their contacts via several different media are given on the signature page of this report.

9. REFERENCES

AMEC Earth and Environmental, 2005, Santa Clara River Enhancement and Management Plan (SCREMP May 2005): Consulting report prepared for the Ventura County Watershed Protection District , the Los Angeles County Department of Public Works Watershed Management Division, and SCREMP Project Steering Committee, 198 p.

Coleman, D., MacRae, C., and Stein, E.D., 2005, Effects of increases in peak flows and imperviousness on the morphology of Southern California streams: Southern California Coastal Water Research Project Technical Report 450. 70 p.

Coulthard, T. J., 2005, Effects of vegetation on braided stream pattern and dynamics, Water Resources Research, 41, W04003, doi:10.1029/2004WR003201.

GeoSyntec Consultants, 2005, Draft Newhall Ranch Specific Plan sub-regional stormwater mitigation plan: Consulting report prepared for Newhall Land, August 2005.

GeoSyntec Consultants, 2004, Appendix C: Technical memoranda: Appendix to the Santa Clara Urban Runoff Pollution Prevention Program (SVURPPP) Hydromodification Management Plan (HMP), six memoranda, multi-paged.

GeoSyntec Consultants, 2002, Hydromodification Management Plan Literature Review: Consulting report prepared for the Santa Clara Valley Urban Runoff Pollution Prevention Program, 80 p.

Glysson, G.D., 1977, Sedimentation in Santa Margarita Lake, San Luis Obispo County, California: U.S. Geological Survey Water-Resources Investigations 77-56, 20 p.

Hecht, B., 1993, South of the spotted owl: Restoration strategies for episodic channels and riparian corridors in central California: in Western Wetlands: Selected proceedings of the 1993 Conference of the Society of Wetland Scientists, Davis, CA: p. 104 -117

Inman, D.L., and Jenkins, S.A., 1999, Climatic change and the episodicity of sediment flux of small California rivers: Journal of Geology, v. 107, p. 251-270

Knudsen, K., Hecht, B., Holmes, D.O, and Flaschka, I., 1992, Hydrologic and geomorphic factors affecting management of the lower Sisquoc River alluvial corridor, Santa Barbara County, California: Consulting report prepared by Balance Hydrologics, Inc. for SP Milling Company, 66 p. + 5 appendices.

Kroll, C.G., and Porterfield, G., 1969, Preliminary determinations of sediment discharge San Juan drainage basin, Orange and Riverside Counties, California: U.S. Geological Survey Open-File Report, 28 p. + 5 plates.

Lynch, H.B., 1931, Rainfall and stream run-off in Southern California since 1769: Metropolitan Water District of Southern California publication, 31 p.

Hoey, T. and Sutherland, A. (1991). Channel morphology and bedload pulses in braided rivers: a laboratory study. Earth Surface Processes and Lanforms, 16:447–462.

Meunier, P., and Metiver, F., 2004, Sediment transport in a micro-scale braided stream: From grain size to reach size: Preprint submitted to Braided Rivers, 2004

Newhall, A.M., and Newhall, G.A., 1928, Report on St. Francis Dam flood. Letter to the Newhall Land and Farming Company, dated March 24, 1928.

Reichard, E.G., 1982, Reconstruction of water availability along the San Luis Rey River in southern California: M.S. thesis, Stanford University, 146 p.

Reichard, E.G., Crawford, S.M., Schipke Paybins, K., Martin, P., Land, M., and Nishikawa, T, 1999, Evaluation of surface-water/ground-water interactions in the Santa Clara River Valley, Ventura County, California: U.S. Geol. Survey Water-Resources Investigations Report 98-4208, 58 p.

Schwartzberg, B.J., and Moore, P.A., 1995, A History of the Santa Clara River: Santa Clara River Enhancement and Management Plan Study report, 79 p., April 1995 (Report stamped 'subcommittee working draft copy not for public dissemination'), 79 p.

SCREMP 2005: See AMEC Earth and Environmental

UWCD and CLWA. 1996. Water Resources Report, April 1996. Prepared by United Water Conservation District and Castaic Lake Water Agency.

Warburton, J. and Davies, T. (1994). Variability of bed load transport and channel morphology in a braided river hydraulic model. Earth Surface Processes and Landforms, 19:403–421.

Wells, W.G., II, 1981, Hydrology of mediterranean-type ecosystems: A summary and synthesis: in Proceedings of the Symposium on Dynamics and Management of Mediterranean-Type Ecosystems, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station General Technical Report PSW-88, p. 426-430

Wohl, E., 2000, Mountain rivers. American Geophysical Union Water Resources Monograph 14, Washington, DC, 320 p.

TABLES

Table 1. Aerial photograph cross section data at selected locations near Newhall Ranch, Los Angeles County, CA. See text for explanation and interpretation of data. Locations of cross section are labeled on Figure 2. Photo sources are listed in Appendix A.

Cross section	location description	photo date	width of active braiding corridor (feet)	width of relict braiding corridor (feet)	is there one primary channel visible?	width of main channel (feet)	number of identifiable channels	total width of channels (including main) (feet)	number of islands	length of islands encountered (feet)	width of islands (feet)	vegetation	other descriptions
X1	downstream of Castaic	8/16/1947	570	1247	yes?	71	3?	107	can't define	n/a	n/a	moderately vegetated with some portions of relict corridor heavily vegetated	Just downstream a heavily vegetated bar is cut by a very distinct secondary channel
		7/20/1966	729	1173	yes	27	1	27	1	497	86	almost no vegetation within primary corridor except two areas near the primary channel and scattered small patches, only scattered vegetation on relict corridor	while there is only one main channel the rest of the primary corridor is section is almost deltaic in planform, spreading out from constriction upstream (possibly high sediment load coming in from Castaic)
		5/26/1989	173	1171	yes, but small	43	1	43	0	n/a	n/a	banks of meander corridor have scattered vegetation (less than 2000) with very little within braiding corridor	meander corridor is very distinct and straight, could be from flood control dredging;
		6/1/1994	337	1167	yes	72	2	97	1	551	171	light to moderate vegetation on braiding corridor banks	very little vegetation within braiding corridor
		2/1/2002	505	984	yes	42	2	50	poorly defined	n/a	n/a	relict braiding corridor is well-vegetated; meander belt/bar is lightly to moderately vegetated; at least one main channel bank is well-vegetated (alternates w/ meanders)	secondary channel essentially cuts off meander
		4/1/2004	505	978	no	n/a	3	87	2	929, 251	248, 56	heavy vegetation along former primary channel; relict corridor also heavily vegetated	there are two distinct channels, approximately the same size
		3/1/2003	510	965	yes	75	1	45	0	n/a	n/a	heavy vegetation on northern bank; some scattered vegetation within active corridor and surrounding low-flow channel	channel branches just downstream of cross section; very similar to 2002 and 2004 photos
		2/1/2005	601	999	no	n/a	3	106	poorly defined	n/a	n/a	no vegetation in main portion of channel; right bank has heavy tree cover, left bank has few trees	the main channel is about 340 feet wide with an obvious overbank deposition area (with very little vegetation)
X2	Upstream of County line	8/16/1947	532	1197	yes	89	2	133	1	355	133	vegetation is heavy (probably trees) on relict corridor; moderate (probably scrub) within active corridor (difficult to distinguish)	very distinguishable difference between active and relict corridor within this reach
		3/6/1963	491	1352	no	n/a	difficult to define	n/a	6	252, 283, 82, 441, 94, 410	44, 57, 52, 76, 38,63	several well-defined islands behind established vegetation (individual shrubs or small trees); relict corridor has moderate to heavy tree cover	very braided planform; switches to predominately single-thread channel just downstream
		5/26/1989	651	651	yes	43	3	108	1	2385	477	relict corridor has scattered trees with moderate to heavy shrub or grass cover; central island (along levee) has similar vegetation	well-defined flood control channel, but has been breached and there is a significant secondary channel to the north of the levees; included a portion of the island between the flood control channel and the secondary channel in the relict channel (no sign of recent deposition)

©2005 Balance Hydrologics, Inc.

Cross section	location description	photo date	width of active braiding corridor (feet)	width of relict braiding corridor (feet)	is there one primary channel visible?	width of main channel (feet)	number of identifiable channels	total width of channels (including main) (feet)	number of islands	length of islands encountered (feet)	width of islands (feet)	vegetation	other descriptions
		6/1/2002	608	1258	yes	131	1	131	0	n/a	n/a	relict corridor on north bank has heavy tree cover; meander bends are eroding tree bank vegetation in places	stream has meandering planform, though meander belt (400' wide) has high sediment deposition and little vegetation; no evidence of flood control levees (meanders have widened to erode levees); active channel includes meander belt and area of significant recent sediment deposition to the north of the meander belt
		2/1/2005	674	1240	yes	97	3	192	1	475	155	almost no vegetation within active channel; relict corridor on both banks has moderate tree cover; much vegetation eroded away since 2002	numerous very small channels present as well
X3	downstream of county line	8/16/1947	362	805	yes, at this xs	80	2	121	can't define	n/a	n/a	outer banks of braiding corridor seem heavily vegetated	there seems to be one main channel through this reach, with extensive deposition of sediment outside of the channel
		7/20/1966	140	714	yes	51	2	77	0	n/a	n/a	banks of braiding corridor are heavily vegetated	
		5/26/1989	273	864	yes	91	2	114	1	136	23	only scattered vegetation on banks of braiding corridor	braiding corridor looks as though it may be a leveed flood control channel
		2/1/2002	249	1466	yes	41	3	79	2	344, 219	66, 36	scattered vegetation on u/s ends of islands; some recent deposition of sediment within relict braiding corridor (which is predominately heavily vegetated	
		2/1/2005	587	1472	yes	97	3	145	1	543	110	no vegetation in active corridor; right bank has heavy shrub cover with some trees, left bank has light shrub cover	
X4	upstream of Piru Basin	8/16/1947	282	885	yes	121	1	121	can't define	n/a	n/a	little to no vegetation within braiding corridor; relict braiding corridor has heavy tree/shrub cover	
		7/20/1966	281	383	no	n/a	3	26	poorly defined	n/a	n/a		
		5/26/1989	318	591	yes	68	1	68	1	91	23	meander belt banks lined with trees; meander belt itself covered with shrubs	"braiding corridor" is actually the meander belt; meander belt outside of channel is heavily vegetated
		2/1/2002	266	426	yes	35	3	45	1	340	36		secondary channels may be present in other photos, but resolution is poor, esp. 1948
		2/1/2005	281	495	yes	44	1	44	0	n/a	n/a	vegetation on right bank of main channel has diverted some flow over the relict corridor, though conditions are similar in 2002; moderate to heavy trees and shrubs on both banks	conditions are very similar to 2002, but with slightly wider and much clearer channel

©2005 Balance Hydrologics, Inc.

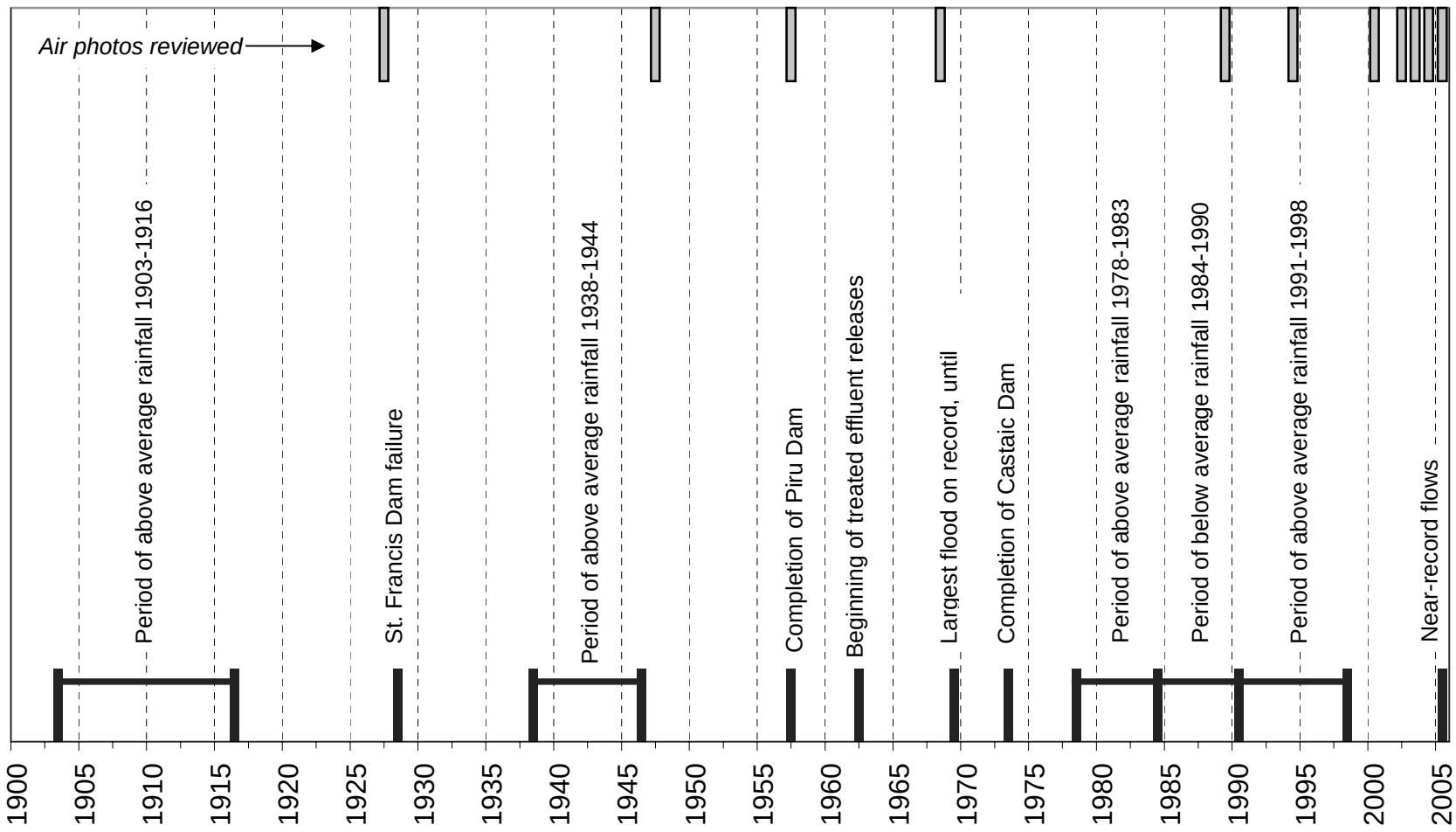
Cross section	location description	photo date	width of active braiding corridor (feet)	width of relict braiding corridor (feet)	is there one primary channel visible?	width of main channel (feet)	number of identifiable channels	total width of channels (including main) (feet)	number of islands	length of islands encountered (feet)	width of islands (feet)	vegetation	other descriptions
X5	upstream of Piru confluence	4/1/1927	1834	3191	no	n/a	many	n/a	3	3060, 1170, 468	540, 450, 90	sparse scrub vegetation within active corridor, but enough to define the complex channel pattern; only slightly more vegetation (or possibly just less recent sediment deposition) in relict corridor	relict channel is mainly an artifact of flow deflection by several long levees just upstream; typical braided stream with channels of varying widths and scales (can not define number of channels due to complexity and scale variation of channels); only measured large islands
		8/16/1947	1449	3066	no	n/a	0	n/a	1	1282	279	island appears heavily vegetated; relict channel has moderate vegetation, possibly some farming	active channel is very burnt in; no evidence of levees, but would be difficult to see
		11/10/1966	957	3051	no	n/a	complex channel pattern	n/a	too complex to define	n/a	n/a	no vegetation within active corridor; sparse scrub vegetation within relict corridor, but very patchy (may be due to clearing)	flood control channel is present down middle of active corridor (196' wide); stream has complex braiding pattern, even with flood control channel present
		6/20/1989	1796	2993	no	n/a	complex channel pattern	n/a	too complex to define	n/a	n/a	light scrub vegetation within active corridor; vegetation is obviously stabilizing small islands, at least until the next big event; relict corridor is sparsely vegetated	little evidence of flood control channel but may have been some excavation in middle of active corridor (~300' wide);
		6/1/2002	1730	2452	no	n/a	5	1000	3	1200, 1085, 1520	384, 406, 400	moderate scrub vegetation on islands within active channel, similar to 1989 but slightly heavier	channels were relatively easy to pick out due to moderate scrub vegetation; channel width does not necessarily correlate to other measurements (where the only measurable parameter was wetted width)
X6	downstream of Piru confluence	4/1/1927	1713	1983	yes	18	1	18	0	n/a	n/a	no vegetation within braiding corridor; only scattered vegetation on relict corridor; heavy trees along portions of the south bank of relict corridor	very wide braided corridor with little definition (too burnt-in to define secondary channels)
		8/16/1947	1767	1983	no	n/a	0	n/a	0	n/a	n/a	looks similar to 1927 conditions	
		9/1/1957	1220	1449	yes	25	3	51	2	875, 1750	325, 425	very sparse scrub vegetation in active corridor; some small trees on relict corridor (where corridor is present)	well-defined flood control channel through this reach (136' wide), but there are several secondary channels outside the levees; diversion ponds present near the north bank; larger island cut by flood control channel
		11/10/1966	1132	1563	yes	32	4	388	2	2125, 750	850, 250	large island is moderately vegetated with scrub and one line of heavy vegetation; relict braiding corridor is similarly vegetated	braiding corridor has been confined on both sides by levees (especially on the northern portion); looks like the southern levee was recently overtopped (that area was included in the relict corridor); main channel divides in two in some areas
		6/20/1989	1082	1082	no	n/a	n/a	n/a	1	685	180	sparse scrub vegetation growing on poorly-defined islands within channel and near piers	lots of recent grading within the channel, several levees in the middle of the corridor and a series of piers on the southern bank
		6/1/2002	1050	1245	no	n/a	none	n/a	0	n/a	n/a	very little vegetation in this portion of the stream; some scattered scrub on relict corridor, even less within active channel	217-foot wide flood control channel begins just d/s of xs (poorly defined, though)

©2005 Balance Hydrologics, Inc.

Cross section	location description	photo date	width of active braiding corridor (feet)	width of relict braiding corridor (feet)	is there one primary channel visible?	width of main channel (feet)	number of identifiable channels	total width of channels (including main) (feet)	number of islands	length of islands encountered (feet)	width of islands (feet)	vegetation	other descriptions
X7	between Piru and Sespe (ground-water upwelling)	8/16/1947	1694	2472	no	n/a	4	difficult to define the widths	can't define	n/a	n/a	this area is heavily vegetated; difficult to distinguish active braiding corridor from relict corridor	looks like there has been some flood control work in this area, two very straight channels through here, but masked some by vegetation
		9/1/1957	1446	2253	yes	168	4	370	2	4624, 8500	272, 408	northern portion of the corridor (including flood control channels) have heavy vegetation outside of the channels; the southern portion of the corridor has sparse vegetation	the main channel, and possibly the secondary channel, have been altered for flood control
		6/20/1989	749	2697	yes	37	2	150	1	1386	449	thick vegetation (with trees) along main channel; very little vegetation otherwise within active braiding corridor; moderate vegetation in northern portion of relict corridor, but only scattered brush in southern	no evidence of flood control alteration; downstream the corridor has been severely constrained by encroaching agriculture
		6/1/2002	551	2767	yes	42	2	65	1	396	108	heavy vegetation (trees) along secondary channel along north bank; scattered shrub (with some trees) vegetation within active corridor, some defining the edges of bars; heavy scrub vegetation on south relict corridor with scattered trees; heavy trees and scrub on northern relict corridor	just upstream there is a distinct main active corridor and an overbank area of deposition; the main active corridor has portions lined with heavy trees, but becomes less distinct further upstream (no vegetation)
X8	just downstream of Sespe Creek	8/20/1947	2003	2003	no	n/a	6	601	can't define	n/a	n/a	limited, if any	photo very burnt in, but channels less well-defined than in other photos
		8/13/1967	701	2203	yes	100	3	250	1	2804	401	limited, if any	one single-thread channel with one minor channel
		6/20/1989	1532	1723	yes, but less so than 1967	153	5	306	poorly defined; small and well-vegetated	n/a	n/a	islands are more heavily vegetated away from main channel; main channel bank is ~75 vegetated w/ thin vegetation line; more vegetation than in other photos	
		6/1/2002	670	1820	no	n/a	3	170	1	801	216	islands are moderately well-vegetated; relict corridor has scattered vegetation, Sespe mainstem has heavy vegetation along low-flow channels	interpretation complicated by Sespe confluence, but looks very similar to 1989 photo

©2005 Balance Hydrologics, Inc.

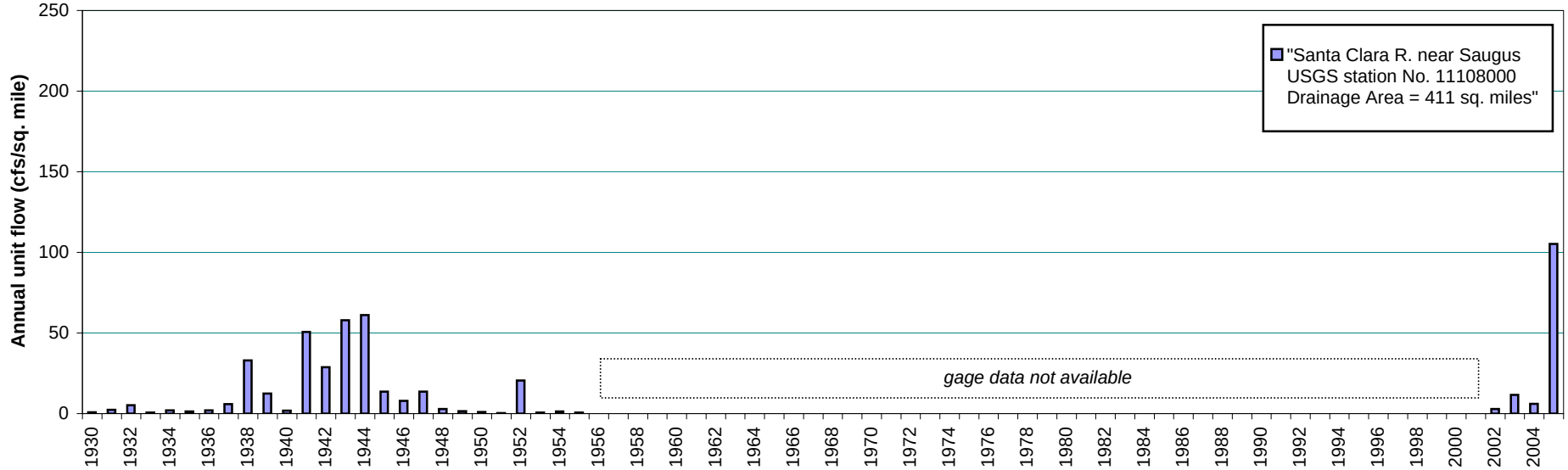
FIGURES

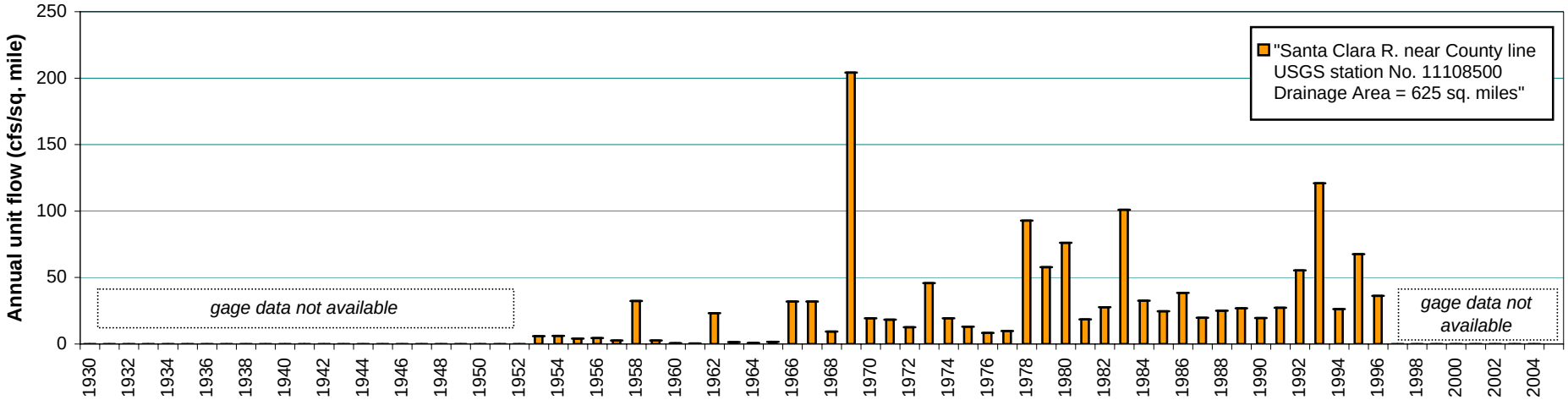


Balance Hydrologics, Inc.

Figure 1. Timeline of selected major events in the upper Santa Clara River, California. Also shown (at top) are the years for which aerial photographs were analyzed.

©2005 Balance Hydrologics, Inc.

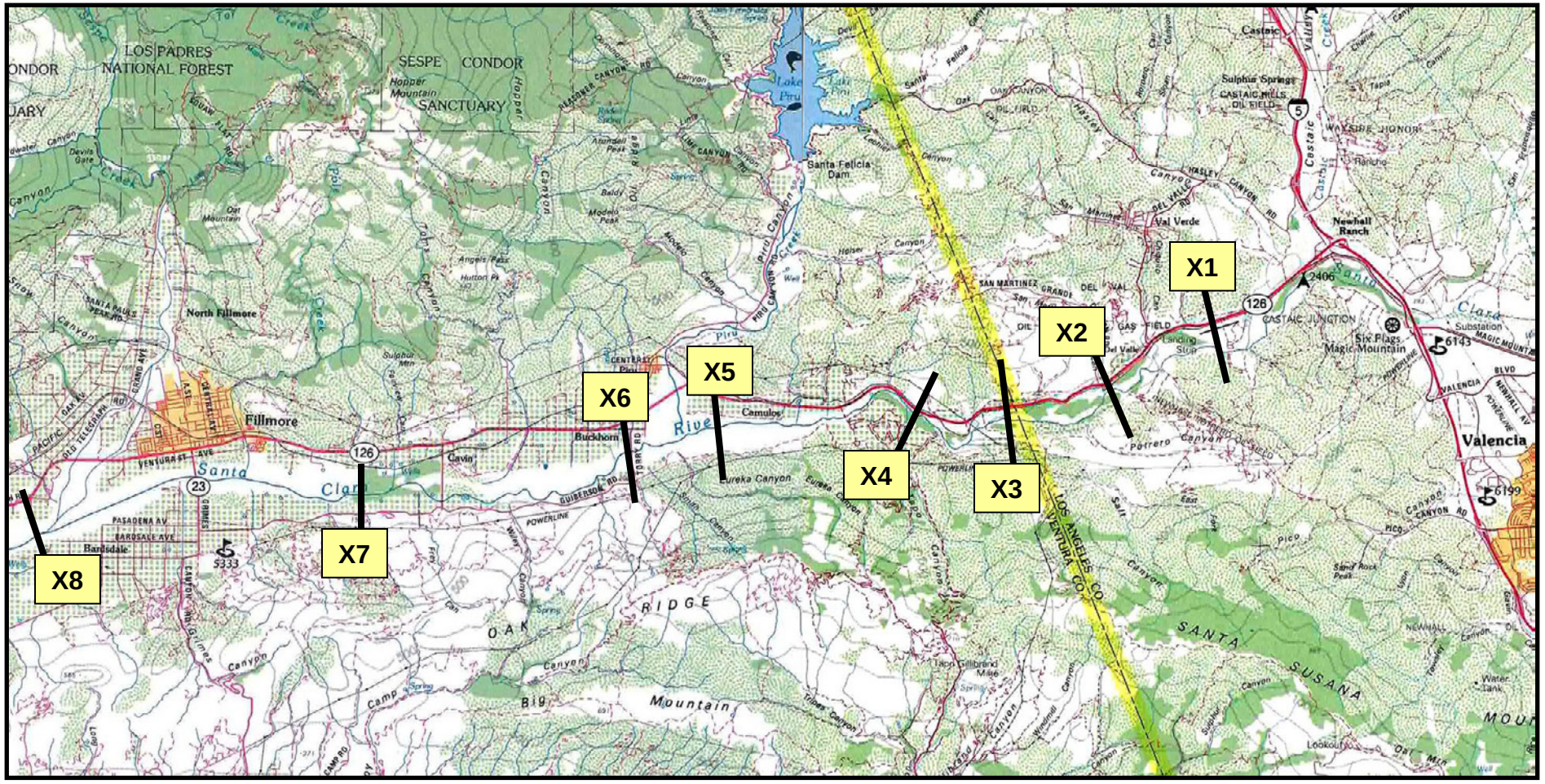




Balance Hydrologics, Inc.

Figure 2. Annual unit runoff (annual flow per square mile) for the Santa Clara River near Newhall at two separate gaging stations. Note that flow in drier years has increased since the 1960s, most likely due to release of treated effluent to the River.

©2005, Balance Hydrologics, Inc.



Balance Hydrologics, Inc.

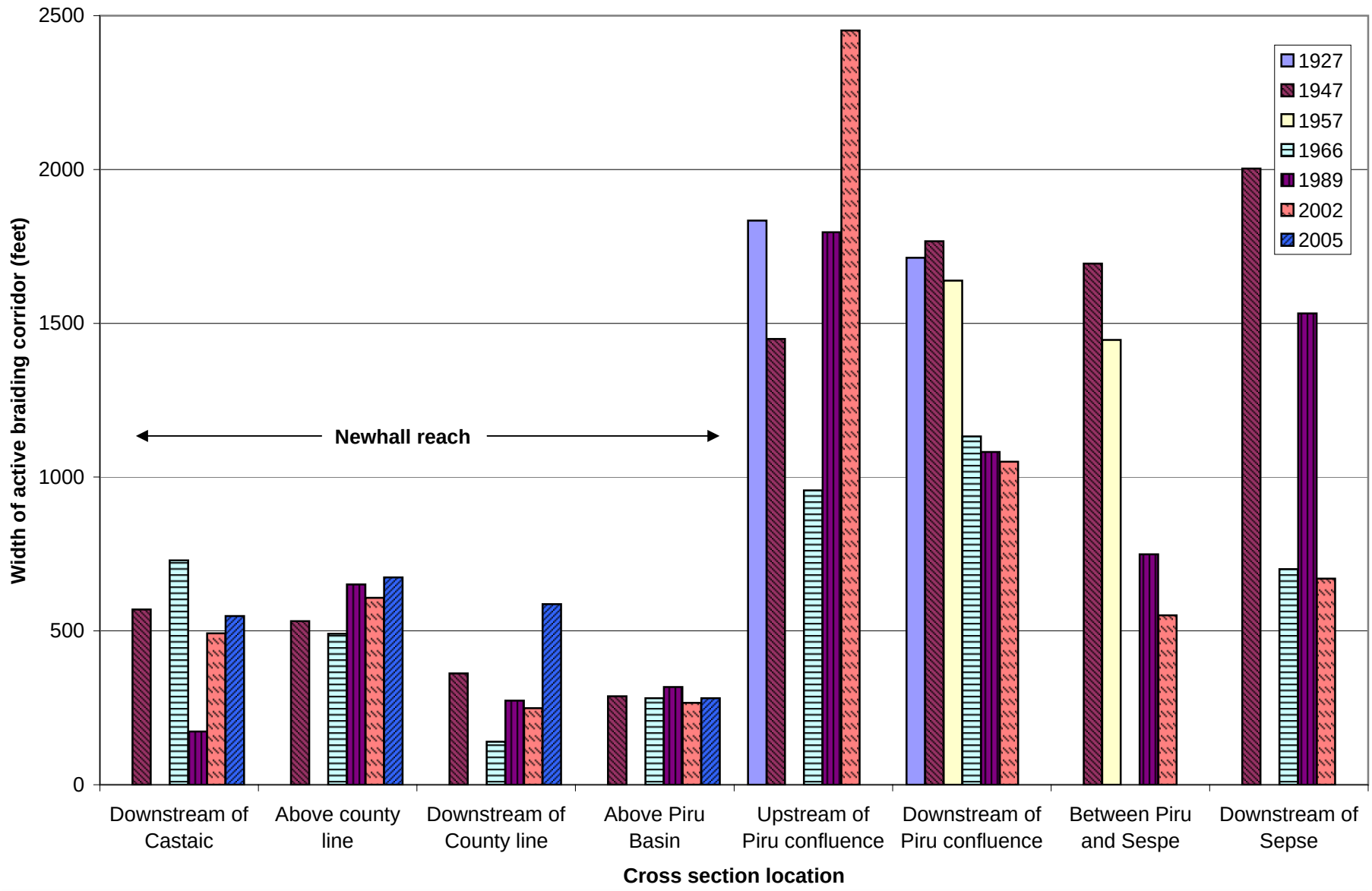
Figure 3. Location of channel cross sections on the Santa Clara River, measured on aerial photographs.

©2005 Balance Hydrologics, Inc.

Balance Hydrologics, Inc.

Figure 4. Comparison of 2004 and 2005 conditions on the Santa Clara River, just downstream of the L.A./Ventura County line. Note that significant channel widening occurred in response to the 2005 events, even in heavily vegetated areas. See appendix A for photo sources.

©2005 Balance Hydrologics, Inc.

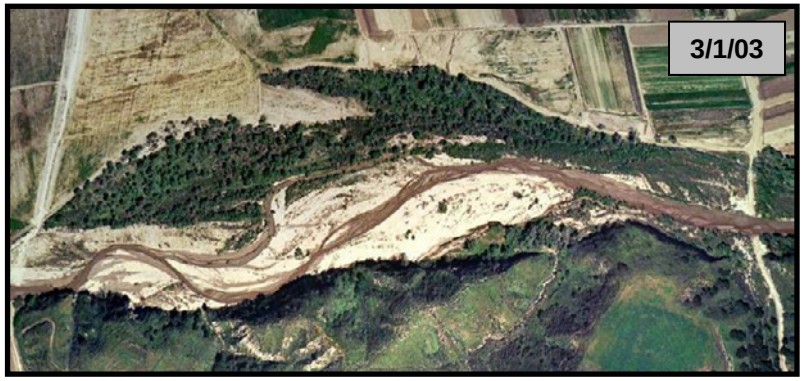


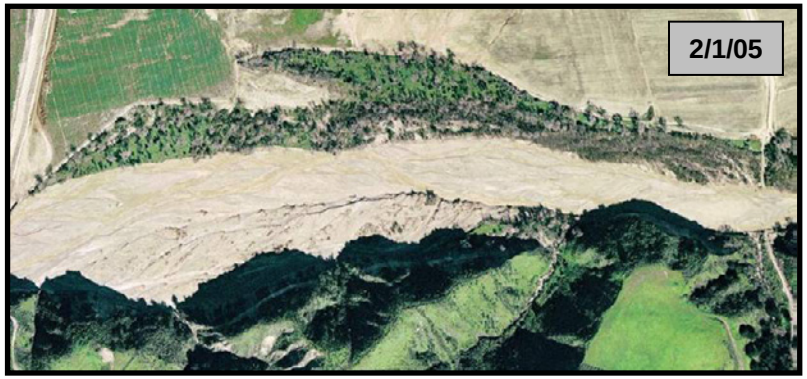
Balance Hydrologics, Inc.

Figure 5. Measurements of active braiding corridor width from aerial photographs, for cross sections on the Santa Clara River.

Photo cross section data.xls, Summary graph

©2005 Balance Hydrologics, Inc.





Balance Hydrologics, Inc.

Figure 6. Progression of aerial photographs downstream of Castaic Canyon, showing channel change between 1993 and 2005. Note that there was little change between 2000 and 2004, but the active corridor widened significantly in response to the 2005 events, and that channel traces within the active corridor were effectively erased. See appendix A for photo sources.

©2005 Balance Hydrologics, Inc.

APPENDICES

Appendix A: Summary of aerial photographs used for assessment of potential hydromodification effects on the Santa Clara River, Newhall, California.

Date	Number of photos	Nominal Scale	Hard Copy?	Electronic copy?	Image Type	Source/Vendor	Remarks
1927	6	2000	yes	yes	b/w	Whittier College: 80, 82, 84, F27, F28, F31	Only available photography prior to the March 1928 collapse of the Saint Francis Dam. Photos show area near Piru confluence
August 16, 1947	34	24000	no	yes	b/w - Vert Cart	USGS_GS-EM, Rolls 3, 5, 7	Previews downloaded already are sufficient.
1957	2	2000	yes	yes	b/w	Whittier College: 109, 123	1957 photos are for justdownstream of Piru Creek. Piru Dam was closed in 1957.
March 6, 1963	1 (2)	21670	no	yes	b/w - Vert Recon	USGS_ARMC630001L0049 a,b	high resolution scans
July 20, 1966	2 (4)	21670	no	yes	b/w - Vert Recon	USGS_ARM6625001L1362 a,b USGS_ARM6625001R1357 a,b	high resolution scans
August 19, 1966	1 (2)	21670	no	yes	b/w - Vert Recon	USGS_ARM6628502L1314 a,b	high resolution scans
September 13, 1966	1 (2)	21670	no	yes	b/w - Vert Recon	USGS_ARM6631405R1165 a,b	high resolution scans
November 10, 1966	2 (4)	21670	no	yes	b/w - Vert Recon	USGS_ARM6638605L1238 a,b USGS_ARM6638605L1242 a,b	high resolution scans
August 13, 1967	1	30000	no	yes	b/w - Vert Cart	USGS_AR1VBUK00010110	Preview already obtained. Downstream of Sespe Creek
May 26, 1989	5	31680	yes	yes	b/w	WAC-89CA, 27-42	LA County
						WAC-89CA, 27-62	LA County
						WAC-89CA, 27-84	LA County
						WAC-89CA, 27-109	LA County
						WAC-89CA, 27-135	LA County
May 1, 1989	6	2000	yes	yes	Color	PAS_89 06-20 PW VEN 7-229	Ventura County
						PAS_89 06-20 PW VEN 7-231	Ventura County
						PAS_89 06-20 PW VEN 7-233	Ventura County
						PAS_89 06-20 PW VEN 7-235	Ventura County
						PAS_89 06-20 PW VEN 7-269	Ventura County
						PAS_89 06-20 PW VEN 7-237	Ventura County
June 1, 1994	n/a	unknown			b/w, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
April 1, 2000	n/a	unknown	no	yes	color, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
February 1, 2002	4	Unknown	no	yes	Color, georeferenced	AirPhotoUSA (from GeoSyntec)	Covers all of Newhall project area

©2005 Balance Hydrologics, Inc.

Date	Number of photos	Nominal Scale	Hard Copy?	Electronic copy?	Image Type	Source/Vendor	Remarks
July 23, 2002	n/a	unknown	no	yes	Color, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
March 1, 2003	n/a	unknown	no	yes	Color, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
April 1, 2004	n/a	unknown	no	yes	Color, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
October 13, 2004	n/a	unknown	no	yes	Color, georeferenced	GlobeXplorer	downloaded select sections from LA and Ventura County
February 1, 2005	n/a	unknown	no	yes	Color, georeferenced	GlobeXplorer	only avaialable for LA County

©2005 Balance Hydrologics, Inc.

APPENDIX G

NEWHALL RANCH HYDROMODIFICATION ANALYSIS

NEWHALL RANCH
HYDROMODIFICATION CONTROL

Prepared for

Newhall Land
Valencia, California

Prepared by

Geosyntec Consultants
Oakland, California
Los Angeles, California

January 2008

Table of Contents

1 Introduction 1
2 Hydrologic Modeling 3
2.1 Hydromodification 3
2.1.1 Hydrologic Processes 3
2.1.2 Geomorphic Processes 4
2.1.3 Runoff Computational Methodology 5
2.1.4 Hydromodification Computational Methodology 6
2.2 Management Strategies 8
2.2.1 Flow Duration Control – On-Site Control Alternative 8
2.2.2 Changes in Channel Geometry & Slope – In-Stream Control Alternative 8
2.2.3 Mixed Control Alternative 9
3 On-site Control Alternative 9
3.1 Flow Duration Control Basins 10
3.2 Selection of Critical Shear Stress & Low Flow Discharge Rate (Qcp) 10
3.3 Flow Duration Control Basin Configuration 11
3.4 Normalized Sizing Charts 13
References 18

Attachment A Basis of Design: Newhall Ranch Tributaries

List of Figures

Figure 1: Conceptualized Configuration of Flow Duration Basin 11
Figure 2: Conceptual Illustration of a Flow Duration Basin 13
Figure 3: Required Flow Duration Control Basin Total Volume 15
Figure 4: Required Flow Duration Control Basin Capture Volume 16
Figure 5: Required Flow Duration Control Basin Area 17

1. INTRODUCTION

The purpose of this report is to summarize hydrograph modification (hydromodification) control alternatives for the Newhall Ranch project areas tributary to the Santa Clara River tributaries: Lion, Long, Potrero, Chiquito, and San Martinez Grande Canyons (herein referred to as "the tributaries"). Geosyntec Consultants has developed and used in this report a state-of-the-art analytical technique to evaluate and address hydromodification impacts that result from watershed development. This unique approach has been developed to provide a more accurate assessment of the changes that take place in stormwater runoff, stream flows, and sediment transport characteristics due to watershed development than traditional hydrologic analysis methodologies. It is intended to allow for development of more effective long-term solutions to protect the receiving channels from excessive erosion and degradation.

Three basic hydromodification control alternatives are available:

1. Hydromodification control using flow duration control basins only (called "on-site control") to mimic the natural hydrologic characteristics (flow rates, volumes, and duration) of the project area.

2. Hydromodification control using geomorphically-referenced natural channel design, such as incorporating in-stream grade control structures to provide an equilibrium slope that maintains the existing sediment transport capacity (called "in-stream control"). This option can also be used to restore already degraded stream channels.

3. Hydromodification control using a combination of flow duration control basins and in-stream grade control (called the "mixed control alternative").

Additional alternatives that were not investigated for this report include "bypass" and storage of excess runoff volumes for irrigation reuse. The bypass alternative consists of piping excess stormwater runoff flows directly to the Santa Clara River instead of to a tributary canyon. The Santa Clara River is capable of withstanding excess flows from the Newhall Land development projects without hydromodification impacts (see further Appendix F, Balance Hydrologics, 2005). This alternative may be feasible for portions of the Homestead and Potrero Valley Projects that are in close proximity to the Santa Clara River. In the irrigation reuse alternative, excess surface runoff could be directed to storage tanks or above ground water features located in parks or a golf course for irrigation reuse, or alternatively, to blend excess stormwater runoff with reclaimed water from the proposed Newhall Water Reclamation Plant for reuse. These additional alternatives may be investigated at the project level.

This report is organized as follows:

Section 2 summarizes hydromodification and its effects on the fluvial geomorphology of the receiving waters, and describes the computational steps used in our analysis. This section also summarizes the hydromodification control options that will be implemented on the Newhall Ranch projects.

Section 3 presents normalized sizing charts for hydromodification (flow duration) control basins for the on-site control alternative and describes the methodology used to produce the charts. These charts provide unit volume and area requirements that are applicable the Newhall Ranch Specific Plan area.

A technical memorandum prepared by Phillip Williams and Associates, Attachment A to this report, provides the basis of design for in-stream control in the Newhall Ranch tributary drainages (Lion Canyon, Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon). Appendix A also describes the existing geomorphic and hydrologic setting within these tributaries.

The evaluation contained in this report was based on preliminary project land use plans and the following assumptions:

- The hydrologic model assumes that the proposed water quality treatment BMPs will infiltrate and/or evapotranspire a minimum of 20% of the captured runoff volume. The water quality treatment BMPs will be sized to capture 80 percent of the average annual runoff volume.

- Existing channel geometry and longitudinal slope are as specified by PACE in the tributary reports for Chiquito, Lion, Long, and Potrero Canyons (PACE 2005).

- The critical shear stress values were primarily based on NRCS soil type data and measured data provided in the Hydraulic, Sediment Yield and Sediment Transport Study conducted by URS (2002) for Chiquito Canyon. Critical shear stress values for Long, Lion and Potrero were determined from bed grain size distributions and channel hydraulics.

- The channel material in the post-developed condition was assumed to be the same as that used for the existing condition. In other words, the material type and critical shear stresses were held constant from pre-development to post-development.

- The amount of bed material (sediment) transported under existing conditions in the stable reaches of each canyon represents the baseline condition used in tributary design to be maintained in the post-development condition.

- Reductions in sediment supply were provided by PWA using the proposed project developing area. Changes in sediment supply (in percent) is accounted for by reducing

the sediment transport capacity (in percent) by an equivalent amount in the post-developed condition.

2. HYDROLOGIC MODELING

Geosyntec modeled the pre- and post-development hydrology, hydraulics, and sediment transport capacity of flows in the tributaries. Two land use scenarios were analyzed: 1) existing conditions and 2) developed conditions with water quality treatment BMPs. Developed conditions include the proposed natural channel designs developed by others.

The existing condition represents pre-development for the NRSP projects. Existing land uses in the NRSP area consist of open space, agriculture, and oil and gas extraction wells with associated access roads. Before human disturbances, channels generally evolved over time to balance watershed characteristics (e.g., rainfall patterns, surface runoff, and infiltration rates) and sediment load (e.g., soil type and erodibility) with channel planform, slope, cross sectional dimensions, and boundary material resilience. The currently stable reaches in the existing condition are the baseline conditions to be maintained after development, as opposed to channel conditions prior to human disturbance

Proposed conditions represent post-development with water quality treatment BMPs in place for each tributary watershed consistent with those proposed in the NRSP Subregional SWMP and the Project Water Quality Technical Reports. Proposed conditions are compared to the existing conditions to evaluate changes in sediment transport capacity created by the proposed project. Project Design Features (PDFs) will be designed to avoid, reduce and/or manage stormwater runoff in a way that reduces potential impacts to less than significant when compared to existing conditions. Reductions in sediment supply caused by covering the landscape is accounted for by reducing the sediment transport capacity in the proposed channel by the same percentage.

2.1. <u>Hydromodification</u>

2.1.1. Hydrologic Processes

It is well documented that urbanization modifies the natural watershed and stream hydrologic and geomorphic processes by altering the landscape, modifying vegetation and soil characteristics, and introducing impervious surfaces and drainage infrastructure. The resulting increases in the volume, frequency, and cumulative duration of runoff from development are known as hydromodification. Changes to the rainfall-runoff regime resulting from development intensifies sediment transport and erosion processes, and often leads to channel degradation and adjustment in channel morphology.

Research over the last decade has concluded that assessment of stream channel stability should address the long-term cumulative effects of all sediment-transporting and erosive flows. As a

result, continuous hydrologic modeling and analysis is required to fully address changes in the full range of geomorphically significant flows and the long-term cumulative effects of watershed development.

Continuous hydrologic modeling incorporates the full distribution of all rainfall events and uses flow duration as a basis for work and sediment transport computations. This approach assesses all of the "geomorphically significant flows" regardless of their magnitude. No assumption is necessary regarding which storm (or storms) adequately characterizes all the important hydrologic conditions. This approach utilizes the entire rainfall record, thereby incorporating small and large storms, frequent sediment transporting flows, wet years and droughts, back-to-back storms, and antecedent conditions.

2.1.2. Geomorphic Processes

Stream channel size and form are established through a balance between the imposed flow energy, sediment type and supply, and the ability of the channel boundary to resist erosion, which is influenced by the presence and density of vegetation. A stable channel is loosely defined as one that neither aggrades nor degrades, but instead maintains its average cross-section, planform, and profile features over time and within a range of variance. In high sediment load systems, channel alignment and profile change frequently within limits. Pulse loads of sediment from episodic events, such as landslides, often result in a slug of sediment migrating downstream through the system. This slug causes aggradation of sediment followed by degradation as the slug is dispersed and transported downstream. This system may not appear stable, creating and destroying channel forms, but all this activity usually stays within the defined flood banks and is a natural condition in Southern California watersheds.

A stable channel system can tolerate short-term disturbances without significant change; e.g., El Nino winters or burned watershed. A disturbance of sufficient magnitude and duration that exceeds the system's ability to self-regulate, such as watershed development, causes the channel to begin a permanent evolutionary change. Persistent changes in watershed hydrology and sediment supply can cause the system to adjust and not return to its previous form, but instead to evolve to a new one.

Research has shown that the frequency and duration of geomorphically significant flows control channel form and the sediment transport processes. Stream restoration professionals typically select a 1.5, 2-, or 5-year peak flow as the design flow for natural channel design. Common terminology refers to this as "bankfull flow", "dominant", or "most effective discharge." However, research has also showed that urbanization changes the most effective discharge from its natural state to a much more frequently occurring flow. The continuous modeling approach explicitly incorporates the geomorphically significant flows under both existing and developed conditions, including changes in frequency of occurrence and magnitude.

2.1.3. Runoff Computational Methodology

The hydromodification analysis uses the USEPA Storm Water Management Model (SWMM) to generate a long-term stormwater flow rate and duration data for each of the canyons. SWMM was selected as it is capable of modeling stormwater treatment devices in addition to drainage areas and pipe and channel networks. SWMM is a public domain model that is widely used for modeling hydrologic and hydraulic processes affecting runoff from urban and natural drainages. The model can simulate all aspects of the urban hydrologic cycle, including rainfall, surface and subsurface runoff, flow routing through the drainage network, storage, and treatment. The model is particularly appropriate for analyzing both pre- and post-development flow duration because the model takes into account the effects of precipitation, topography, land use (accounting for any change in impervious cover), soils, and storage and treatment by Best Management Practices (BMPs) on surface runoff, infiltration, and evapotranspiration.

The SWMM model is designed to run in continuous simulation mode such that longer-term, more realistic hydrologic and hydraulic analyses could be performed. The continuous simulations allow for a direct frequency and duration analysis of flows in individual sub-watersheds and main-stem hydraulics. The continuous hourly rainfall record used for the analysis extends for 31 years, from 1972 through 2002.

Each canyon sub-watershed is divided into catchments to account for differences in topography, soils, and post-development land use. SWMM subdivides each catchment (drainage area) into two inclined planes, one for impervious areas, and one for pervious areas. A non-linear reservoir algorithm, coupling Manning's equation and the continuity equation, is applied to estimate runoff, taking into account rainfall intensity, initial losses, evapotranspiration, and infiltration (for pervious areas). The width and length of each plane is selected based on the drainage area configuration and existing and proposed drainage features. Thus, in addition to rainfall, input data characterizes imperviousness, soils, topography, and losses associated with evapotranspiration, infiltration, and initial losses. Flows are then routed to BMPs (where present) and then to the main/collector channels and pipes. SWMM uses dynamic routing of stormwater flows through natural channels or constructed channels and pipes to the outfalls to the receiving water. Outputs of continuous stream flow hydrographs are then used in the hydromodification computations described below.

Runoff volumes and flows are predicted for two scenarios:

- the pre-development (existing) condition, and
- the post-development with BMPs condition.

Further detail on the SWMM analysis used for this report is provided in Appendix B of the NRSP Sub-Regional SWMP.

2.1.4. Hydromodification Computational Methodology

The basis of the hydromodification analysis method is to compare the total amount of work that would be expected to move sediment and contribute to the erosion and deposition processes between pre- and post-development conditions. The total amount of work done can be thought of as equivalent to the total sediment load transported over a long period of time. The comparison is accomplished by considering the relative changes between pre and post project conditions as a ratio called the Erosion Potential (Ep). This approach does not presume the accuracy of sediment transport equations, but rather looks at the magnitude of change in work imposed on the channel by watershed development and looks at the magnitude of change in the transport of bed material. Comparing changes in terms of ratios is preferred because it reduces the affects of inaccuracies and uncertainty in the methodology and calculations.

Episodic events of fire, debris flows and/or landslides contribute slugs of sediment that migrate through the canyons as large scale sediment waves. At any given location, local channel dimensions and slope can change in response to episodic events. Although this methodology may consider several cross sections along the tributary alignment, it does not draw conclusions regarding the transport capacity between reaches. The dynamic nature and frequency of change during large flow events makes comparisons between reaches a short-term academic exercise. Instead, we look at the change in work between pre- and post-development continuously over a long rainfall record at representative cross-sections along the length of the channel.

Channel Hydraulics: Hydraulic calculations convert modeled flow rates to depth, velocity, and shear stress based on cross-section geometry, roughness, and slope. Shear stress is the force applied to the channel boundary during any given flow rate. Shear stress, depth, and velocity are taken from the central channel as opposed to the cross sectional average. The computations are completed following the Army Corps of Engineers HEC-2 method, where conveyance (K) is computed and summed between individual elevation points. Channel hydraulics are computed using normal flow[2] assumptions.

Work Index: The direction of current research is to use indices[3] to distinguish between eroding and non-eroding, or stable and unstable channel conditions (Booth, 1990; Bledsoe, 2001; MacRae, 1996; and SCVURPPP, 2005). Indices are attractive because they are simple to use and less expensive to apply compared to full scale sediment transport modeling. Sediment transport equations are only approximate and should be verified with field measurements. An un-calibrated sediment transport model is essentially an index method.

---

[2] "Normal flow" assumptions mean that the slope of the water surface is the same as the slope of the channel bed, and no backwater conditions occur.

[3] "Indices" are metrics, such as the output from the Work Index or selected Sediment Transport equations, that can estimate, within several order of magnitude, parameters of interest. Indices are not intended as precise estimates.

Three forms of work indices are applied in this analysis:

Work Index	Description	No.
$W = \sum_{i=1}^{n} k \cdot (\tau_i - \tau_c)^a \cdot \Delta t_i$	Total Work Done (arbitrary units) Andrew Simon's bank stability model (2002)	(1)
$W = \sum_{i=1}^{n} (\tau_i - \tau_c) \cdot V \cdot \Delta t_i$	Total Work Done (ft-lbs/sq-ft) Effective stream power integrated over time.	(2)
$W = \sum_{i=1}^{n} \left(\tau_i / \tau_{ri} \right)^a \cdot \Delta t_i$	Wilcock-Crowe dimensionless sediment transport function. Incorporates grain size distribution and sand fraction (2003).	(3)

Where τ_c = critical shear stress that initiates bed mobility or erodes the weakest bank layer, τ_i = applied hydraulic shear stress, τ_{ri} = reference critical shear stress, V = mid-channel velocity (ft/sec), Δt_i = duration of flows (in hours), k = an erodibility coefficient, a = exponent and n = length of flow record.

The application of these indices requires some discussion. During the initial development of this methodology, Equations 1 and 2 were used to evaluate changes in work done on both the toe channel banks as well as the stream beds (SCVURPPP 2005, MacRae 1996). A recent advancement is the addition of Equation 3, which applies to the transport of bed material (sands and fine gravel). Another improvement is the use of Equation 1 as a model to predict the failure of *consolidated bank materials*. Andrew Simon, USDA Agricultural Research Service (2002), is using this equation with field measurements to determine the erodibility of consolidated bank materials. Therefore, Equations 1 and 2 are applied to represent changes in work done on consolidated bank materials, and Equation 3 is applied to represent changes in amount of *unconsolidated bed material* transported downstream.

The approach is to compare the Work Index between pre- and post- development scenarios. The relative change is represented as the *Erosion Potential* (Ep). The Erosion Potential, expressed as a ratio, is defined as:

$$Ep = \frac{W_{post}}{W_{pre}} \qquad (4)$$

Where W_{post} = work index estimated for proposed development, and W_{pre} = work index measured for the baseline condition.

MacRae (1993, 1996) recommended that the Erosion Potential remain the same under both developed and undeveloped conditions over the range of geomorphically significant flows. Management strategies that balance the future sediment transport characteristics (at baseline or below to account for reductions in supplies) are considered effective at achieving stable conditions and are the basis of the recommended hydromodification management approach.

For each drainage area upstream from a cross section of interest, a target Ep value must be defined. The goal is to match the long-term cumulative sediment load transported in the post-development condition to that of the pre-condition. Given the variety of factors that affect stream channel response, it is not necessary to achieve an Ep of exactly 1.0 in all cases. Therefore, the target is considered a mean value within an allowable range of tolerance or uncertainty. Although MacRae does not explicitly state a criterion, evaluation of his conclusion suggest MacRae is using a value of 20% as a decision criterion. Soar and Thorne (USACE, 2001) define a sediment transport capacity/sediment supply ratio (CSR) and suggests a value of 10% as a criteria for preserving channel stability. Geosyntec (SCVURPPP, 2005) correlated Ep to observed field conditions (stable and unstable) to empirically relate the likelihood of stream channel instabilities to the erosion potential. On the basis of this correlation, a 20% range about the target Ep has been selected as an acceptable criterion. Impacts analysis and control effectiveness including in-stream modifications are evaluated for their ability to maintain the target Ep = 1 ± 20%. To account for reductions in sediment supply, a lower target must be established in order to prevent stream erosion. For example, if an area experiences a 40% decrease in sediment supply due to development, the baseline Ep of 1.0 must be reduced by 40%, giving a target Ep value of 0.60. In other words, our goal for management is to reduce the post-project sediment transport capacity to 60% of the pre-project condition. Under these conditions, impacts analysis and control effectiveness are evaluated for their ability to maintain the target Ep at 0.6 ± 20%.

2.2. Management Strategies

2.2.1. Flow Duration Control – On-Site Control Alternative

Stream erosion/deposition and sediment transport processes are functions of the long-term cumulative effects of geomorphically significant flows. Maintaining the long-term cumulative duration of geomorphically significant flows maintains the existing capacity to transport sediment and promotes long-term stability. Flow duration control was first discussed in the literature by Derek Booth (1990), of the University of Washington. The flow duration method is essentially an analysis of distributions of all flows as opposed to using a design storm event. A distribution of hourly rainfall is transformed to a distribution of hourly runoff using the hydrologic model. The distribution of runoff is then converted to a long-term cumulative flow duration series.

Flow duration control is a design methodology to maintain the existing distribution of in-stream flows above the critical flow for bed mobility and as a result maintains the existing capacity to transport sediment.

2.2.2. Changes in Channel Geometry & Slope – In-Stream Control Alternative

Where on-site flow duration controls cannot be implemented or are insufficient to achieve the target Ep ± 20%, in-stream controls can be implemented. In-stream controls involve modifying

the receiving stream channel slope and geometry so that it can convey the new urban flow regime while reducing the potential for erosion aggradation and damage to habitat. Modifications must ultimately be designed according to fluvial geomorphic principles and must meet the hydromodification management objective (the target Ep ± 20%). Key principles include:

a) Reduce the applied shear forces by reducing the longitudinal slope, and modifying the cross sectional geometry such as by reducing the depth.

b) Reduce longitudinal slope by using environmentally sensitive grade control measures and natural materials.

c) Maintain or increase flow energy dissipation along the stream channel by installing, or leaving in place, features that add roughness (e.g., dense vegetation planting).

d) Implement biotechnical engineering solutions to increase the resistance of the stream channel to the increased flow energy.

e) Maintain hydrologic connectivity between streams and floodplains. Use floodplains for flood storage, riparian habitat, recreation, and water quality.

The analysis compares the pre- and post-development longitudinal channel profiles over the length of tributary channel to identify a new longitudinal profile that maintains the existing sediment transport capacity given the new imposed flow regime. Appendix A to this report provides the basis of design for in-stream control in the Newhall Ranch tributary drainages (Lion Canyon, Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon).

2.2.3. Mixed Control Alternative

A mixed control alternative is defined as a combination of on-site control and in-stream control. Mixed control alternatives may be investigated at the project level for the Legacy Village, Homestead, and Potrero Valley Projects.

3. ON-SITE CONTROL ALTERNATIVE

This section discusses the development of normalized design and sizing charts for flow duration control basins designed according to flow duration criteria for the on-site control alternative. The design charts are based on matching the flow duration curves from undeveloped land using local soil and geologic information including infiltration rates and stream channel resiliency (i.e., critical shear stress values). These design charts provide the volume and area requirements for flow duration control basins. On-site flow duration control basins, or other types of BMPs that can provide storage, that are designed to match the pre-project flow duration condition are considered to meet the hydromodification control management objective.

3.1. Flow Duration Control Basins

A flow duration control basin is essentially a dry extended detention basin that is designed to provide hydromodification control. As shown in Figure 1 below, the flow duration control facility is conceptualized as having two pools, a low flow pool (Zone A) and a high flow pool (Zone B). The low flow pool is designed to capture the difference in runoff volume between the pre- and post-development conditions. It will capture small storms that typically do not produce runoff from undeveloped land, the initial portions of larger storms, and dry weather flows. The increase in runoff volume must be either released to the ground via infiltration, released to surface water at a fraction of the receiving stream's threshold for bed mobility (i.e., Qcp), diverted to a safe discharge location such as the Santa Clara River, and/or stored for irrigation reuse. The high flow pool is designed to detain and release higher flows to maintain the pre-development flow regime. The flow duration control basin can also serve as a water quality treatment facility by assuring that the water quality basin design criteria are met.

The flow duration control basin is sized using an iterative process of adjusting basin storage as well as selecting and adjusting the outlet structure. A stage-storage-discharge relationship is defined for the design under consideration. The 31-year time series (January 1972 to December 2002) of post-development runoff predicted by the SWMM model is routed through the facility and the stored volume and discharges are computed for each time step (i.e., In-Out = Δ Storage), according to the routing methodology defined in Hydraulics, A Guide to the EXTRAN, Transport and Storage Modules of the USEPA SWMM 4 (1988). Outflow can take the form of infiltration, evapotranspiration, flows less than Qcp, diversions, weir flow, and overflow. A wide range of outlet design styles are possible, such as weirs, orifices, sand filters, and risers.

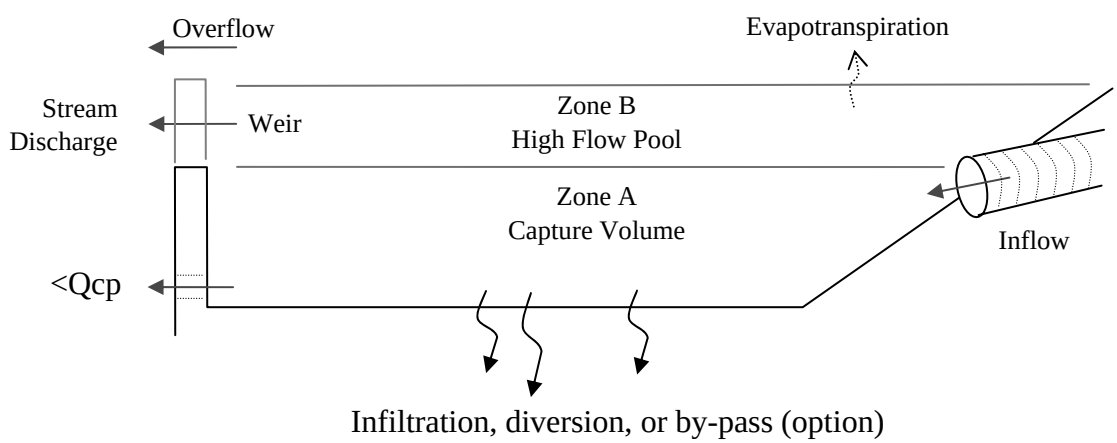


Figure 1. Conceptualized Configuration of Flow Duration Basin

3.2. Selection of Critical Shear Stress & Low Flow Discharge Rate (Qcp)

The critical flow for bed mobility (Qc) is the threshold flow that creates an applied hydraulic shear stress equal to the defined critical shear stress for the channel boundary. The critical

shear stress is based on either bed material or bank material, which ever is least resistant, and can be adjusted depending on the density of vegetation. Qcp is the fraction of Qc that is apportioned to the flow duration control basin discharge if there is more than one basin in the watershed. For the watersheds analyzed for this report, the critical flow for bed mobility ranges from 1 cfs to 35 cfs, depending on boundary material, channel geometry, roughness, and longitudinal slope.

With the exception of Chiquito Canyon, no field samples of bed and bank material were collected in the canyons at the time of this analysis, and thus information on boundary material (e.g., wetted perimeter of stream) properties was obtained from NRCS soils data (NRCS, 2005). In Chiquito Canyon, where bed material was measured by URS (2002), the median grain size is 0.9 mm. The selected critical shear stress for this grain size is 0.06 lbs/sq-ft (ASCE Manual No. 77, Figure 9.5, pg 334) On the basis of this information, the following boundary material properties were selected for analysis and used throughout this report:

1. Chiquito Canyon: Bed material D_{50} = 0.9 mm, τ_c = 0.06 lbs/sq-ft.
2. Lion Canyon (soil type: Metz, MtC) = loamy-sand. τ_c = 0.055 lbs/sq-ft.
3. Long Canyon (soil type: Castaic, CnG3) = silty-clay-loam. τ_c = 0.05 lbs/sq-ft.
4. Potrero Canyon (soil type: Yolo, YoA) = loam. τ_c = 0.05 lbs/sq-ft.

The values assume little compaction and generally loose bed and bank material. If a moderate amount of compaction was present, the critical shear stress values could be increased to 0.10 lbs/sq-ft, which would result in a 15% to 20% reduction in computed Ep values. Bed and bank material sampling is recommended to more accurately estimate the critical shear stress for future refinements of this analysis.

Given the estimated critical flow values computed in this analysis and the uncertainties in boundary material, and based on an average or representative channel geometry, a value of 2 cfs was selected as the Qcp for a 100 acre tributary area. The 100 acre size was chosen because it is close to the typical catchment size that would drain to a single water quality or flow duration control basin. Qcp is important when local soils are low infiltrating, clayey soils. Because Qcp and infiltration are the only means of discharging the increased runoff volume, their relative values determine which is the controlling factor. Both infiltration and Qcp are applied in the sizing charts herein.

3.3. Flow Duration Control Basin Configuration

Flow duration control basins discussed herein do not provide flood control per the requirements of the Los Angeles County Hydrology Manual. If flood control is desired in these facilities, they would ultimately be designed to meet the Los Angeles County requirements for both

flood control and hydromodification control. Stormwater treatment can also be accomplished in such facilities.

Due to the large number of possible basin configurations, some design features were held constant in the preparation of the sizing charts. Basin depths were limited to six feet to avoid triggering dam safety requirements. The outlet structure was limited in type and size, and held constant as much as possible.

Figure 2 presents a conceptual illustration of a flow duration basin. The basin has 2:1 side slopes and a depth of 6 feet for the purposes of this report; the basin length and width would vary by drainage catchment size and percent imperviousness. Infiltration occurs everywhere the surface is inundated. The bottom four feet of the basin represents Zone A, the capture volume; whereas the top two feet represents Zone B, the flow duration matching volume.

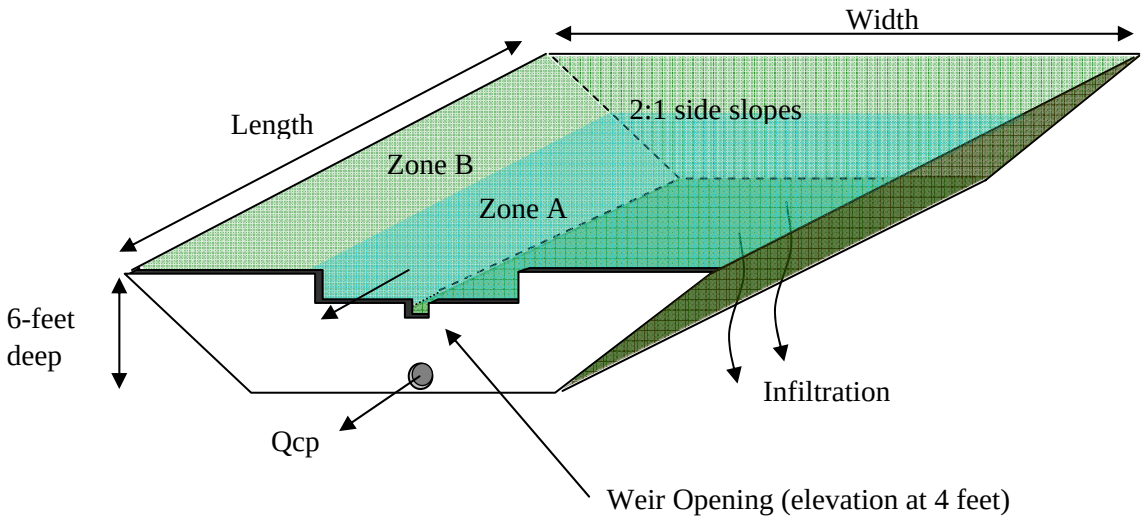


Figure 2. Conceptual Illustration of a Flow Duration Basin

Various outlet configurations and basin size combinations could be developed to meet the flow duration matching criteria. The sizing charts were developed using a constant outlet configuration, as much as possible, to provide consistency. In order to achieve the correct flow control using the sizing charts, this standard outlet design must be used in the design of the basin.

The low flow discharge (Qcp) can be controlled by an orifice hole in a headwall or by using a sand filter/buried perforated outlet pipe design. Any other design that controls the low flow discharge to below Qcp would also be acceptable. The orifice is sized so that it discharges Qcp just at the overflow weir elevation; i.e., six feet in these examples. Experience from similar projects has found that the size of the orifice hole is acceptable (> 4 inches) for approximately 20 acre tributary areas and greater. Orifice holes that are less than four inches have a tendency to plug with small debris, and therefore should be avoided for maintenance reasons. For

tributary areas less than 20 acres in size, or a tributary area that results in an orifice size less than four inches, a sand filter/buried perforated outlet pipe can be used as an outlet structure. This type of outlet is sized so that the discharge into the perforated pipe is equal to Qcp. The weir outlet is designed so that its crest occurs at the top of Zone A, the capture volume, and is used to discharge the high flow pool (Zone B).

3.4. Normalized Sizing Charts

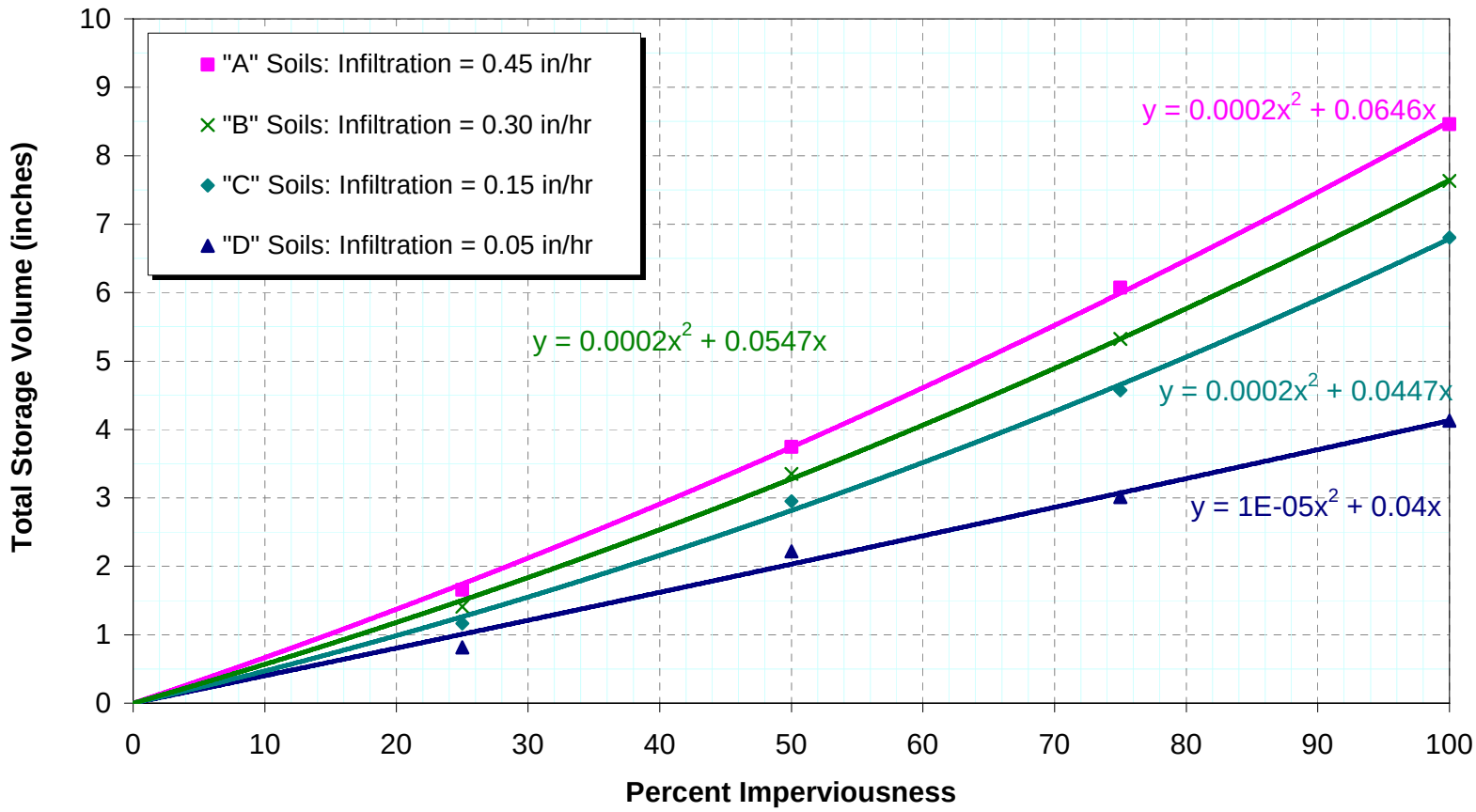
Figures 3 through 5 present the normalized sizing charts developed for the Newhall Ranch watersheds. Figure 3 and 4 provide the total volume (Zone A and B in Figure 2 above) and the capture volume (Zone A in Figure 2 above) requirements, respectively, and Figure 5 provides the surface area requirements assuming a 6-foot deep storage basin with 2:1 side slopes. Note that these charts are specific to the assumptions of 2:1 side slopes, a 6-foot depth, and a specified outlet design. Alternative sizing charts could be prepared for alternative design assumptions. The sizing charts are based on runoff from a 100 acre area. Sizing curves are provided for four tributary area soil types (Hydrologic Groups A, B, C and D) assuming the following infiltration rates in saturated soil conditions:

- Soil type “A” with 0.45 in/hr infiltration.
- Soil type “B” with 0.30 in/hr infiltration.
- Soil type “C” with 0.15 in/hr infiltration.
- Soil type “D” with 0.05 in/hr infiltration.

Unit total storage volume and capture volume (acre-inches per acre of tributary area) can be determined from Figures 3 and 4 based on the imperviousness of the flow duration basin’s tributary catchment area and the tributary area soil type (or infiltration rate). For example, a tributary area with 50 percent imperviousness and soils with an infiltration rate of 0.15 in/hr requires 1.8 acre-inch per tributary acre of capture volume and 2.8 acre-inch per tributary acre of total stormwater storage.

Figure 5 presents a flow duration control basin surface area sizing chart. A deeper basin will result in smaller surface area requirements. Surface area can be adjusted according to depth between three and eight feet as long as the capture volume and total volume remain as specified in the sizing charts presented in Figures 3 and 4. The use of the sizing chart beyond these limits would require further verification that the basin design is achieving the desired hydromodification control objectives. Using the tributary area’s estimated percent imperviousness, the *Unit Area* requirement from Figure 5 is multiplied by the total tributary area to derive the total required land area to meet the flow duration criteria. For example, a tributary area with 50% imperviousness and an infiltration rate of 0.15 in/hr requires the

equivalent of 4.1% of the tributary area for a flow duration control basin that is six feet deep with 2:1 side slopes and a weir crest at four feet.

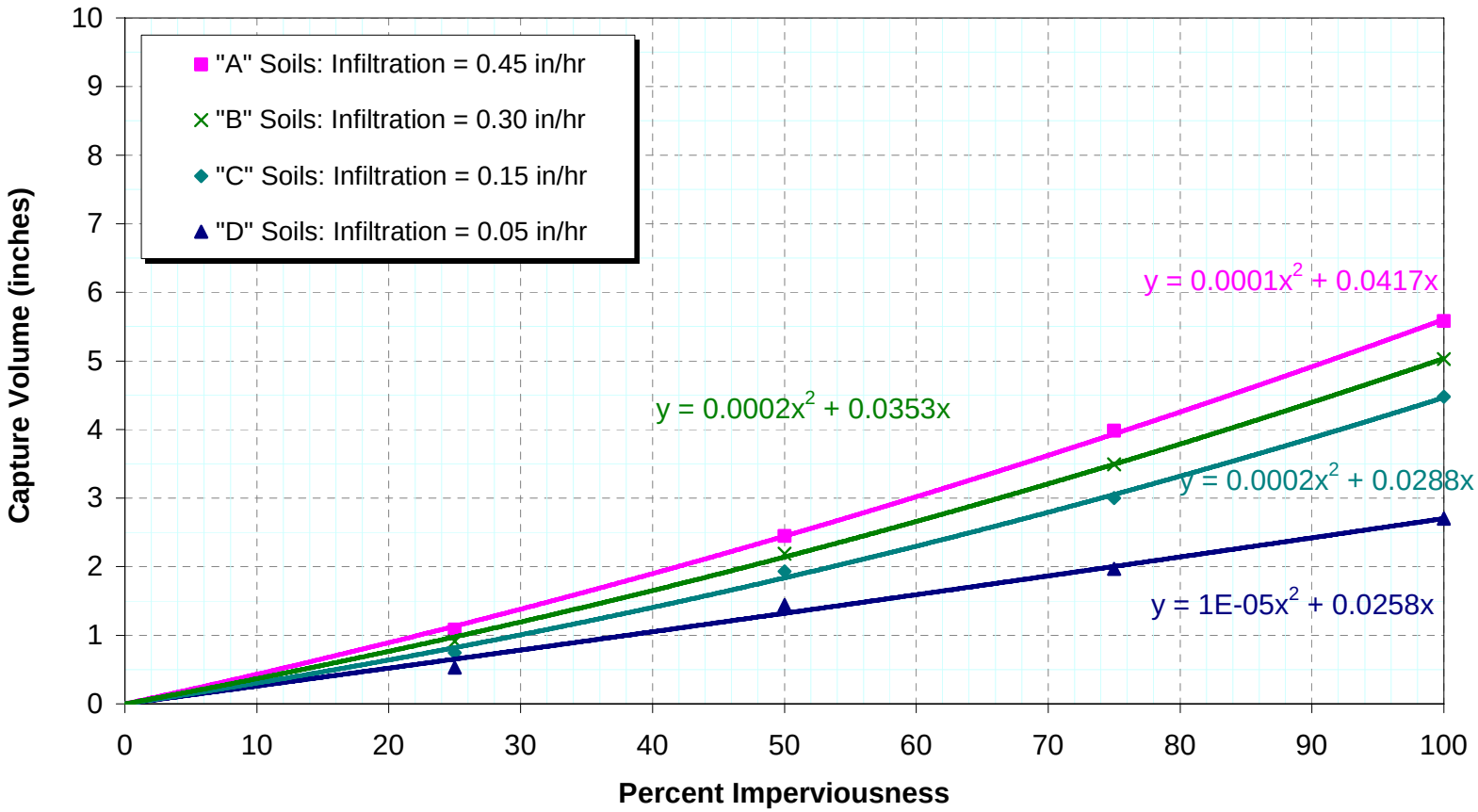


Required Flow Duration Control Basin Total Volume

Newhall Precipitation; Qcp = 2 cfs/100 acres

Figure 3

GeoSyntec Consultants

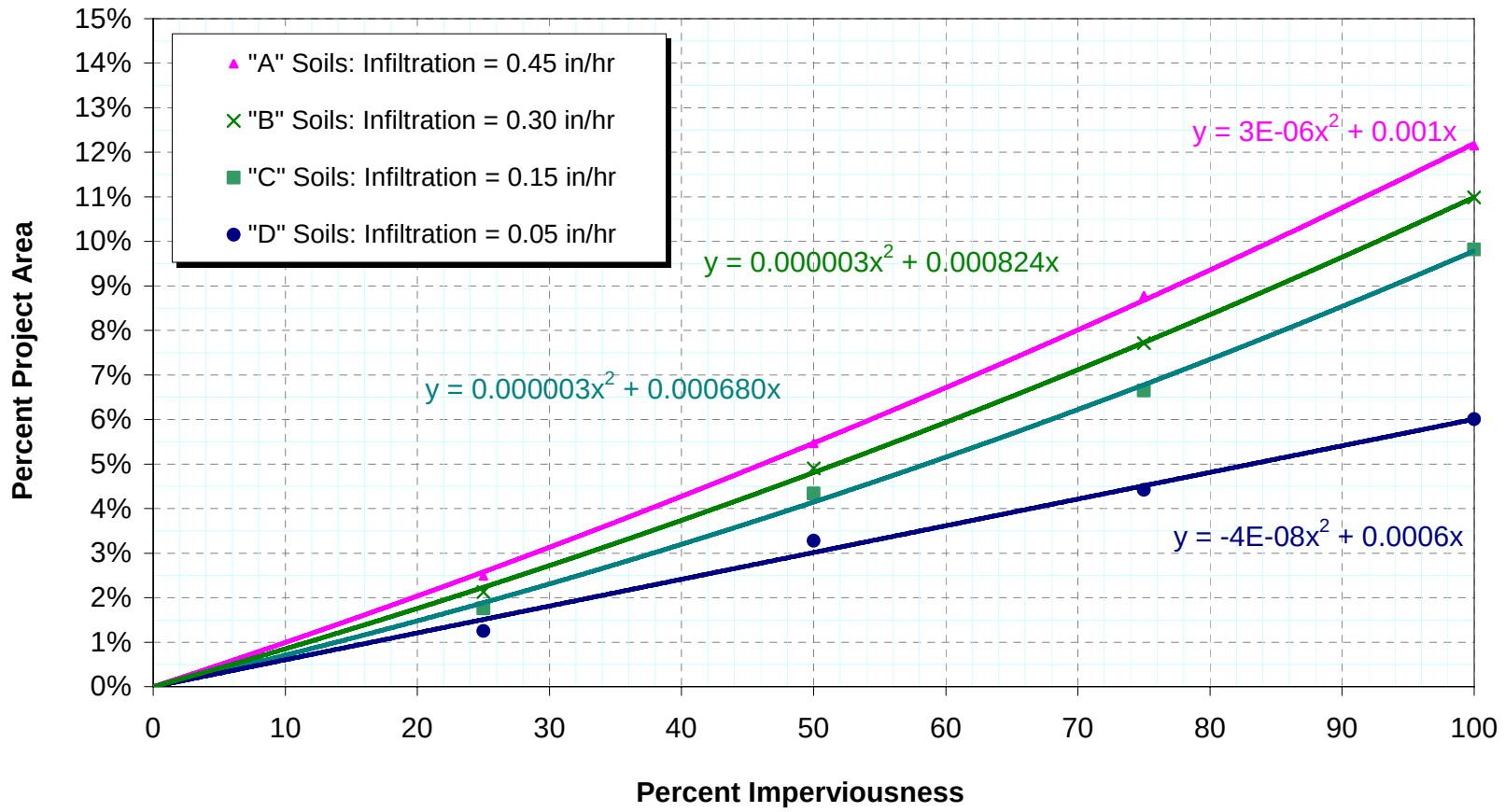


Required Flow Duration Control Capture Volume

Newhall Precipitation; Qcp = 2 cfs/100 acres

Figure 4

GeoSyntec Consultants



Required Flow Duration Control Basin Area

6-foot deep basin, Weir Crest at 4 feet

Figure 5

GeoSyntec Consultants

REFERENCES

Bledsoe, Brian P. and Chester C. Watson. 2001. Effects of Urbanization on Channel Instability. Journal of the American Water Resources Association, vol. 37 (2). Pg 255-270.

Bledsoe, Brian P. and Chester C. Watson. 2001b. Logistic Analysis of Channel Pattern Thresholds: Meandering, Braiding, and Incising. Geomorphology, vol. 38, pg 281-300.

Balance Hydrologics, Inc., 2005. Assessment of Potential Impacts Resulting from Cumulative Hydromodification Effects, Selected Reaches of the Santa Clara River, Los Angeles County, California. Prepared for Geosyntec Consultants by Balance Hydrologics, Inc. October 2005.

Booth, Derek, B. 1990. Stream-channel incision following drainage-basin urbanization. Water Resources Bulletin, vol 26, pg 407-417.

Geosyntec Consultants. 2002. Final Report SWMM Hydrology and Hydraulics Modeling For Chiquito Canyon.

MacRae, C.R. 1993. An Alternate Design Approach for the control of Instream Erosion Potential in Urbanizing Watersheds. Proceedings of the Sixth International Conference on Urban Storm Drainage, Sept 12-17, 1993. Torno, Harry C., vol. 2, pg 1086-1098.

MacRae, C.R. 1996. Experience from Morphological Research on Canadian Streams: Is Control of the Two-Year Frequency Runoff Event the Best Basis for Stream Channel Protection. Effects of Watershed Development and Management on Aquatic Ecosystems, ASCE Engineering Foundation Conference, Snowbird, Utah, pg 144-162.

Musgrave, G.W., “How Much Water Enters the Soils, “ U.S.D.A. Yearbook, U.S. Department of Agriculture, Washington, D.C., 1955, pp.151-159.

Natural Resources Conservation Service (NRCS), United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for Antelope Valley Area, California [Online WWW]. Available URL: "http://soildatamart.nrcs.usda.gov" [Accessed December 2005].

PACE, 2005. Newhall Ranch Habitat Management Plan River Drainage Analyses, Draft Floodplain Hydraulics Impacts Assessments for Chiquito Canyon, Lion Canyon, Long Canyon, and Potrero Canyon Watersheds. Prepared for Newhall Land by Pacific Advanced Civil Engineering, Inc. Fountain Valley, CA., April 2005.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), 2005. Hydromodification Management Plan, Final Report.

Simon, A.; G. Hanson and K. Cook (USDA ARS). Non-Vertical Jet Testing of Cohesive Stream Bank Material. ASAE Annual International Meeting, CIGR XVth World Congress, July 2002.

URS. 2002. Hydraulic, Sediment Yield and Sediment Transport Study. Prepared for Newhall Land by URS Corporation.

USACE, Channel Restoration Design for Meandering Rivers, Phil Soar and Colin Thorne, ERDC/CHL CR-01-1September 2001.

APPENDIX G
ATTACHMENT A
BASIS OF DESIGN: NEWHALL RANCH TRIBUTARIES

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
720 California St., Suite 600
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

M E M O R A N D U M

Date:	April 14, 2008
To:	Newhall Land Company
Organization:	Philip Williams and Associates, Ltd.
From:	Andrew Collison, Adam Parris, Jeffrey Haltiner, and Vince Geronimo
PWA Project #:	1820
PWA Project Name:	Newhall Ranch
Subject:	**Basis of Design: Newhall Ranch Tributaries**

1. INTRODUCTION AND OVERVIEW

This document describes the existing geomorphic and hydrologic setting and provides the basis of design for a restored stable channel and floodplain for the tributary drainages in the Newhall Ranch area (Lion Canyon, Long Canyon, Potrero Canyon, Chiquito Canyon, and San Martinez Grande Canyon; herein referred to as "the tributaries"). Channel and floodplain stabilization are required for a variety of purposes: to mitigate for historic watershed disturbances (primarily increased runoff due to ranching, oil and gas extraction, and the construction of unimproved roads); to accommodate proposed future increases in runoff and reduction in sediment delivery resulting from land development; to support a diversity of native vegetation and wildlife habitat; and to provide a visual amenity to the Newhall Ranch Specific Plan (NRSP) development projects.

The present channel systems include combinations of stable and unstable reaches, with substantial sediment production from hillside slope failures and channel/bank erosion. From a channel stability perspective, the construction of housing and associated urban infrastructure within the NRSP area will result in increased peaks and duration of runoff (hydrograph modification) and a reduction in sediment supply. To be stable under future conditions, the stream channels will require a lower than existing gradient and somewhat increased flow capacity (width and depth). The tributaries will be designed to convey sediment under future conditions with a "dynamically stable channel" (neither long-term erosion nor deposition) and to support the proposed native re-vegetation program. This memo describes the tributary channel design and analysis approach. Design elements include channel gradient, width and depth, as well as planform sinuosity and riparian corridor width.

1.1 DESIGN CRITERIA

The channel and floodplain will meet the following design criteria:

- Geomorphic stability – the channel will not aggrade with sediment or erode its banks or bed excessively. The bankfull channel will be sized for the dominant (channel forming) discharge.
- Hydraulic/Flood conveyance – the floodplain will convey the capital flood (Qcap) with a minimum of 3 feet of freeboard, and meet LA County standards for flood channels.
- Ecological function – the channel and floodplain will provide for the proposed ecological function, supporting a combination of riparian habitat, coastal sage scrub, oak woodland, etc., as appropriate. Grade control structures, culverts, and other hydraulic structures will be designed to accommodate wildlife requirements.
- Hydromodification – The combined urban runoff management program, in conjunction with the channel design, will address potential "hydromodification" impacts. The channel will not aggrade or generate excess sediment from erosion or create a larger than natural downstream impact from sedimentation associated with hydrograph modification.
- Low maintenance – the channel and associated structures will require minimum maintenance. The channel and floodplain will not require sediment removal or vegetation clearance. Drop structures will require monitoring annually during the initial establishment period. Once the system is established and revegetated, there will be no regular maintenance required. A program for periodic checking/monitoring of the channel corridor will be established. Infrequent access may be required following extreme flow events.

The designs will represent an optimization of the above project goals. To minimize long-term maintenance and possible impacts to the restored habitat, a more active initial restoration design will be developed. A relatively conservative equilibrium channel slope will be assumed for the initial design, based on the assumption that some minor channel aggradation is preferable to erosion. Potential aggradation will be evaluated and accounted for in the channel hydraulic design and freeboard analysis. Because the focus of the design of the majority of the channel length is to create a "natural" channel system, with high riparian and habitat value, the tributary designs will require very infrequent maintenance or access by heavy equipment. However, the maintenance access system will accommodate easy/frequent access to those elements likely to require more frequent monitoring and maintenance (water quality basins, culverts, bridge crossings). In addition, the channel design will have adequate capacity, freeboard, and setbacks from the development that the need for direct channel access will likely not be required during the wet/rainy season. Monitoring and possible channel maintenance can be accomplished during the dry season.

1.2 REGULATORY FRAMEWORK

The channel designs must meet a variety of regulatory requirements. Channels must be designed to meet Los Angeles County Department of Public Works (LACDPW) guidelines while meeting the hydromodification control requirements of the Los Angeles County municipal separate storm sewer (MS4) Permit established by the Los Angeles Regional Water Quality Control Board (LARWQCB). In some cases, these regulatory requirements require specific design approaches using different analysis methodologies. For example, LACDPW requires event-based designs that are focused on stability during low frequency-high magnitude events, while the LARWQCB appears likely to adopt a continuous

simulation method that incorporates all geomorphically significant flows in the design for hydromodification control. These approaches may produce slightly conflicting channel dimensions. The goal of the tributary design is to comply with the requirements and the objectives of all of the agencies. Where there are differences between the agency methods, we describe these and provide our recommendations on the preferred design parameters. Some of the methodologies are still developing, as traditional flood and channel management strategies are evolving to integrate habitat, public access, aesthetic goals, and agency requirements.

The tributary design goals, which are to design a stable channel corridor that provides flood protection, habitat values, aesthetics, and appropriate access, are consistent with both the goals and requirements of all of the various regulatory agencies.

1.3 DESIGN APPROACH

The available approaches to stable channel design can be grouped into three categories:

- *Field reference reach approach* – channel design based on field measurements made at stable reference reaches in local watersheds with similar sizes, runoff regimes and sediment characteristics.
- *Empirical methods* – channel design is based on observed correlations between inputs (watershed area, discharge, sediment yield) and outputs (channel width, depth and slope) for a similar physiographic and climatic region.
- *Analytical methods* – channel design is based on physically-based numerical modeling such as sediment transport modeling.

Each of these methods has benefits and limitations. Of the channel parameters, estimating "equilibrium channel gradient" is the first and most important parameter. Considering the complexity of actual channel morphology, a combination of several different methods will be used, including local reference conditions, empirical and analytical approaches. This provides a "sensitivity analysis" and allows the design to select an optimal design slope that balances the analysis uncertainty with the tributary design goals. This may suggest using an average of the gradients from these methods, or a value that is supported by a preponderance of evidence based on the specific site conditions and risks. Safety features will be designed into channel structures to accommodate the level of uncertainty in final equilibrium slope without structural damage. Three different methods of calculating channel width, depth and slope that fulfill the LACDPW and LARWQCB requirements will be used that are based on performance of channel designs in a variety of settings.

Channel width, depth and slope are interdependent. In keeping with standard river restoration design practices, a "slope first" design approach will be used in which channel equilibrium gradient is determined, followed by width and depth. In this approach, the stable channel gradient is estimated first. The difference between the existing and future (stable) slope then determines the amount of the total gradient that must be stabilized using grade control structures (GCSs), which will be designed as a

sequence of step-pools, drop structures, armored channel sections, or other suitable alternative hydraulic structures. These hydraulic structures are then designed to be hydraulically-stable during the design flow (capital flood or "Q_{cap}").

2. PROJECT HYDROLOGY: DEVELOPMENT OF DESIGN DISCHARGES

The dominant discharge will be used as the design basis for the main low flow channel, in keeping with standard geomorphic practices. Dominant discharge is the flow that cumulatively transports the majority of sediment over a long period of time. This analysis approach assumes dominant discharge is equivalent to bankfull flow for purposes of channel design. Using continuous rainfall-runoff simulation for the Newhall Ranch watersheds, Geosyntec calculated the dominant discharge; this corresponded closely with the 2-year recurrence interval storms as determined using a continuous flow model for the post-developed condition. Based on our review, the 2-year recurrence interval storms as determined using a continuous flow model for the post-developed condition will be used as the design event for the low flow channel, insuring that these designs are also consistent with the LACDPW approaches.

3. CHANNEL SLOPE DESIGN

The design channel slope will be dynamically stable (should neither erode nor accumulate excess sediment over the long-term). Small amounts of cyclical erosion and deposition are expected, and accounted for, in any channel composed of soft materials in the short term, but the long term patterns should be of equilibrium between erosion and deposition. The tributary channel slopes will be designed using LA County methods. The resulting slope will then be verified using the erosion potential method (Ep) and field geomorphic data and adjusted if necessary. We will verify the reasonableness of the design slopes using actual channel slopes measured from a variety of developed and undeveloped watersheds in the region.

These methods are described below.

3.1 METHOD 1. LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS METHODS

LACDPW has developed two methods of calculating equilibrium channel gradient (Table 2). The first is an empirical method that is suitable for rapid analyses of small channels. The second is an analytical method, using sediment transport equations, that is more complex. We include analyses using both methods as appropriate.

Table 2. Summary of LA County Methodologies

	Method 1a – LACDPW empirical method	**Method 1b - LACDPW analytical method**
Inputs	Existing conditions flow velocity Proposed conditions flow velocity Existing conditions channel slope Proposed conditions reduction in sediment supply	Upstream water and sediment inputs
Events Assessed	Qcap and 0.25Qcap	0.25Qcap
Approach	Nomograph based on empirical relationships for LA County. Use nomograph to identify slope reduction for both events and use the lower of the two slopes	Use sediment transport modeling to size channel to convey water and sediment at design flows without erosion and use the lower of the two slopes
Output	Reduction in existing slope required to achieve equilibrium	Equilibrium width, depth and slope of channel

3.1.1 Method 1a: LACDPW Empirical Method

The LACDPW empirical method involves comparing pre- and post-project channel velocity and sediment availability for Qcap and 0.25 Qcap. Equilibrium slope is estimated from the nomograph (Figure 2) based on changes in velocity and sediment supply. PWA developed a spreadsheet to automate interpolation from the nomograph and calculate the resulting stable channel slope.

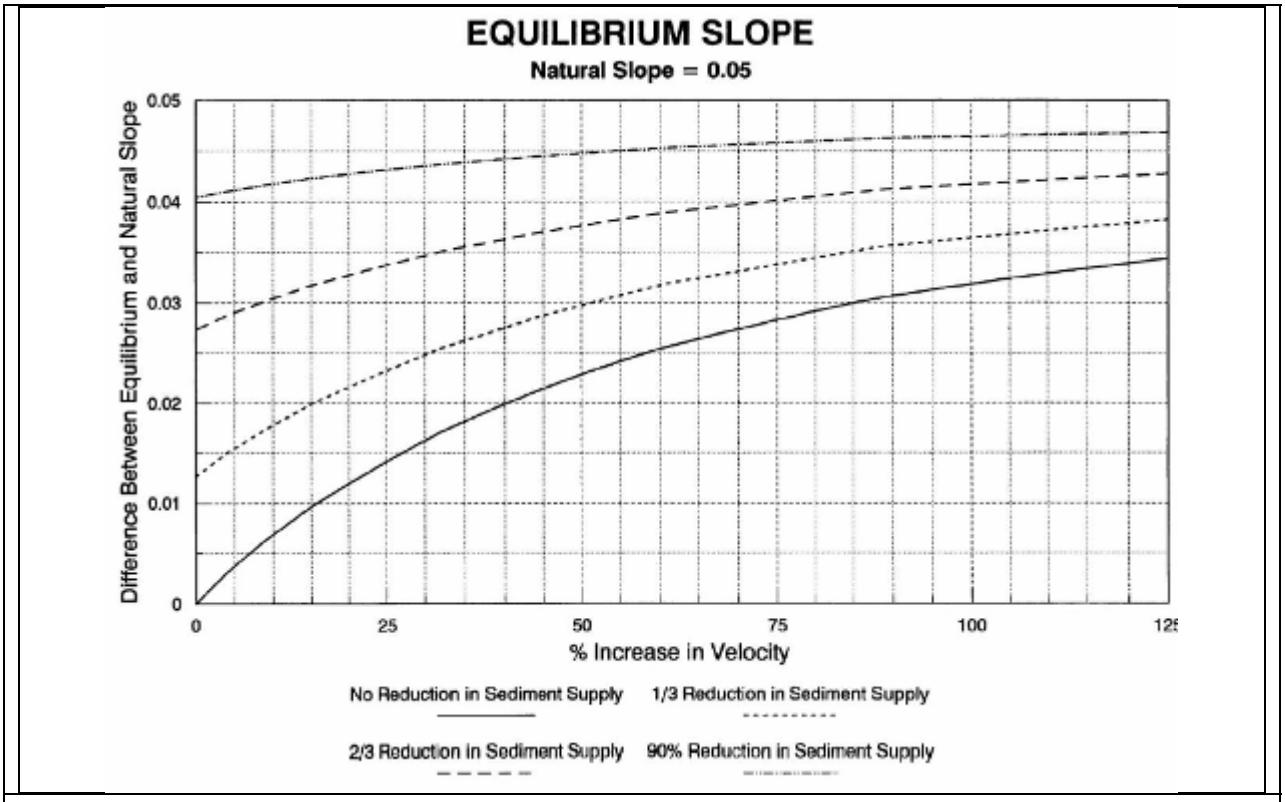


Figure 2. Nomograph for estimating equilibrium slope.
Source: LA County Dept of Public Works, 2006. Appendix C.

3.1.2 Method 1b: LACDPW Analytical Method

This method is specified for soft bottomed channels with levees. The approach is based on applying a sediment transport equation for pre- and post-project conditions and iteratively adjusting channel slope until post-project sediment transport is equal to pre-project. The method requires selection of the most appropriate of the following sediment transport equations:

1. Meyer-Peter, Muller equation
2. Einstein bed load equation
3. Einstein suspended load methodology
4. Colby methodology

Reid and Dunne (1996) review a large number of sediment transport equations for suitability based on the number and accuracy of field verifications on different types of channel. They recommend the following applications (Table 11, p.100):

Meyer-Peter/Muller model: gravel bedded and braided channels, and small sand bedded streams
Einstein and Colby: medium and large sand bedded channels

3.2 VERIFICATION USING EROSION POTENTIAL METHOD

Erosion potential (Ep) is a measure of the change in the long-term, cumulative effective work done on the channel by hydraulic forces between a pre-project and post-project condition, which represents the change in sediment transport capacity. 'Effective work' is calculated based on the difference between the applied boundary shear stress and the critical shear stress of the boundary materials or bed sediments represented by the complete grain size distribution. The ratio between existing and proposed effective work or sediment transport capacity (Ep) is used to evaluate whether the designed channels will be stable under proposed flow conditions. Ep calculations are made using continuous rainfall-runoff simulations in the EPA Storm Water Management Model (SWMM) for 31 years of available record. The resulting flow time series are applied to a sediment transport model to calculate Ep for a series of existing and proposed cross sections.

Proposed conditions are typically compared to the existing condition; however, for channel design where the existing condition is unstable, the baseline used for comparison is based on stable reference reach(es). When reduction in sediment supply is an important physical element in stable channel conditions, the target Ep is adjusted accordingly. When post-developed flows are increased and reductions in sediment supply are not important, the target ratio of existing and proposed Ep is set to 1.0. That is, the proposed design attempts to match the baseline conditions (i.e., the future sediment transport condition is equal to the existing sediment transport condition).

When reduction in sediment supply is important, an equivalent reduction in the transport capacity is needed. For example, a project that reduces sediment supply to 30% of its baseline level requires the transport capacity to also be reduced to 30% of its baseline condition; i.e., Ep = 0.30. A correlation between observed field conditions (channel stability) and predicted erosion potential for 49 cross-sections within four separate California watersheds showed that as the erosion potential begins to exceed the target by 20 to 30 percent, the probability of stream channel instabilities begins to increase rapidly (SCVURPPP, 2005). The Ep verification methodology therefore incorporates a risk-based approach that limits the variance in erosion potential to ±20% of the target, as the risk of hydromodification impacts is low in this range.

Table 1. Description of Ep Verification Method

	Verification Method - Geosyntec Application of the Erosion Potential Model
Inputs	Runoff from continuous rainfall-runoff model (SWMM) Reduction in sediment supply Bed particle size distribution, bank material type, vegetation density Existing and proposed channel geometry and longitudinal slope
Events Assessed	Continuous range of geomorphically significant flows

	Verification Method - Geosyntec Application of the Erosion Potential Model
Approach	1. Compute work done and sediment load transported for existing geometry and flow conditions using range of sediment transport and work equations. Identify stable and unstable sections. 2. Scale target Ep based on reduction in sediment delivery (e.g., 40% reduction in sediment requires 40% reduction in E_p). Identify the appropriate baseline condition for comparison. 3. Calculate Ep for the proposed channel design at several cross sections. 4. Refine slope until future Ep does not deviate from the target Ep by more than ±20%.
Output	Width, depth and slope of channel that is within 20% of target Ep, adjusted for sediment reduction.

3.3 VERIFICATION USING FIELD DATA AND SAM SIMULATIONS

3.3.1 In addition to verification using the Ep method, we assess the proposed channel design using field data from the Newhall Ranch area. This check is performed to assess the geomorphic stability of the creek. Data on equilibrium slope were collected in Newhall Ranch by measuring channel gradient in stable channel reaches. These are often located immediately upstream of grade control structures. These were compared with watershed area, (used as a surrogate of annual discharge). The resulting plot is shown in Figure 3. A measure of stable channel gradient under post-development conditions can be determined by looking at the channel gradient of watersheds with the same runoff as the post development watershed. For example, a 1-square mile watershed in which post-development runoff is doubled will lead channel slopes to adjust to a gradient appropriate to a 2-square mile watershed, assuming the same sediment delivery.

3.3.2 To compensate for reductions in sediment supply we performed a sensitivity analysis using the USACE Stable Channel Design Model SAM to determine the degree to which reductions in sediment supply affected equilibrium slope. We used this method as a check to ensure the channel designs were geomorphically-appropriate to the site.

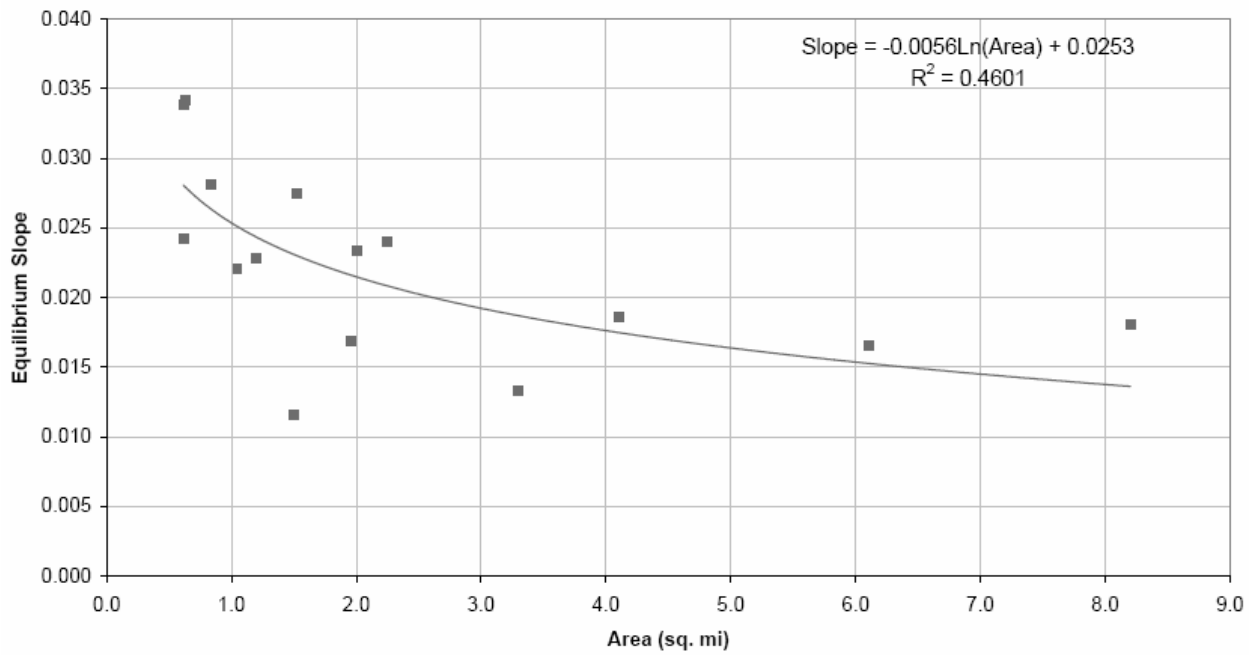


Figure 3. Equilibrium Slope for Rural Reference Reaches

3.4 SELECTION OF DESIGN CHANNEL SLOPE

Each of the above three design approaches (LA County, Ep, and reference reach/field data methods) produces a slightly different estimate of stable slope. Based on these estimates, we will select a design slope that falls between the high and low end of the estimates, based on the preponderance of evidence for the most likely stable slope. In general, this approach produces a relatively conservative estimate of the stable channel slope, to insure that stabilization structures are not undermined. In order to anticipate possible aggradation impacts, the selected slope for flood control performance will be assessed, using the highest of the previously estimated design slopes as an estimate of the maximum aggradational condition.

3.5 DESIGN SLOPE IMPLEMENTATION

Where extensive development will take place in the watershed and plans call for channel re-grading (Long Canyon and Potrero Canyon), or where the existing channel is degraded and some development will take place in the watershed (Lion Canyon), step-pool design structures (described in Section 5) will be designed and located to create a channel gradient with the selected slope.

Where channels are not degraded and less extensive development will take place in the watershed (San Martinez Grande Canyon and San Martinez Chiquito Canyon), grade control structures will be used to maintain the existing slope.

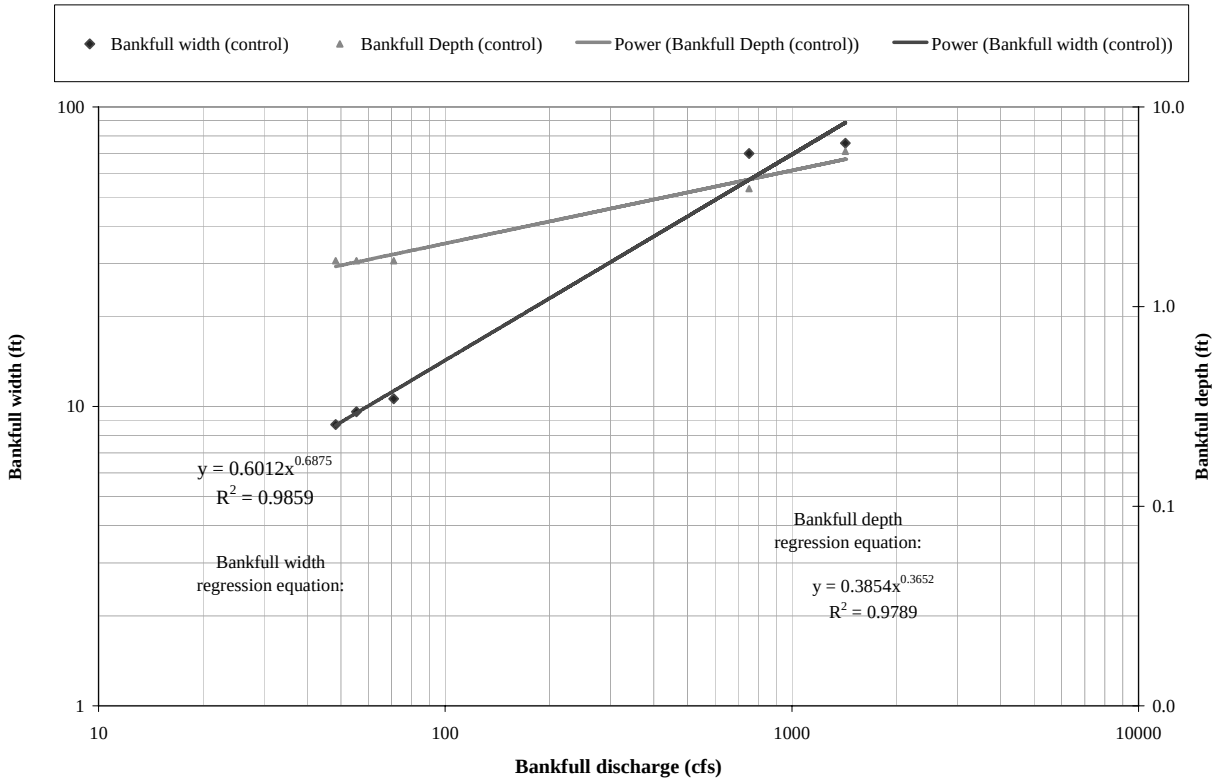
4. CHANNEL WIDTH AND DEPTH

Channel width and depth are calculated using an empirical approach using local reference reaches (Coleman et. al. 2005), verified by an erosion potential assessment to ensure that the design meets the appropriate target erosion potential within the 20 percent threshold.

4.1 SOUTHERN CALIFORNIA FIELD REGRESSIONS

The Stormwater Monitoring Coalition (SMC) (Coleman et al., 2005) performed a geomorphic assessment of streams in disturbed and un-disturbed watersheds of Southern California. This study provides regional regressions between dominant discharge and channel geometry for Southern California stream channels, and identifies predictive relationships between changes in impervious cover and stream channel enlargement for use in stream management. Eleven watersheds in Southern California, including five canyons in LA and Ventura counties near the Newhall Ranch, were selected based on detailed guidelines including watershed size, natural channel bed and banks, and development covering five to ten percent of the watershed area. Based on geomorphic assessment, historic analysis of development conditions, and ground survey, the SMC developed predictive relationships between dominant discharge and bankfull channel width as well as dominant discharge and cross sectional area (shown in Figure 4). We integrate the results from these channel systems with the estimates produced by other methods.

Figure 1. Southern California Stream Morphology Relationships



Note: Plots derived from Coleman et al. (2005) Table 5.6. Data are only from control (undeveloped) sites

4.2 SELECTION OF A DESIGN CHANNEL WIDTH AND DEPTH

Following estimation of design parameters with the different methods, a proposed channel cross-section is selected which is likely to be most stable (falls between the high and low end of the estimates). The selected combinations of width, depth and slope are evaluated hydraulically to ensure that flow velocities are reasonable and unlikely to erode over the longer term.

4.3 SELECTION OF A DESIGN CHANNEL WIDTH AND DEPTH

Following estimation of design parameters with the three methods, a proposed channel slope is selected which is likely to be most stable (falls between the high and low end of the estimates). The selected combinations of width, depth and slope are evaluated hydraulically to ensure that flow velocities are reasonable (bankfull flow velocities of typically less than 6 ft/sec where feasible (based on estimated channel roughness values) unlikely to erode over the longer term.

5. STEP-POOL DESIGN

Where the three methods utilized predict that the bankfull channel gradient will be considerably flatter than the existing gradient, drop structures or armored channels will be required to take up the elevation difference between the existing and proposed stable slopes. To maximize vegetation, aquatic, and wildlife habitat and maintain a natural channel appearance, a range of types of step-pool structures and armored riffles will be used to accommodate the drops in channel elevation. Construction of these structures will likely include large boulders, rip rap, Armorflex, soil cement, or concrete and will mimic natural step-pool function and morphology (as identified in reference reaches) in appearance and hydraulic function.

5.1 SELECTION OF MULTIPLE SMALL STEPS OR FEWER LARGE STEPS

Two approaches have been taken to controlling channel grade, to be used in different settings. Where the existing stream course and valley is going to be significantly altered by mass grading we consolidate drops in a smaller number of larger drops, to allow for greater lengths of non-armored channel between drops. Where the goal is preservation of existing channel habitat and little mass grading is proposed for the channel and floodplain area we use larger numbers of smaller drops (approx. height 3 feet) to control grade. Selection of these approaches is made based on the habitat value of the existing creek corridor and the infrastructure and mass grading needs of the surrounding development.

5.2 DESIGN PROCEDURE

The approximate initial step-pool dimensions are determined using the approach of Thomas et. al. (2000). Once the approximate structure dimensions are determined, this initial dimension is then tested using HEC-RAS to optimize the height of the step, gradient of the ramp, depth and width of pool and elevation of the apron/tail water. HEC-RAS flow estimates are also used to develop flow discharge per unit width for sizing rock to be used in the grade control structures or for bank protection. The detailed analysis and final design for the step-pool structures will be described in final design technical memorandums.

5.3 GRADE CONTROL CONCEPTS

Some of the potential types of step-pool structures and armored riffles that could be used to accommodate drops in channel elevation are described below and illustrated in Attachment A. Final design will be dependent upon the analysis of the individual channel reach conditions, constraints, and requirements.

5.3.1 Grouted Sloping Boulder (GSB) Drop

Boulders, typically 24-inch minimum in all directions, would be placed on the face of the grade control structure, the crest, the lower part of the side slopes, and the stilling basin. Twelve inches of grout would be placed at the bottom 30-50% depth of the boulders to lock them together. Typical vertical drop heights for this type of grade control structure can be greater than 3 feet and are proposed at up to 15 vertical feet. The structure length and width varies depending on the design flow; typical structure dimensions may be 100 feet long by 60 feet wide. Planted riprap would be placed along the approach, in the upper voids of

the boulders, along the upper banks, and downstream of the stilling basin (lay down toe). Seepage control would consist of a metal or vinyl sheet pile across the width of the structure and weep drains that daylight through the grouted boulders.

5.3.2 Soil Cement Grade Control Structure

On-site sandy soils will be combined with adequate cement to form a soil cement mixture that when placed mimics the sandstone outcrops in the area. Facings and lateral protection will be built by constructing the soil cement slope protection in successive horizontal layers (6-10 inches thick). Facing slopes can be steeper than GSB Drops with the steepest recommendation at nearly 1.5:1 (H:V); constructed by setting back subsequent lifts. Typical vertical drop heights for this type of grade control structure can be greater than 3 feet and are proposed at up to 15 vertical feet. The structure length and width varies depending on the design flow; typical structure dimensions may be 80 feet long by 80 feet wide. Planted riprap may be placed along the approach, in the approach at the crest, along the upper banks, and downstream of the stilling basin (lay down toe). Soil cement could be mixed on-site, placed, compacted, finished and cured resulting in a strong durable, erosion-resistant material with low permeability. If required, seepage control would consist of a metal or vinyl sheet pile synthetic liner or other impermeable material across the width of the structure and weep drains that daylight through the soil-cement lifts.

5.3.3 Sculpted Concrete Drop Structure

Colored, poured and shaped concrete will be molded to form an aesthetic modification to the grouted sloping boulder style of drop. Design of for these drops will be conducted individually but similar to the GSB Drop. Construction is typically conducted with a single monolithic full-depth pour or using a two pour system over steel reinforcement then contoured and textured to finish. Planting wells may be considered to help revegetated and conceal the structure. Facing slopes are roughly similar to GSB Drops with the steepest recommendation at nearly 3.0:1 (H:V). Typical vertical drop heights for this type of grade control structure can be greater than 3 feet and are proposed at up to 10 vertical feet. The structure length and width varies depending on the design flow; typical structure dimensions may be 100 feet long by 80 feet wide. Planted riprap would be placed along the approach, in the approach at the crest, along the upper banks, and downstream of the stilling basin (lay down toe). Seepage control could consist of a metal or vinyl sheet pile synthetic liner or other impermeable material across the width of the structure and weep drains that daylight through the poured grout mixture.

5.3.4 Non-Grouted Boulder Step Pool

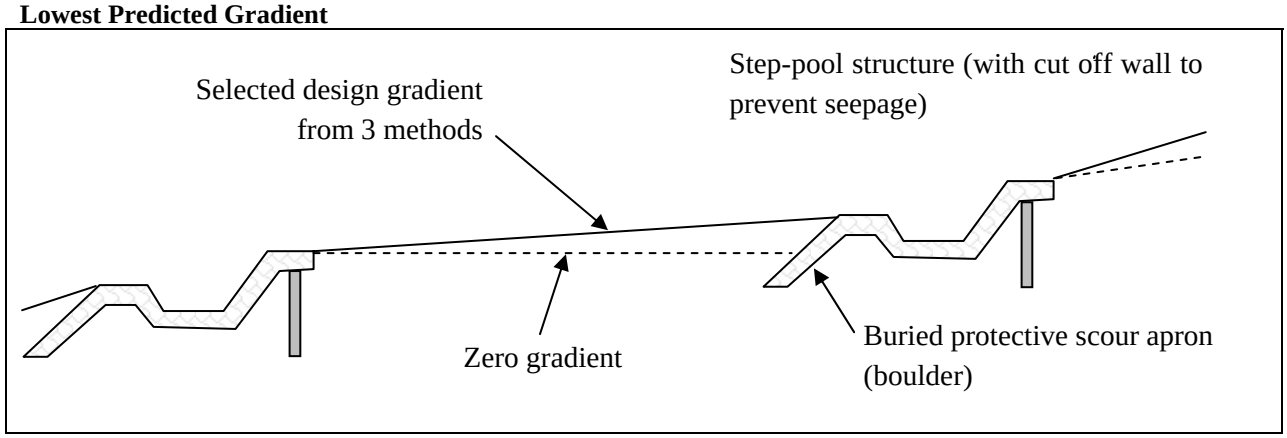
Boulders, comprised of various sizes between 24-inch and 36-inch minimum in all directions, would be placed on the face of the step-pool structure, the crest, the lower part of the side slopes, and pool. The sub-base of the structure will be adequately designed using a mixture of compacted soil and riprap. The boulders would be individually placed and chinked to lock them together. Plants will also be used to prevent boulders from dislodging. The crest boulders would be placed on top of a metal or vinyl sheet pile wall and grouted to the buried check wall to form the crest. The check wall would extend to the width of the floodplain corridor and will be notched at the step-pool structure. The non-grouted boulder step-pool will be designed for less than Qcap and have typical dimensions of roughly 50 feet by 50 feet. Planted

riprap would be placed along the approach, in the upper voids of the boulders, along the upper banks, and downstream of the pool.

5.3.5 Grade Control Scour Apron

Grade control structures would include a buried toe scour apron made of appropriately sized rock on the downstream end of the step-pool structure to accommodate the most conservative slope assumptions (i.e., assume that a completely flat slope develops) to insure that the structures will still have integrity and channel downcutting will be prevented (see Figure 2 below). The designs will also include intermittent buried rock sills across the floodplain to protect from erosion or outflanking of the step pools. For a typical design of 1% channel gradient and structures every 100 feet, the worst case scenario (adjustment of the channel to zero gradient) would be 12 inches of toe erosion on each structure.

Figure 2. Conceptual Sketch of Step-pool Structures Showing Relationship Between Design Gradient and Lowest Predicted Gradient



6. EXISTING GEOMORPHIC CONDITIONS ASSESSMENTS

PWA conducted reconnaissance-level geomorphic assessments and collected sediment samples from the beds and banks of the tributaries to support sediment transport modeling, geomorphic and channel design activities.

6.1 DATA COLLECTION

Fieldwork was carried out between February 7 and 9, 2006, with repeat visits to selected sites in summer of 2006. The channels were walked for their entire length within the Newhall Ranch project area. Sediment samples were collected approximately every 1,000 feet along the channels. Sites were selected by pre-programming GPS coordinates along the streambed at fixed intervals and then identifying geomorphically-typical reaches close to the site. At each sampling point the nearest mid–channel or point bar was selected and a sample taken from a position one third from the upstream edge of the bar, in

accordance with sediment sampling protocols outlined by Reid and Dunne (1996) and Thomas and Gee (2005). Sediment taken from this location is believed to be representative of average-sized sediment that is in transport through the system. Samples were collected by digging a 6 inch pit in the bed and transferring the entire sample to a polythene bag. Bank samples were taken from actively eroding banks where they appeared to be the main source of sediment in the channel. Typically in all creeks studied the bed samples had a thin veneer of gravel but were dominated by sand beneath that. Samples were transferred to Cooper Testing Laboratory for particle size distribution. Most samples were clearly non-cohesive and were analyzed by wet sieving. A few appeared to be cohesive and were sampled using the hydrometer method to differentiate silt and clay from coarser sediment.

A reconnaissance-level geomorphic assessment was conducted, primarily focused on the degree of channel incision (disconnection between the bankfull channel and floodplain). This was assessed by running a HEC-RAS model with the 5-year flow (model and data supplied by PACE) to determine the extent to which the 5-year flow was confined in a well defined bankfull channel or not. This was based on the observation of SCCWRP (Coleman et. al. 2005) that stable channels in this area contain the 5-year flow. Where the 5-year flow did not fill what appeared to be the bankfull channel and qualitative geomorphic evidence supported the assessment the channel was classified as incised or widening.

6.2 LION CANYON

The sample locations and particle size distribution curves are shown in Attachment B, with typical sediment sizes and channel geomorphic assessment for context.

6.2.1 Summary of Sediment Characteristics

7 samples were classified as sand with 1 gravel.

6.2.2 Summary of Geomorphic Assessment

Lion Canyon has steep headwaters (above the project boundary) that supply large amounts of sediment into the aggrading upper reach producing an undersized channel (Attachment B, Images #1 – 6) with local erosion on outside bends. (All images hereafter referenced for Lion Canyon are in Attachment B). Primarily aggradational conditions continue downstream producing a well connected and vegetated floodplain (Images 7-9). This incorporates a reach with mature oaks (Images 10-13) and an additional aggraded reach with a well connected floodplain downstream (Image 14). There is a very sharp transition from aggrading to deeply incised, eroding conditions at the road crossing, which acts as a grade control protecting the upper reaches from incision. The source of the incision is likely uncontrolled drainage from the unimproved road surface. Downstream of the grade control is a 12 foot high knickpoint (Image 15) and a reach of deeply incised channel with some failing banks (Images 16 and 17 near to more mature oaks). This reach opens up into a wider section (Images 18-20) that has historically experienced incision into what appears to be material derived from the right hillside (identified by the geotechnical assessment as a former quarry spoil deposit). This material has constrained the channel and deflected it over to the left bank terrace where it is actively eroding and causing slab failures (Image 19). Despite the longer-term appearance of incision (e.g. abandoned floodplain terraces), the bed in this reach appears to have recently

aggraded (evidenced by very shallow channel and 'buried' appearance of channel features, e.g. Image 20). Downstream the channel remains historically incised with erosion on the outside bends but with local bed aggradation and the formation of a small new floodplain on the inner bends (Images 21-22). The right valley side looking downstream is undercut by the creek, creating a high unstable slope. This reach culminates in a 8 foot high knickpoint which suggests that the channel is now eroding the bed sediment deposited in the 2004-05 floods.

6.3 LONG CANYON

The sample locations and particle size distribution curves are shown in Attachment C, with typical sediment sizes and channel geomorphic assessment for context.

6.3.1 Summary of Sediment Characteristics

All 18 samples were classified as sand with most defined as 'poorly graded sand with gravel'.

6.3.2 Summary of Geomorphic Assessment

Long Canyon is characterized by a very steep, unstable headwaters reach (outside the project area) that becomes aggradational downstream. Most of the canyon is then aggradational with some sections of wide floodplain, before passing though a culvert and into a constructed earth channel that conveys it to the Santa Clara River.

The upstream headwaters reaches (Attachment C, Images 243a and 242a) are deeply incised and highly unstable, with actively eroding channels that generate a large volume of sediment. (All Long Canyon images referred to hereafter are in Attachment C.) Downstream the channel becomes complex with evidence of local cycles of erosion and deposition in sub reaches. For example, Image 242d shows an aggraded reach with a headcut that indicates more recent upstream-migrating incision. However, the net long term trend throughout most of Long Canyon between the headwaters and the culvert at the lower end of the Onion Field is aggradational, as evidenced by the high width to depth ratio of the channel, the presence of sand-buried bed and channel features, the well connected floodplain and the braided channel form. The channel passes through a locally slightly incised but undersized reach (Images 241c and b) before entering a slightly aggrading section (Images 240a and b). The channel then enters a locally confined reach (Images 239) with actively eroding relict terraces on the outside bend before emerging into another aggradational, unconfined reach with an extensive active floodplain (Images 238). Downstream the channel becomes aggradational but with active lateral erosion on the southwest bank by the road (Images 237). Further downstream the channel remains aggradational (Images 236) with laterally eroding outside bends where the channel has migrated against relict terraces (Images 235). The channel passes through a short, slightly entrenched reach (Images 234) before widening and aggrading (Images 233, 232). Downstream the channel becomes slightly confined with a higher floodplain, but still overall relatively stable conditions (Images 231). Below this point the creek enters a constructed trapezoidal flood channel that conveys it to the Santa Clara River.

6.4 CHIQUITO CANYON

The sample locations and particle size distribution curves are shown in Attachment D, with typical sediment sizes and channel geomorphic assessment for context.

6.4.1 Summary of Sediment Characteristics

All 7 samples were classified as 'sand'. Chiquito Canyon is a mixture of well and poorly graded sand and gravel.

6.4.2 Summary of Geomorphic Assessment

Chiquito Canyon enters the project area in a confined reach with very high, unstable banks (Attachment D, Images 449, 449b). (All Chiquito Canyon images referred to hereafter are in Attachment D.) Further downstream it exits its confined canyon and enters a long reach that is dominated by a series of large alluvial fans on the east bank (Images 450a through 452c). These fans are supplying abundant sand to the creek and the channel has formed low banks in the toe of the fan that have little erosion resistance, in part due to the arable land use and lack of woody vegetation. As a result this reach is aggrading and widening. Further downstream (Images 453 through 453b) the channel becomes slightly confined as it cuts through former terraces, leaving abandoned terraces on the banks that are actively eroded on outside bends. The channel however appears to be aggrading within this setting. Towards the downstream end of the tributary (Images 454 and beyond) the channel remains slightly confined and has been modified by a series of bridges, culverts and artificial channel sections. In places these appear to cause local backwaters and sediment deposition (e.g. Image 453-4b). Downstream of the transportation corridor the channel enters the alluvial fan of Chiquito Canyon near its confluence with the Santa Clara River. The channel is leveed here and has aggraded strongly, to the point where the channel is higher than the surrounding fan surface. There is a high potential for the channel to avulse at this point.

6.5 SAN MARTINEZ GRANDE CANYON

The sample locations and particle size distribution curves are shown in Attachment E, with typical sediment sizes and channel geomorphic assessment for context.

6.5.1 Summary of Sediment Characteristics

All five samples were classified as 'sand'. San Martinez Grande Canyon is mostly well graded sand with silt and gravel.

6.5.2 Summary of Geomorphic Assessment

Grande Canyon combines a series of reaches alternating between unconfined stable reaches with small inset floodplains and confined, slightly incised and unstable conditions with actively eroding outside bends. The upper reach has a well defined and relatively stable bankfull channel that contains the 5-year flow adjacent to a small inset floodplain (Attachment E, Images 345a-b). (All Grande Canyon images referred to hereafter are in Attachment E.) Downstream the channel is more confined and many outside bends are actively eroding into relict raised floodplain terraces, creating steep and failing banks (Images 354c, 346a, 346b, 346-7a, 3467b). Downstream of this reach the valley opens up and we again encounter

more stable conditions (Images 347a, 347b) with small floodplains that persist towards the downstream end of the channel (Images 348b, 348c).

6.6 POTRERO CANYON

The sample locations and particle size distribution curves are shown in Attachment F, with typical sediment sizes and channel geomorphic assessment for context.

6.6.1 Summary of Sediment Characteristics

Of the total samples, 18 were classified as sand, 3 silt and 3 gravel. Sediment in the downstream reaches was classified as fines.

6.6.2 Summary of Geomorphic Assessment

Potrero Canyon has steep headwaters with incised, erosive channels (Image #1) that deliver a lot of coarse sediment to a downstream braided reach (Attachment F, Images #2-7). (All Potrero Canyon images referred to hereafter are in Attachment F.) The downstream reach is relatively stable with areas of slight incision some of slight aggradation (Images #8-10). There is a short reach where the channel is confined against the valley side and is deeply incised with highly unstable banks (Image #11). The channel then become more stable, though again with some fluctuations between slightly erosive and slightly aggradational sub reaches (Images #12, 23, 22). The channel then has a long and unusual reach of alkaline meadow much of which takes the form of a swale rather than a channel (Images 20, 19, 18). Towards the downstream end the channel becomes increasingly well defined, culminating in an unstable knickpoint that is migrating headwards. The channel transitions sharply into a steep, incised section with several knickpoints (Image #17c) before emptying into the Santa Clara River.

7. REFERENCES

Coleman, D., MacRae, C., Stein, E.D. (2005). Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams – Southern California Coastal Water Research Project Technical Report 450.

LACFCD, (1982). Design Manual, Hydraulic, Los Angeles County Flood Control District, March, 1982.

Los Angeles County of Public Works. (2006). Sedimentation Manual. 2nd Edition.

LADPW, (2006). Hydrology Manual, Los Angeles County Department of Public Works, Alhambra, California, December 1971, revised 2006.

Ponce, V. M. (2001). Colby (1964) Sediment Transport Online Calculator. http://octavian.sdsu.edu /~ponce/colby/colbyform.html

Reid, L. M. and T. Dunne, (1996). Rapid Evaluation of Sediment Budgets. GeoEcology Paperback. Catena Verlag Gmbh. 164 p.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), (2005). Hydromodification Management Plan. Prepared by Geosyntec Consultants for the Santa Clara Valley Urban Runoff Pollution Prevention Program. April 21, 2005.

Thomas D. B., Abt, S. R., Mussetter, R. A, and Harvey, M. D. (2000). A Design Procedure for Sizing Step-Pool Structures. Joint Conference on Water Resource Engineering and Water Resources Planning and Management 2000

Thomas, William, and Gee, D. M. (2005). Sedimentation in Stream Networks (HEC-6T) – Supplement to the User Manual. 36 p.

US Army Corps of Engineers. (2004). HEC-RAS and SAM Software. Version 3.1.2.

ATTACHMENT A

Grouted Sloping Boulder Drop

Placed, stepped boulders with voids grouted

Grouted Sloping Boulder Drop

SOIL CEMENT DROP STRUCTURE

PWA

Sculpted Concrete Drop Structure

Non-Grouted Boulder Step Pool

ATTACHMENT B

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

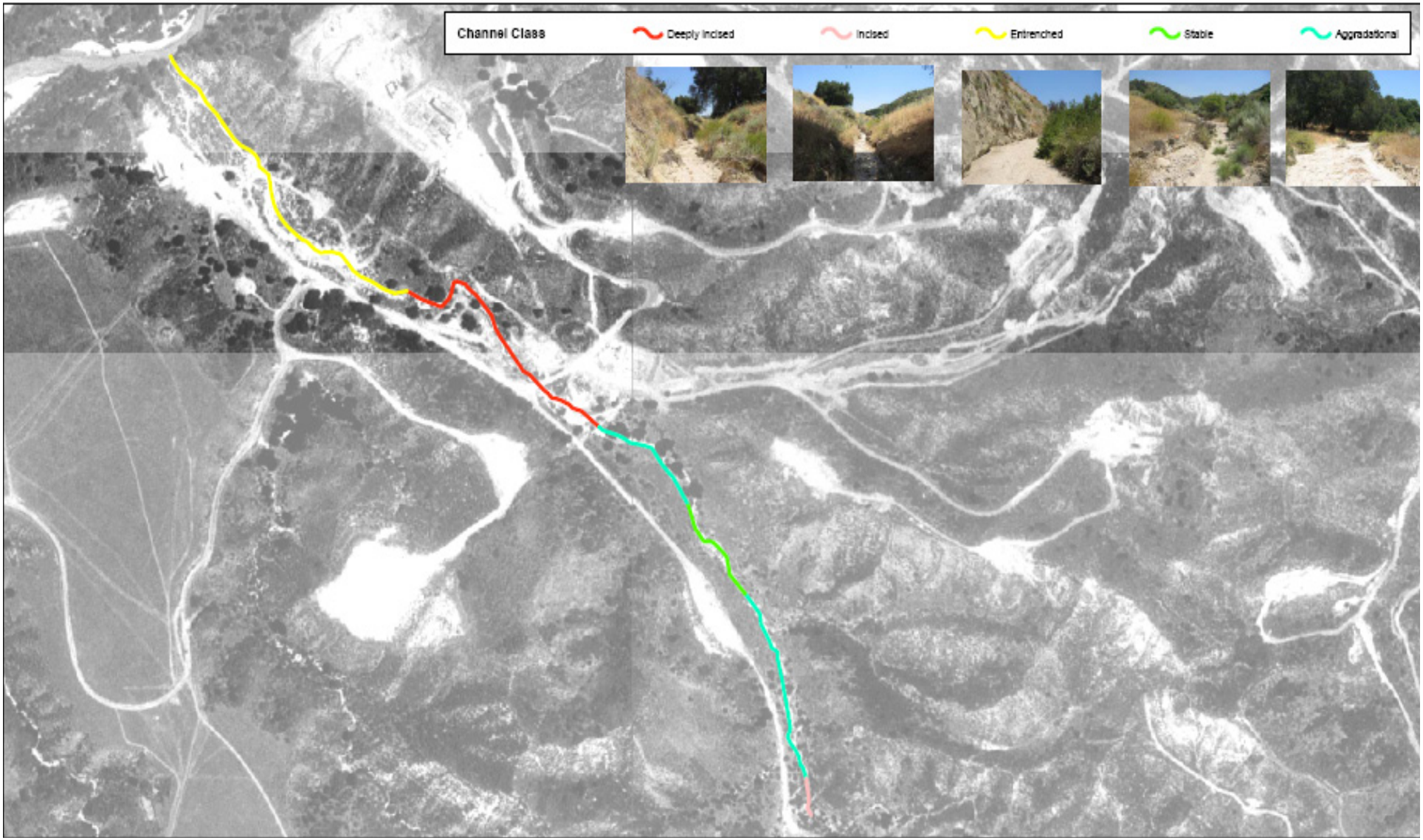
Lion Canyon

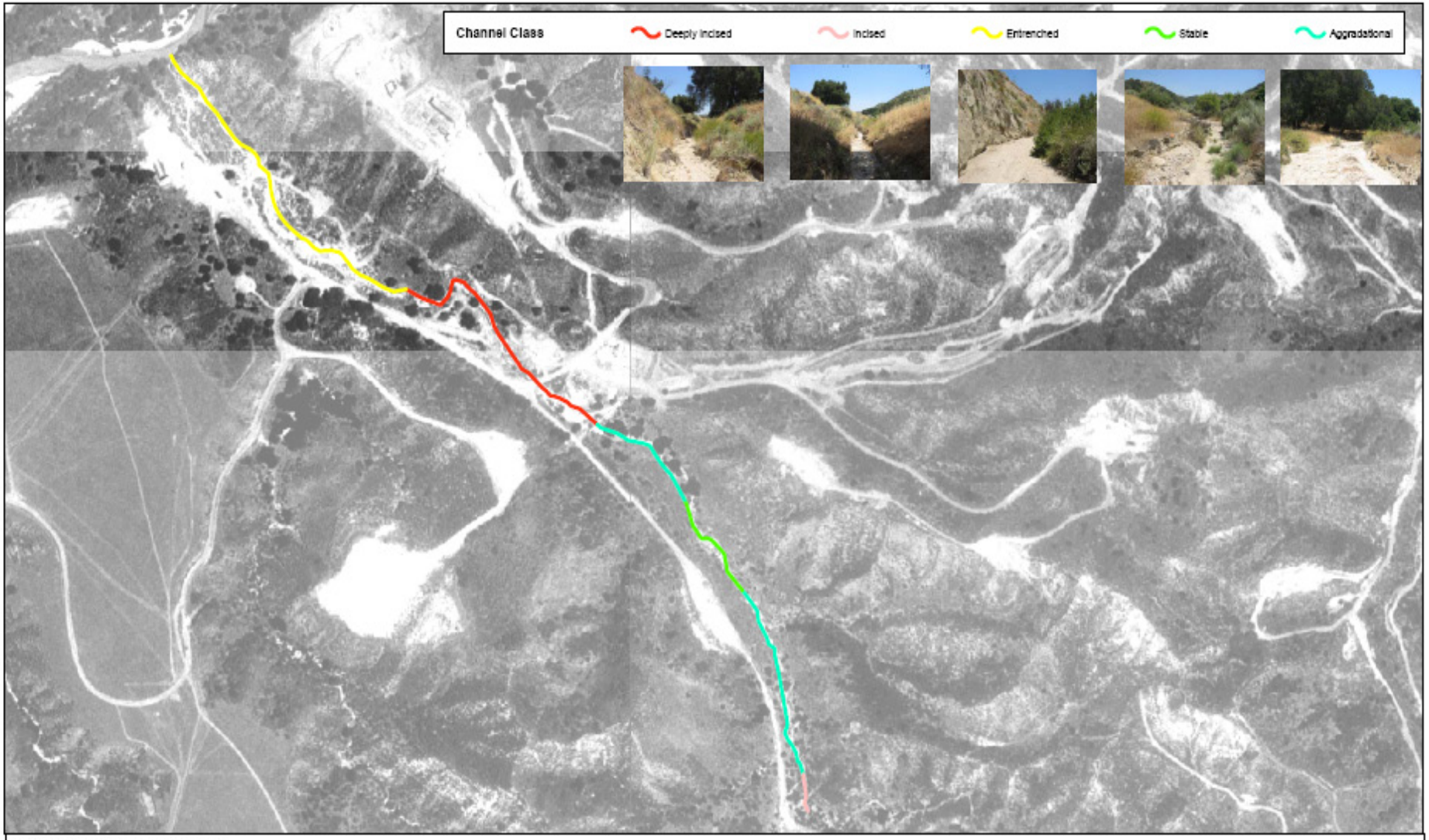
Geomorphic Reconnaissance

Lion Canyon

Geomorphic Reconnaissance

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303





Source: USGS (images), PWA (Geomorph)

N

0 500 1,000 2,000 Feet

figure 1

Newhall Ranch

Geomorphic Stream Assessment Map - Lion Canyon

ref. 1820

PWA

\\fs1\GIS\NewhallRanch\Geomorph4aust_307\Geomorph4aust\1820_Geomorph_Lion_307.mxd

Slightly eroded

Lion #1

Aggraded

Lion #2

Slightly eroding outside bends, aggrading channel

Lion #4

Aggrading

Lion #5

Aggrading

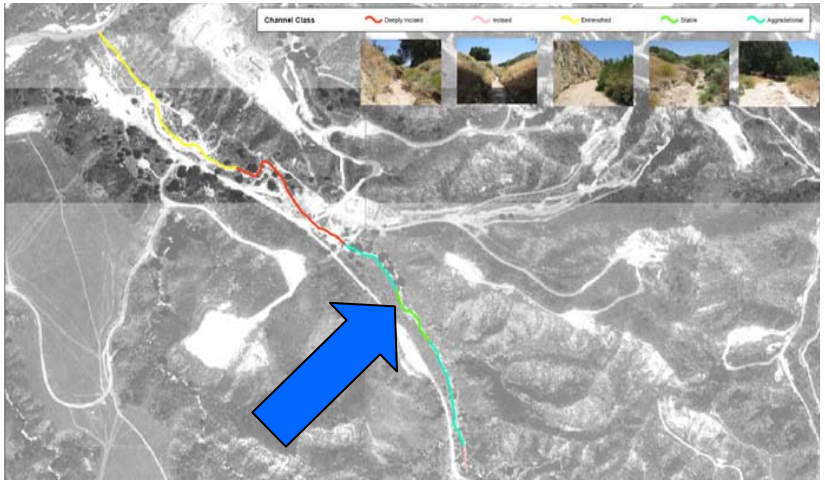
Lion #6

Stable – slightly aggrading

Lion #7

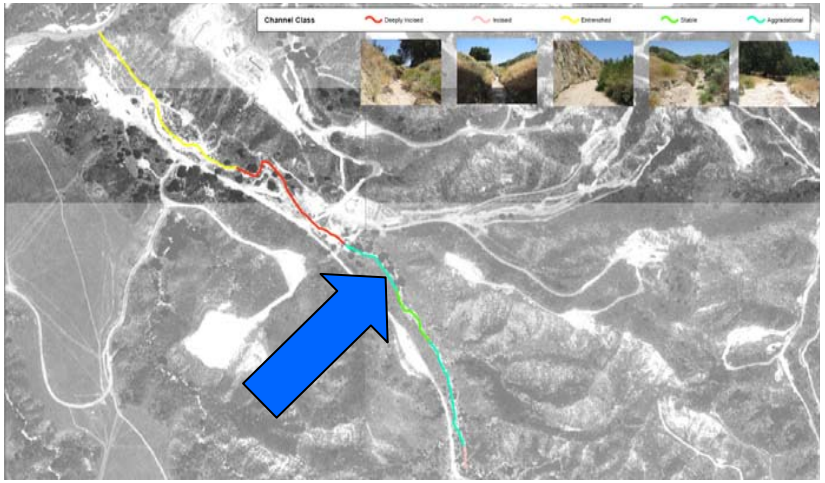
Stable

Lion #8



Stable – slightly aggrading

Lion #9

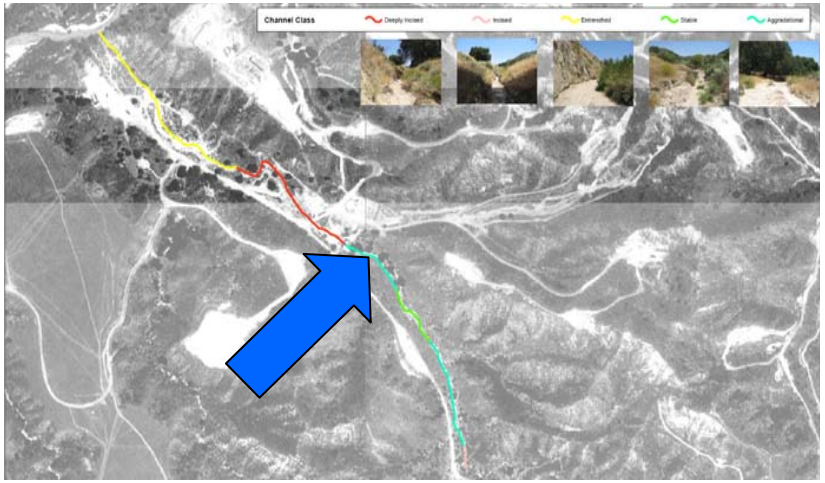


Aggrading

Lion #10

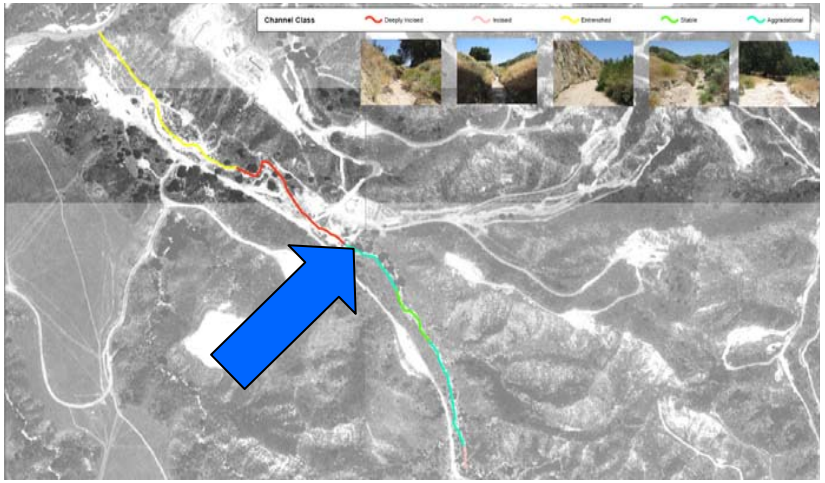
Heavily aggrading

Lion #11



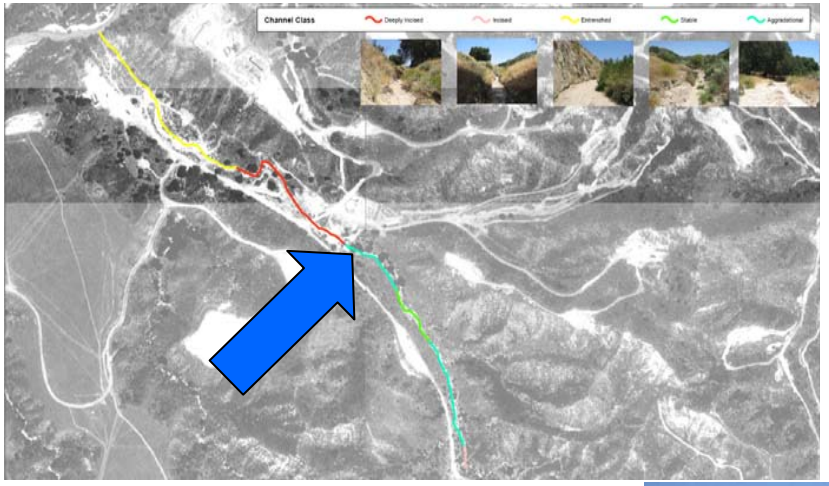
Aggrading

Lion #12



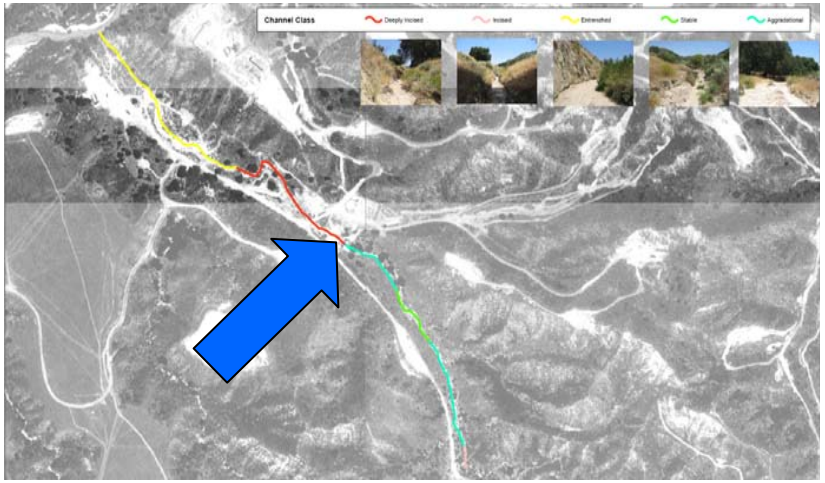
Heavily aggrading

Lion #13



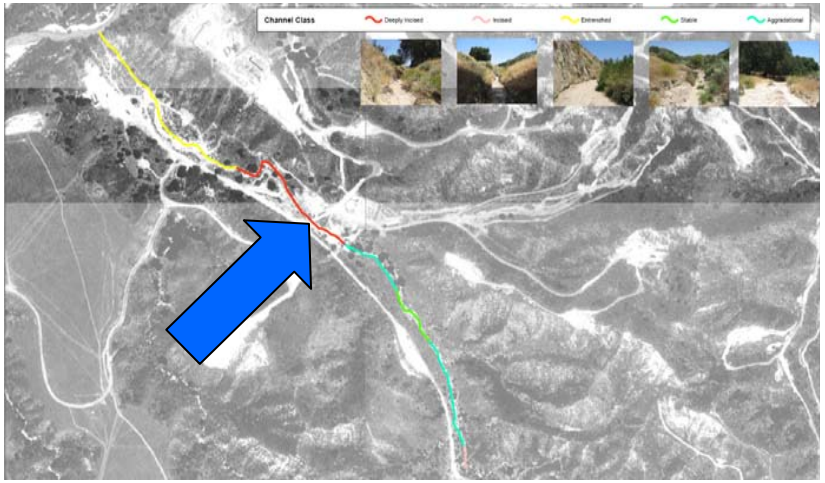
Slightly aggrading

Lion #14



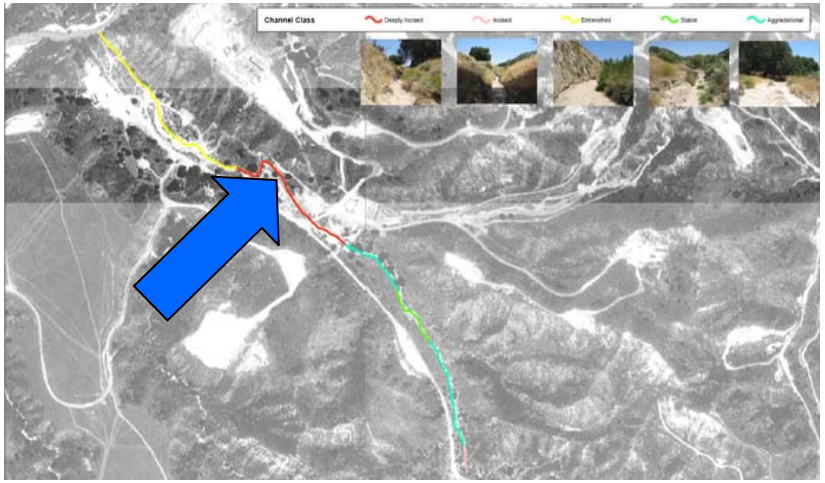
Deeply incised

Lion #15



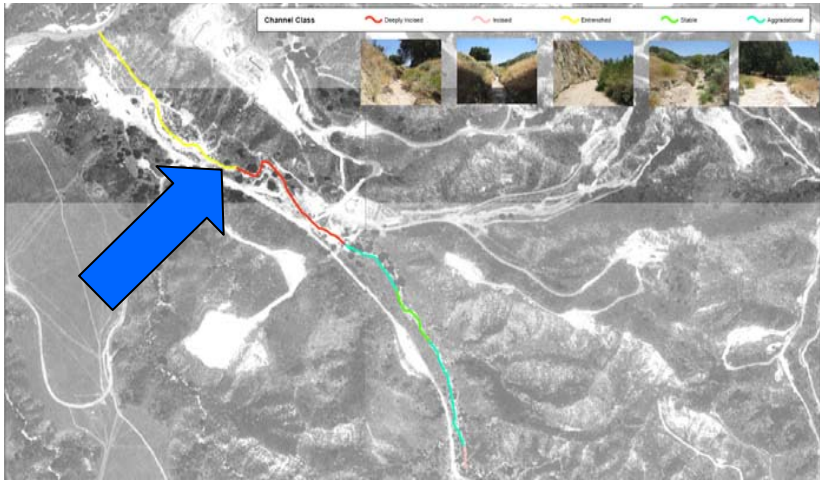
Deeply incised

Lion #16



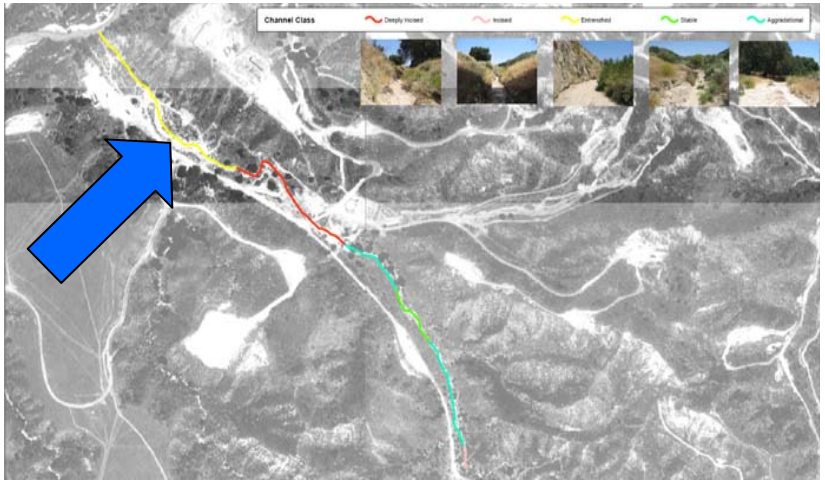
Deeply incised

Lion #17



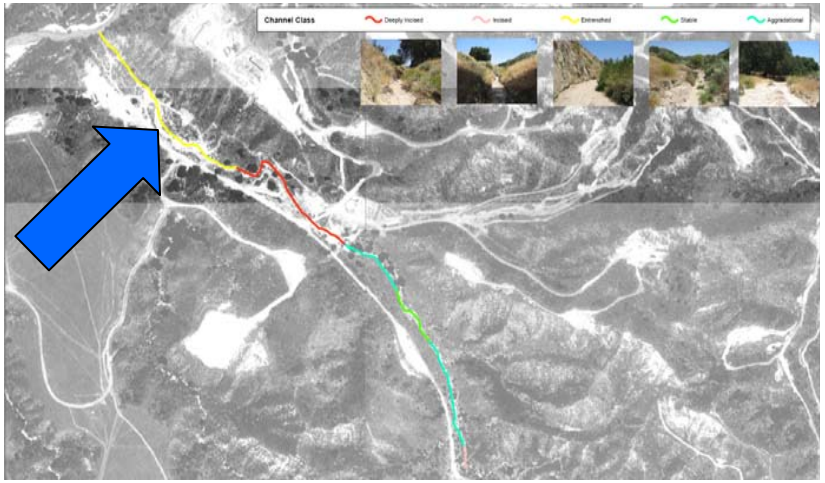
Historically incised but experiencing recent aggradation – relict terraces eroding on outside bends

Lion #18



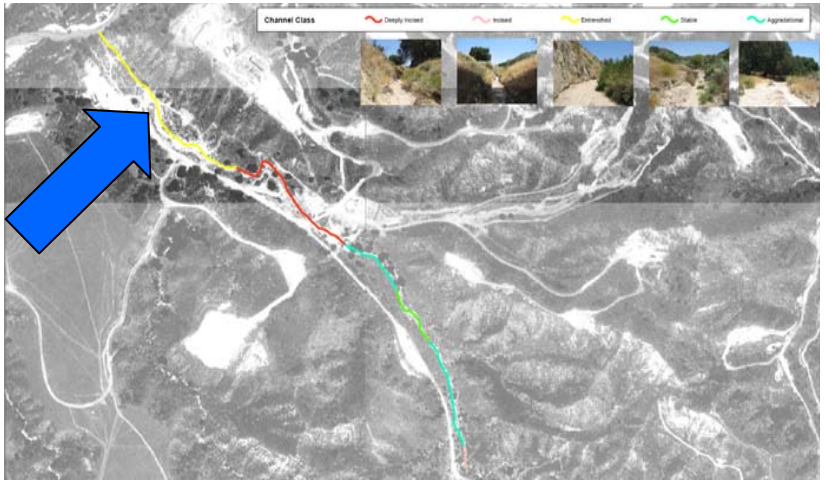
Historically incised but experiencing recent aggradation – relict terraces eroding on outside bends

Lion #19



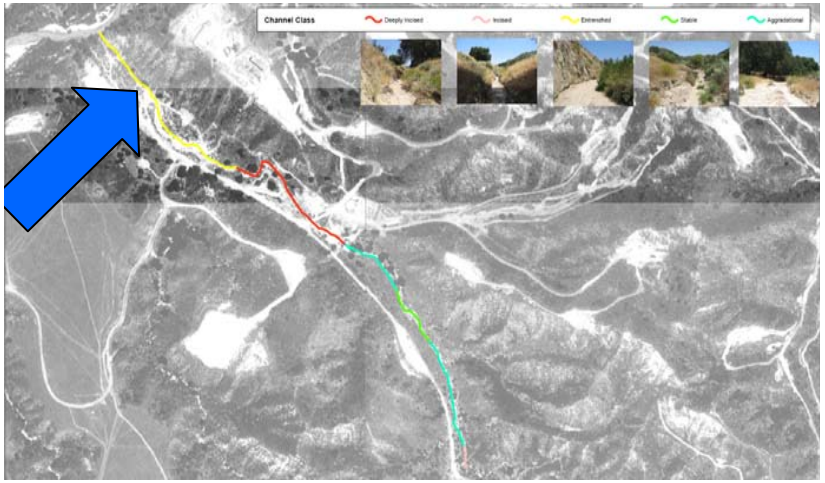
Historically incised but experiencing recent aggradation – relict terraces eroding on outside bends

Lion #20



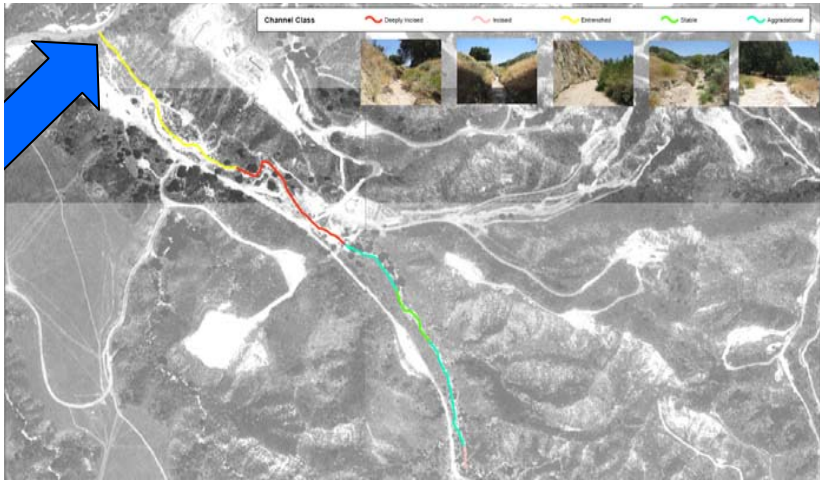
Historically incised but experiencing recent aggradation – relict terraces eroding on outside bends

Lion #21



Historically incised but experiencing recent aggradation – relict terraces eroding on outside bends and large undercut valley side

Lion #22



Historically deeply incised with undercut valley side – knickpoint is incising recently deposited sediments

Lion #23

ATTACHMENT C

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

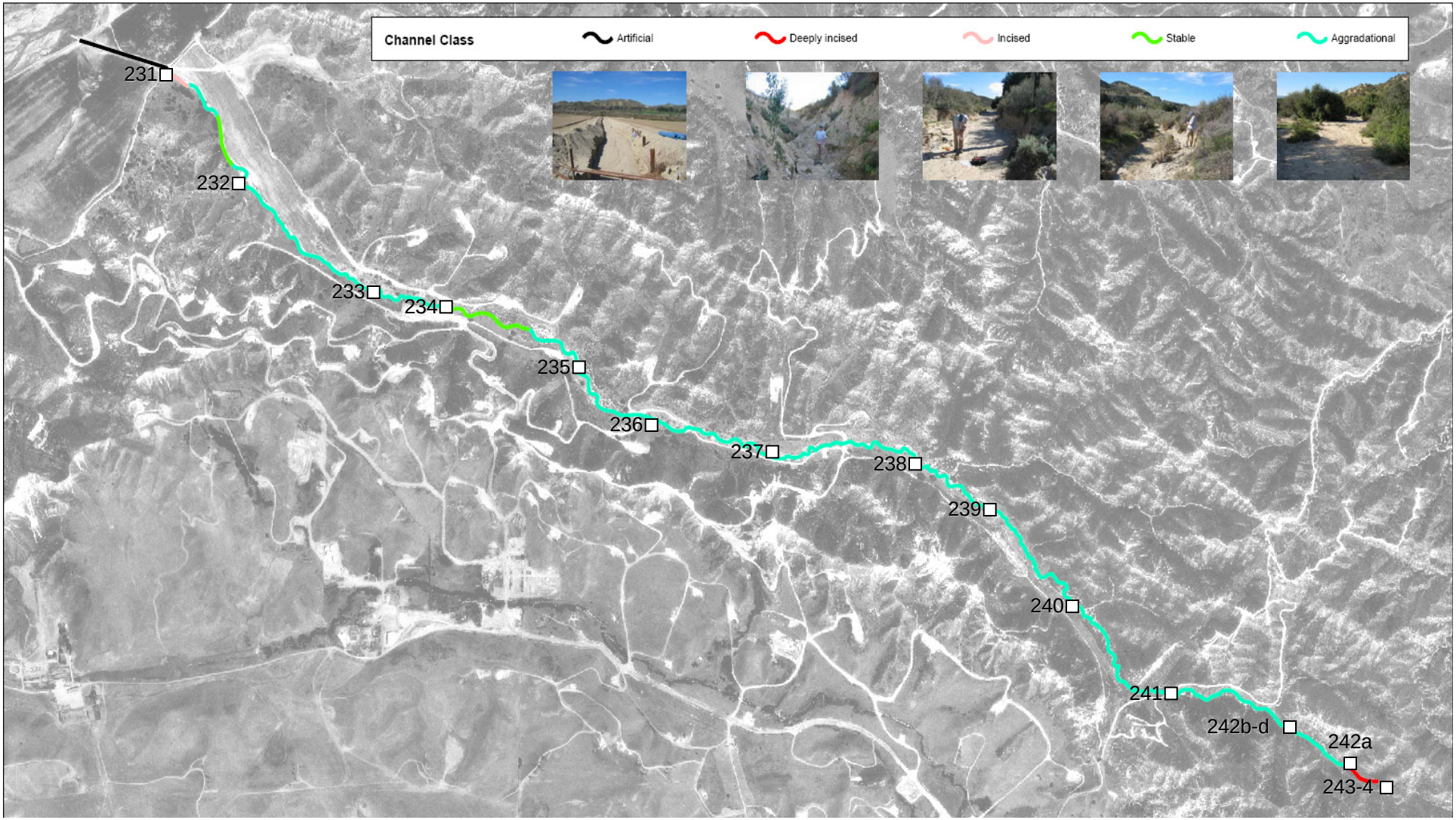
Long Canyon

Geomorphic Reconnaissance

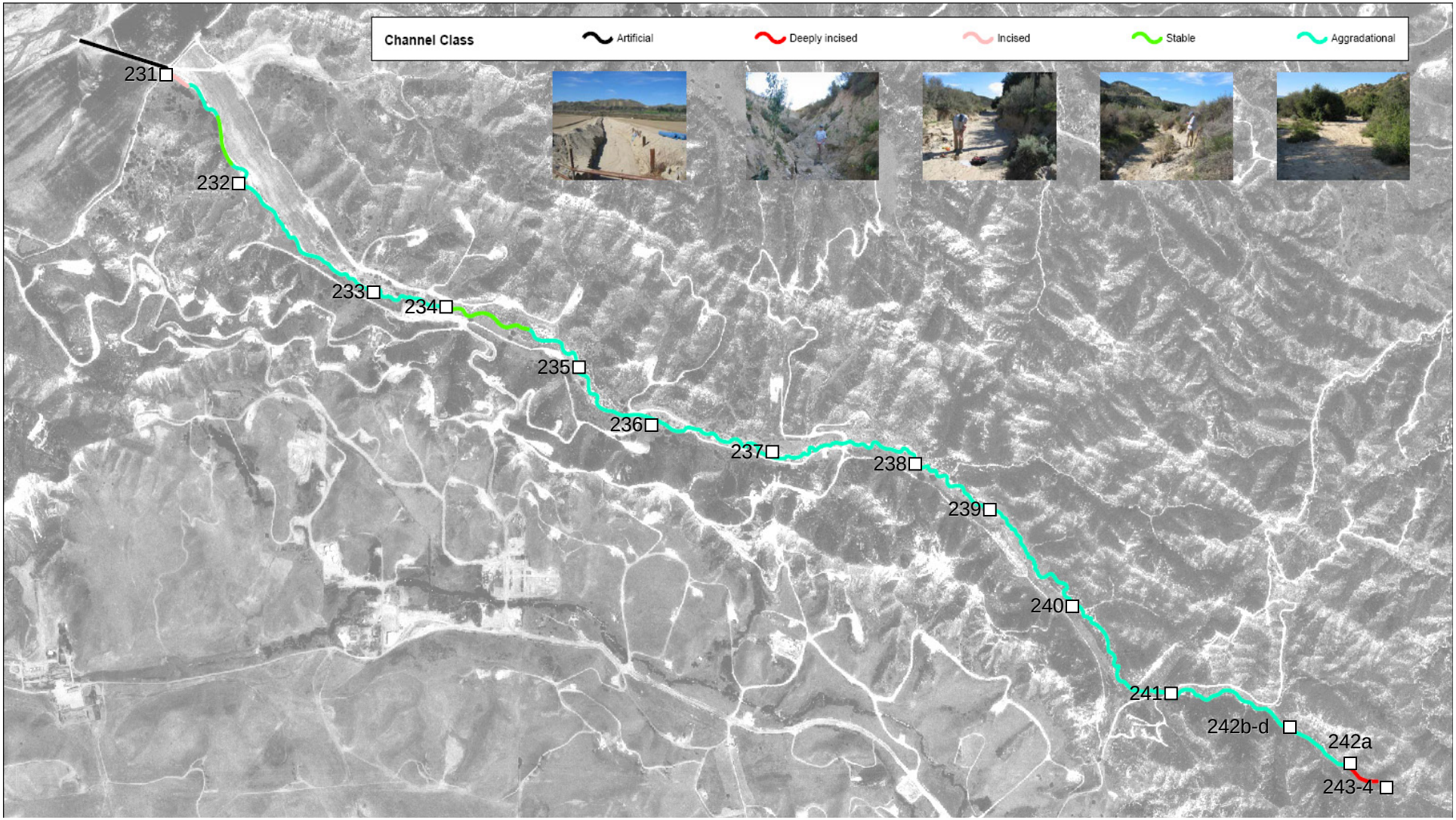
Long Canyon

Geomorphic Reconnaissance

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com



Reach Classification and Photo Points



Headwaters of canyon showing highly eroded slopes

Long #243a

Deeply incised headwaters reach
Long #242a

Sediment sample
LONG #244
BED (Bulk Sample)
Long #244

Aggraded reach (upstream) with channel sediment being eroded by migrating headcut from downstream reach
Long #us_242d

Aggraded reach
Long #242d

Aggraded reach in historically entrenched section
Long #242c

Sediment sample
LONG #242
BAR
Long #242b

Narrow, slightly entrenched reach showing recent aggradation
Long #241c

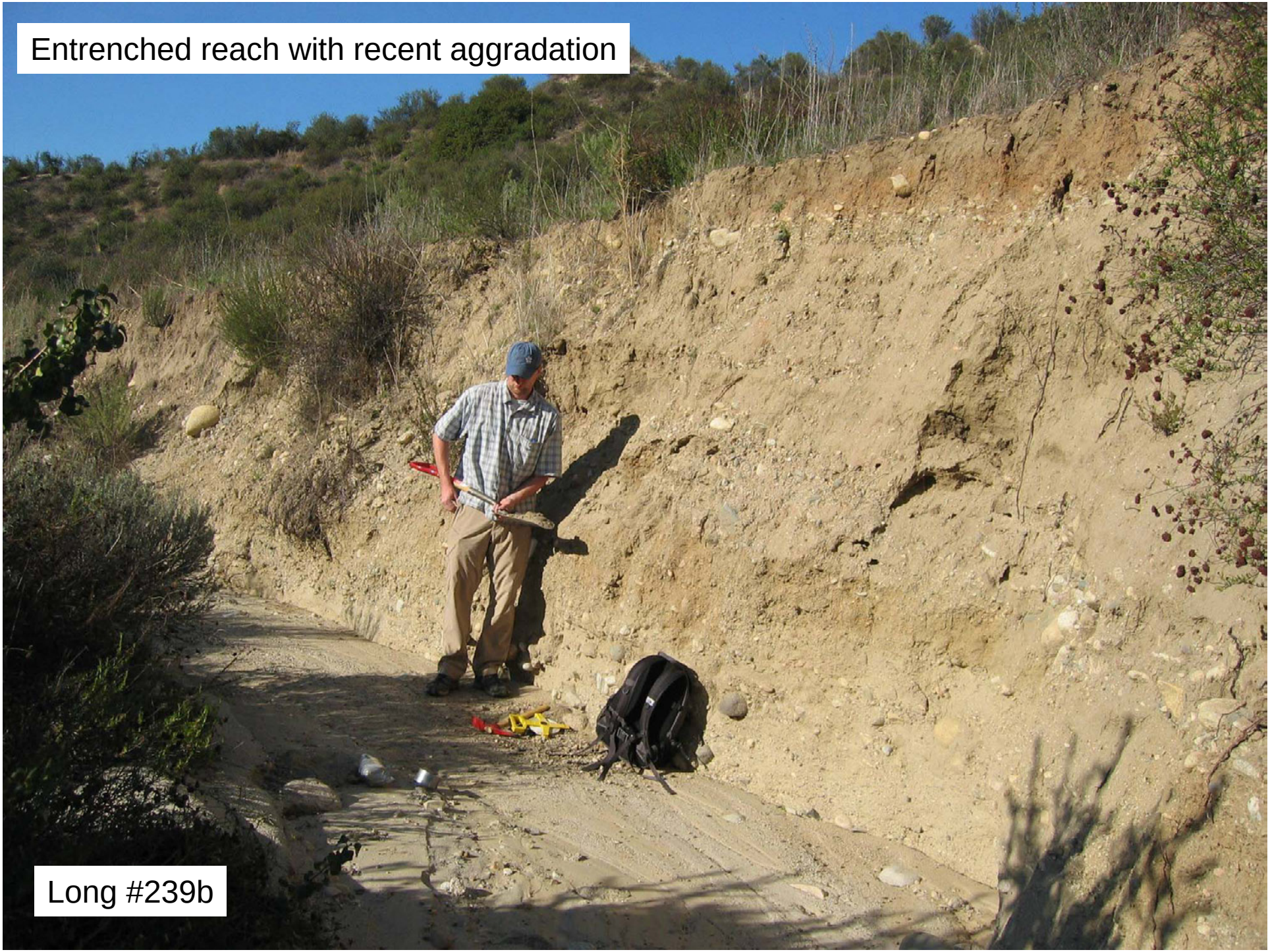
Narrow, slightly incised reach showing recent aggradation
Long #241b

Sediment sample
LONG #241
BAR
Long #241

Highly aggradational reach
Long #240b

Highly aggradational reach
Long #240a

Sediment sample
LONG #240
BAR
Long #240


Entrenched reach with recent aggradation
Long #239b

Entrenched reach with recent channel aggradation
Long #239a

Sediment sample
LONG #239
BAR
Long #239

Aggradational reach with low floodplain
Long #238c

Aggradational reach with low floodplain
Long #238b

Aggradational reach with low floodplain
Long #238a

Sediment sample
LONG #238
BAR
Long #238

Aggradational-widening reach with low floodplain on inside bend, eroding terrace on outside
Long #237b

Aggradational-widening reach with low floodplain on inside bend, eroding terrace on outside
Long #237a

Sediment sample
LONG
SITE 237
BAR
Long #237

Aggrading reach with low floodplain
Long #236b

Aggrading reach with low floodplain
Long #236a

Sediment sample
LONG #236
BAR
(above 9(S)
Long #236

Aggrading reach with low floodplain on inside bends, eroded terrace on outside
Long #235b

Aggrading reach with low floodplain on inside bends, eroded terrace on outside
Long #235a

Entrenched reach with recent channel aggradation,
low floodplain on inside bends, eroded terrace on outside
Long #234b

Entrenched reach with some channel aggradation,
low floodplain on inside bends, eroded terrace on outside
Long #234a

Aggrading reach with low floodplain on inside bends, eroded terrace on outside
Long #233a

Sediment sample
LONG #233
BAR
Long #233

Aggrading reach with low floodplain on inside bends, laterally eroded terrace on outside
Long #233b

Aggrading reach with low floodplain on inside bends, laterally eroded terrace on outside
Long #232a

Aggrading reach with low floodplain on inside bends, laterally eroded terrace on outside
Long #231d

Slightly entrenched reach with medium height floodplain terraces
Long #231

Slightly confined reach with medium height floodplain terraces
Long #231b

Constructed channel
Long #231c

ATTACHMENT D

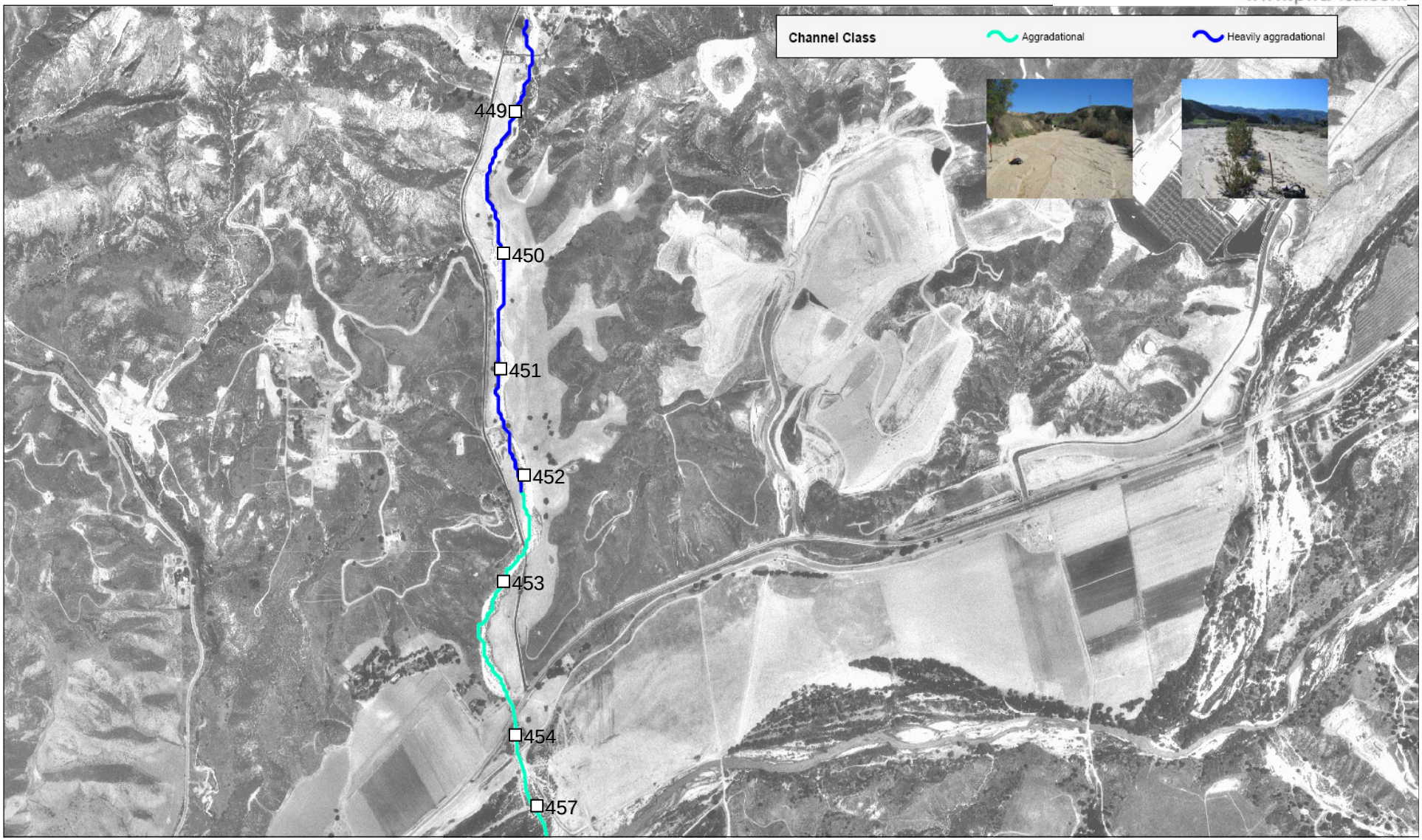
PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

Chiquito Canyon

Geomorphic Reconnaissance

Chiquito Canyon
Geomorphic Reconnaissance

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com



Reach Classifications and Photo Points

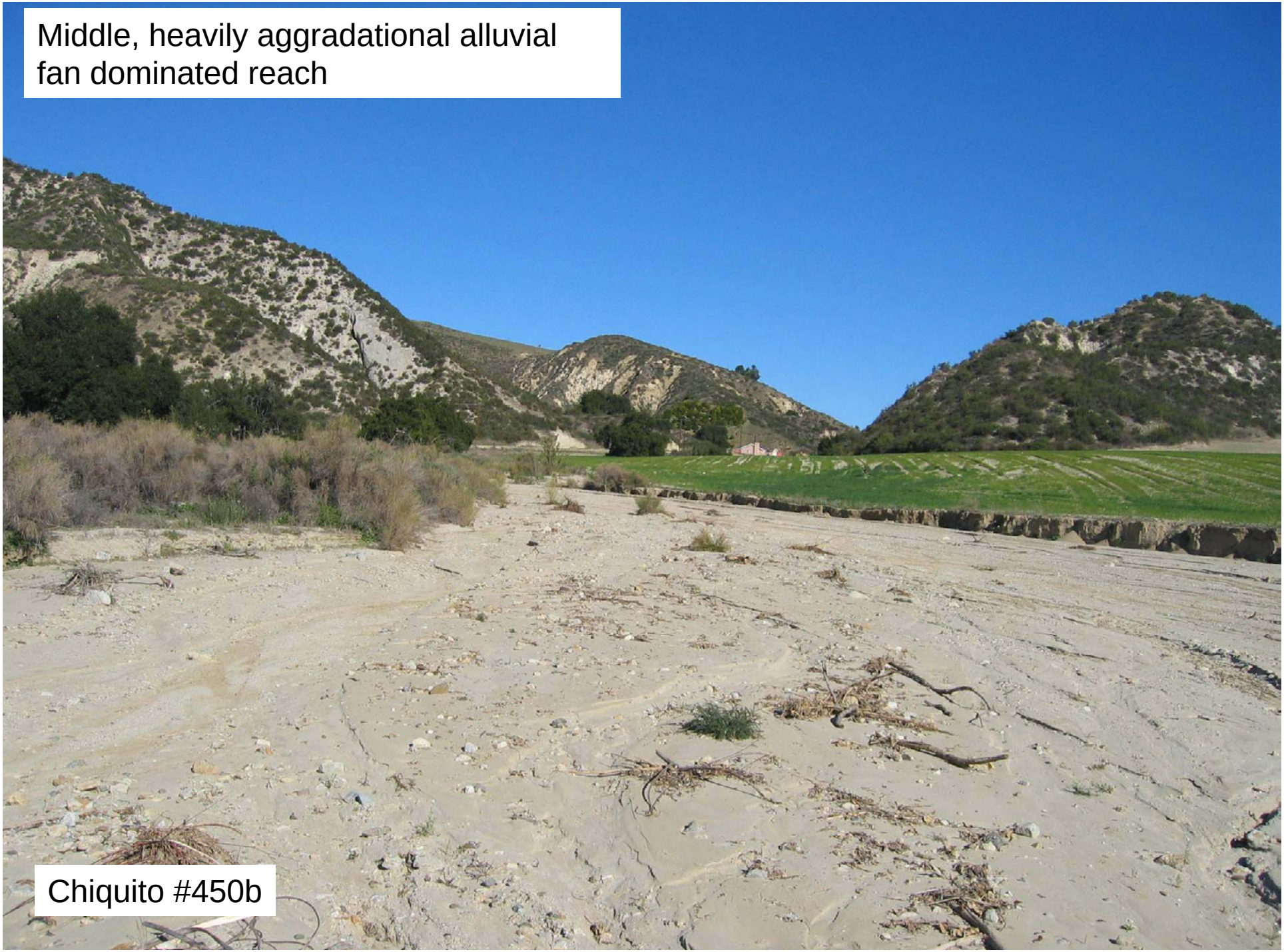
Chiquito #449

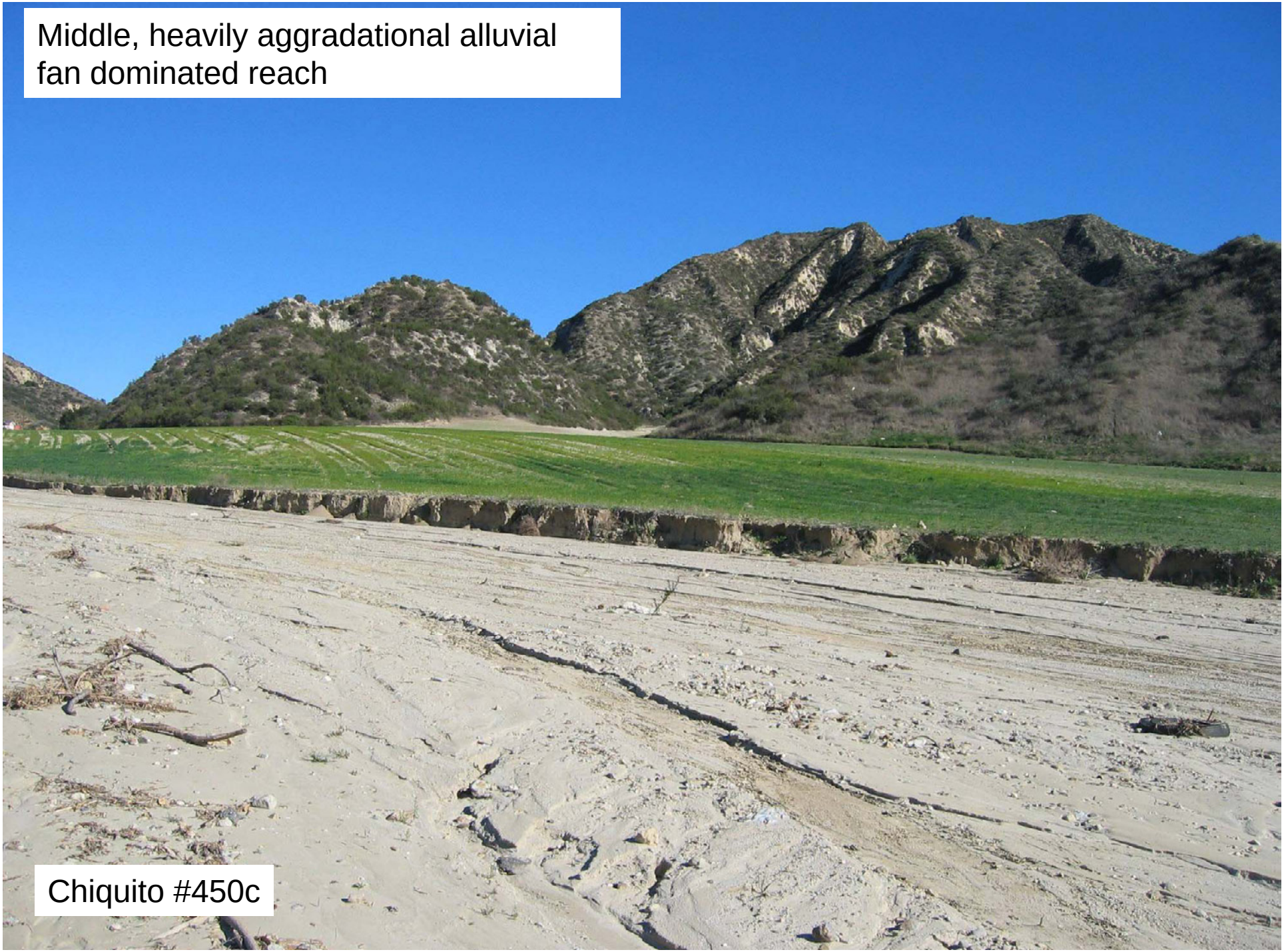
Bed sample

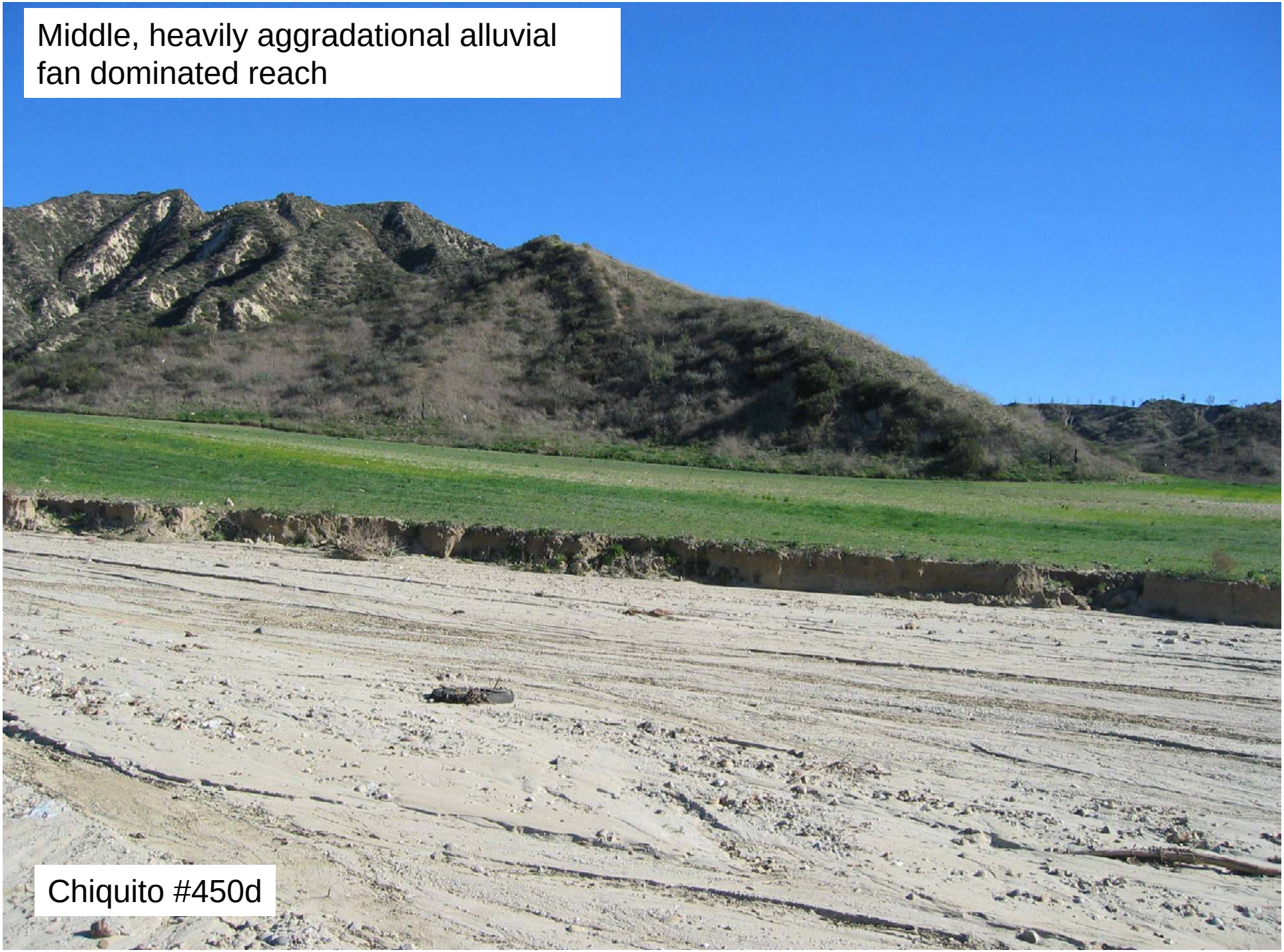
Slightly confined upper reach
Chiquito #449b

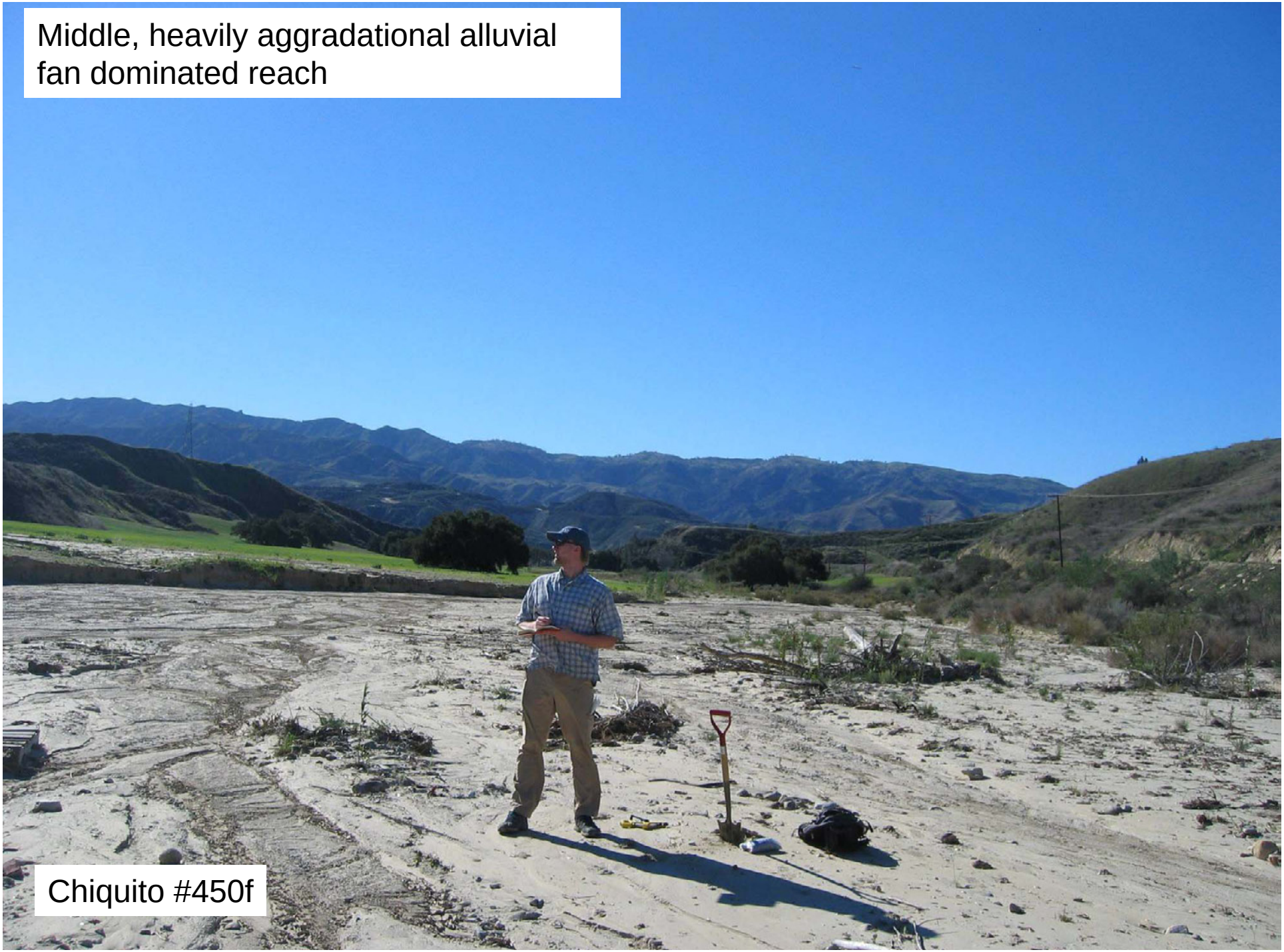
Chiquito #450

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450a


Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450b


Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450c


Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450d


Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450f

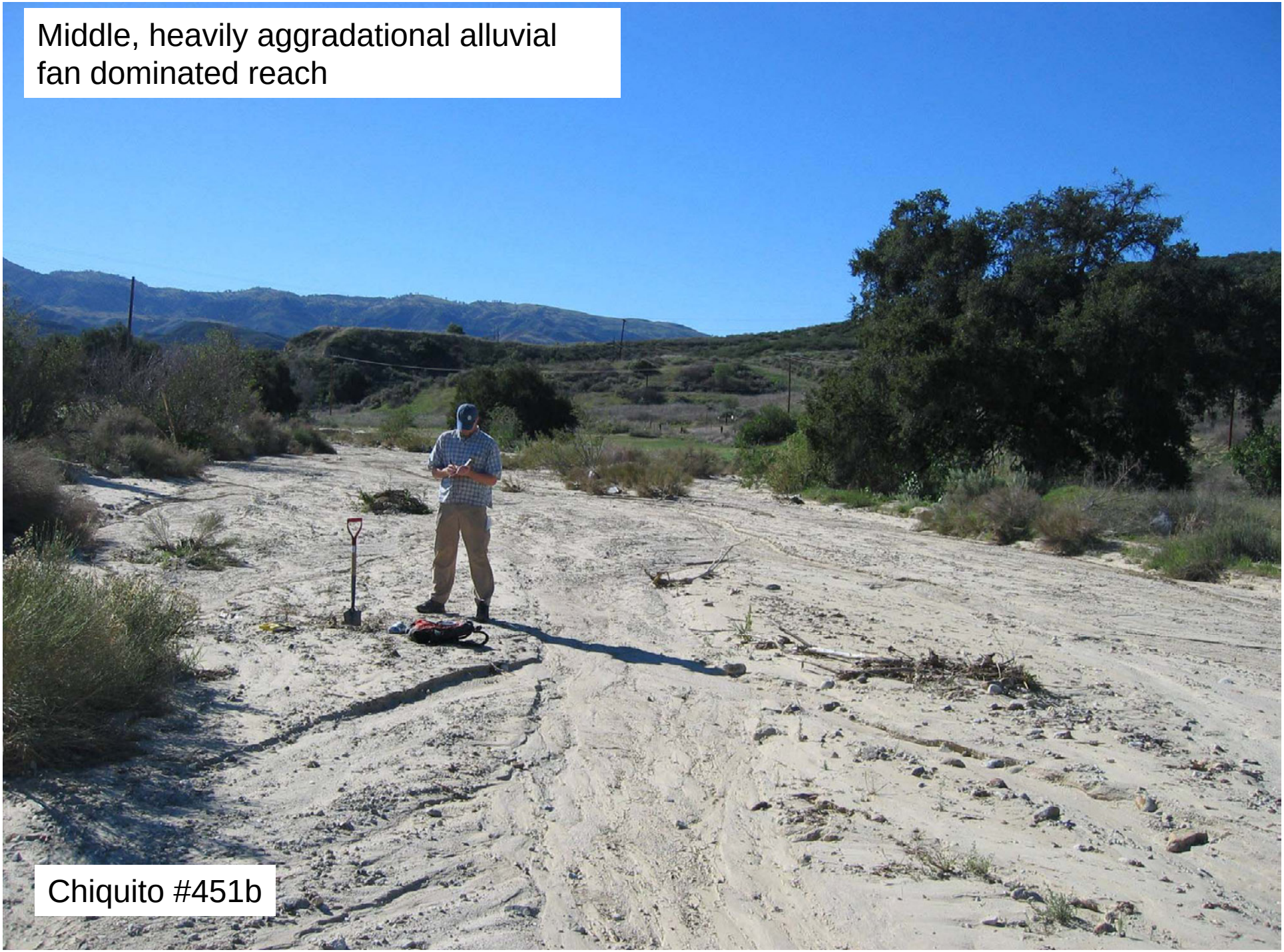
Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450g

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450h

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450i

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #450j

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #451a


Middle, heavily aggradational alluvial fan dominated reach
Chiquito #451b

Chiquito #452

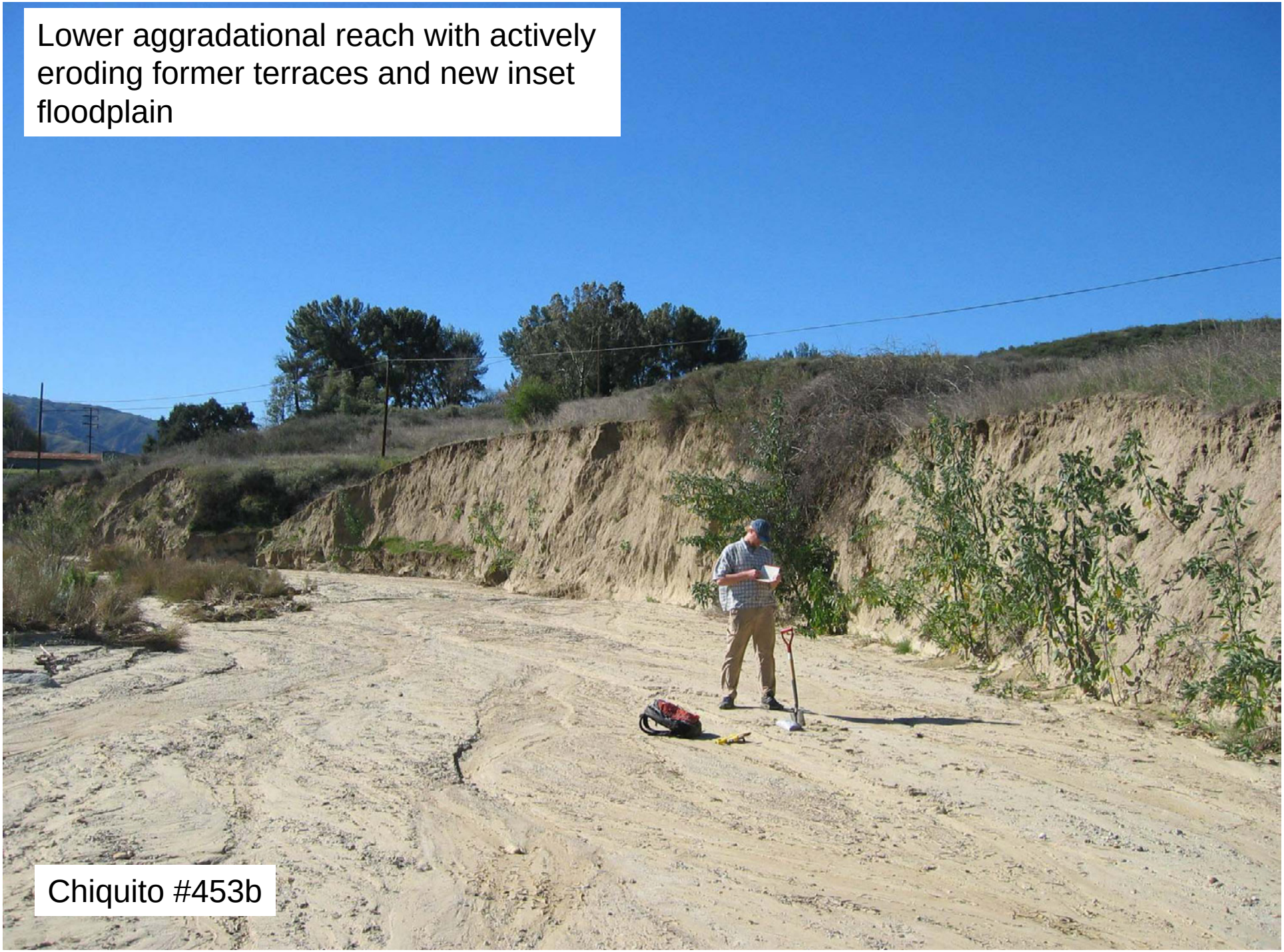
Middle, heavily aggradational alluvial fan dominated reach
Chiquito #452a

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #452b

Middle, heavily aggradational alluvial fan dominated reach
Chiquito #452c

Chiquito #453

Lower aggradational reach with actively eroding former terraces and new inset floodplain
Chiquito #453a


Lower aggradational reach with actively eroding former terraces and new inset floodplain
Chiquito #453b

Chiquito #454

Lower aggradational reach with actively eroding former terraces and new inset floodplain
Chiquito #454a

Lower constructed reach
Chiquito #454b

Lower aggradational reach
Chiquito #453-4b

Lower constructed reach
Chiquito #453-4a

Chiquito #456

Lower aggradational
constructed reach
Chiquito #456a

Lower alluvial fan
Chiquito #457
© 2008 Europa Technologies
© 2008 Tele Atlas
Google
Pointer lat 34.416468° lon -118.656382° elev 900 ft Streaming 100%
Eye alt 2003 ft

ATTACHMENT E

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

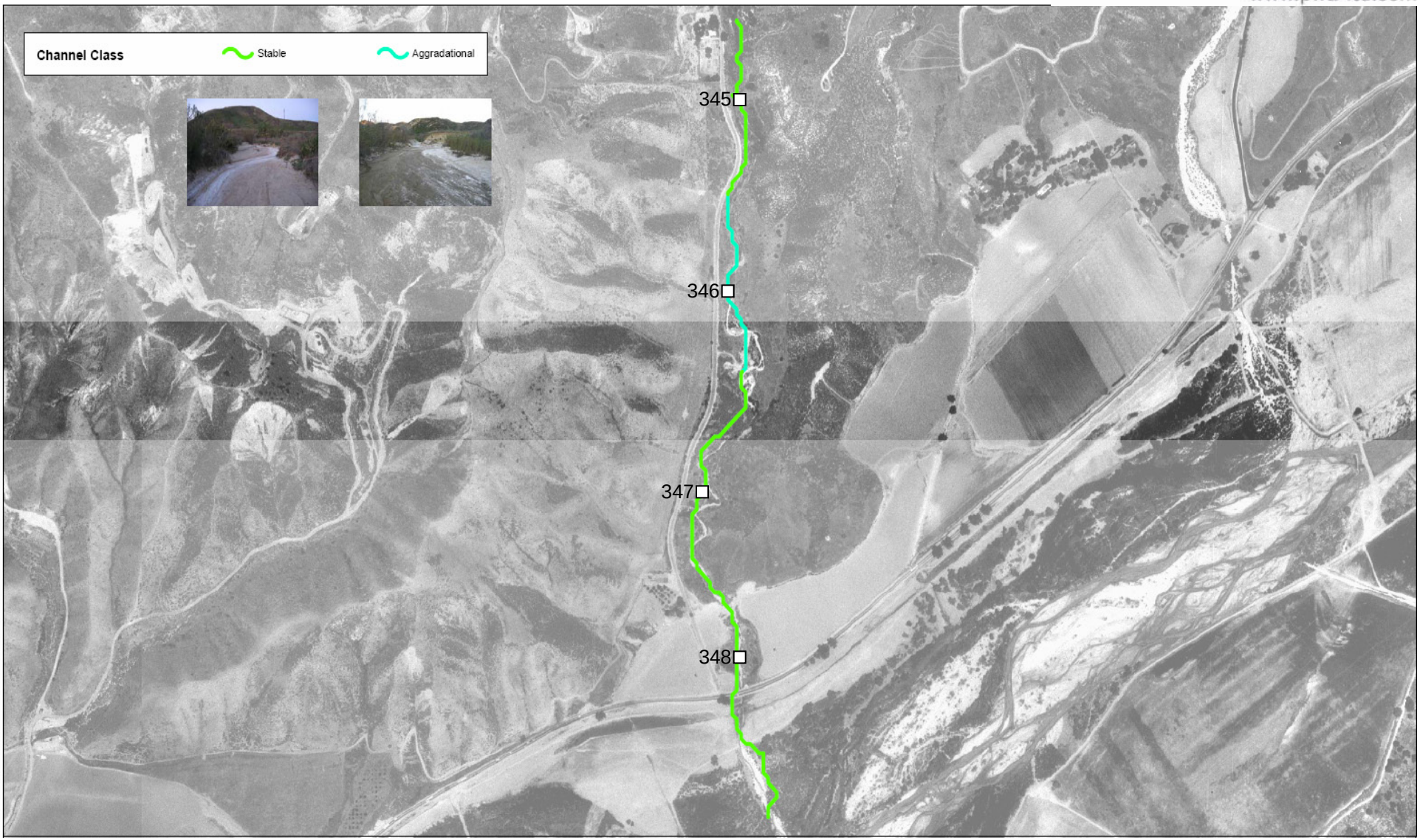
Grande Canyon

Geomorphic Reconnaissance

Grande Canyon

Geomorphic Reconnaissance

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com



Reach Classification and Photo Points

Bed sample

Grande #345

Stable – aggrading channel with inset floodplain

Stable – aggrading channel with inset floodplain – some overwidening

Widening with active bank erosion on abandoned floodplain terraces

Sediment sample

Grande #346

Widening and aggrading with active bank erosion on abandoned floodplain terraces

Widening and aggrading with active bank erosion on abandoned floodplain terraces

Unstable – eroding outside bend condition

Grande #346-7a

Unstable – eroding outside bend condition

Sediment sample

Grande #347

Moderately stable condition with eroding upper terraces and stable new inset terraces

Moderately stable – slightly aggradational condition with eroding upper terraces and stable new inset terraces

Sediment sample

Grande #348

Moderately stable
– slightly aggradational condition

Moderately stable
– slightly aggradational condition

ATTACHMENT F

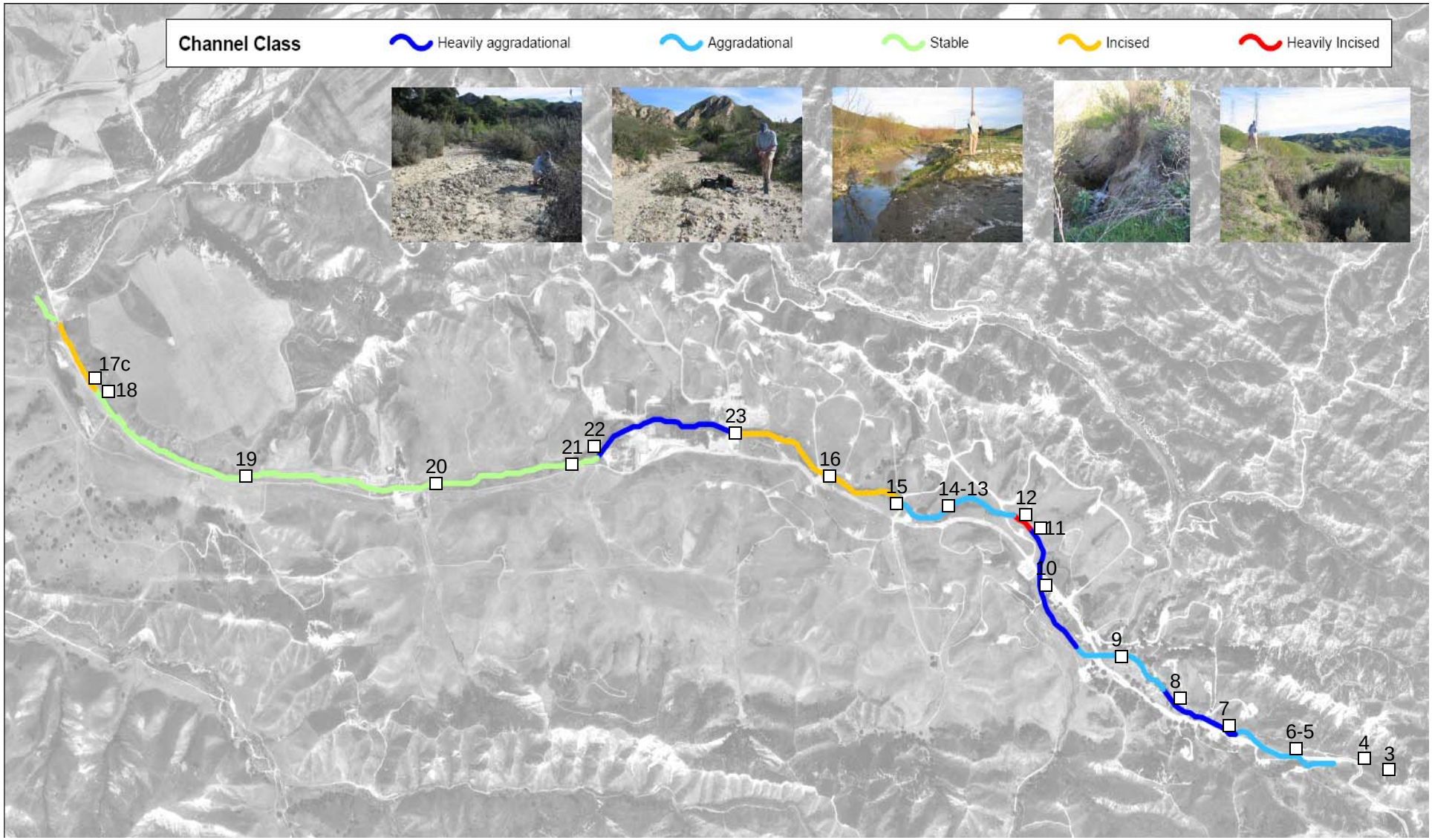
PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

Potrero Canyon

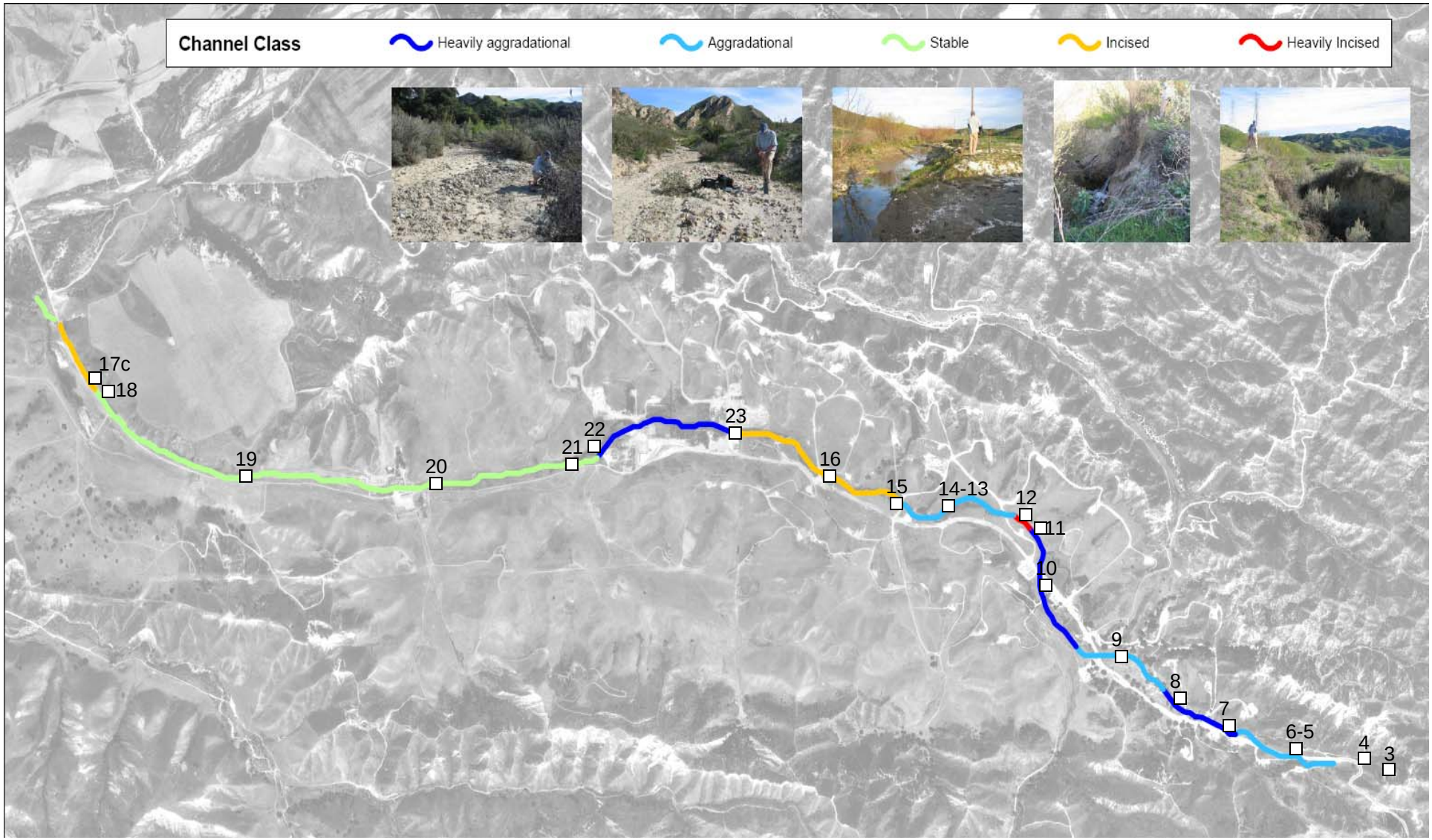
Geomorphic Reconnaissance

Potrero Canyon
Geomorphic Reconnaissance

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com



Reach distribution

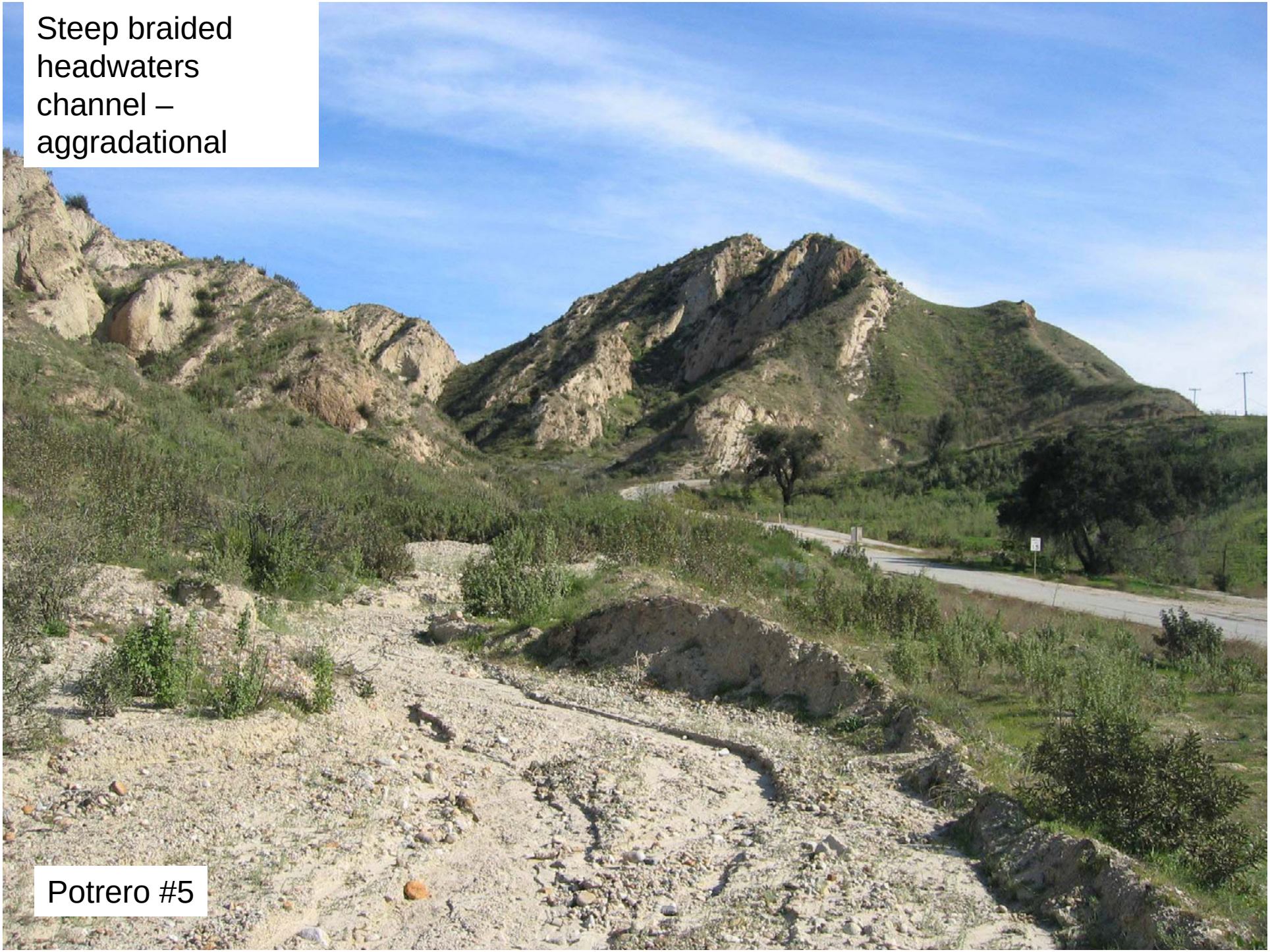


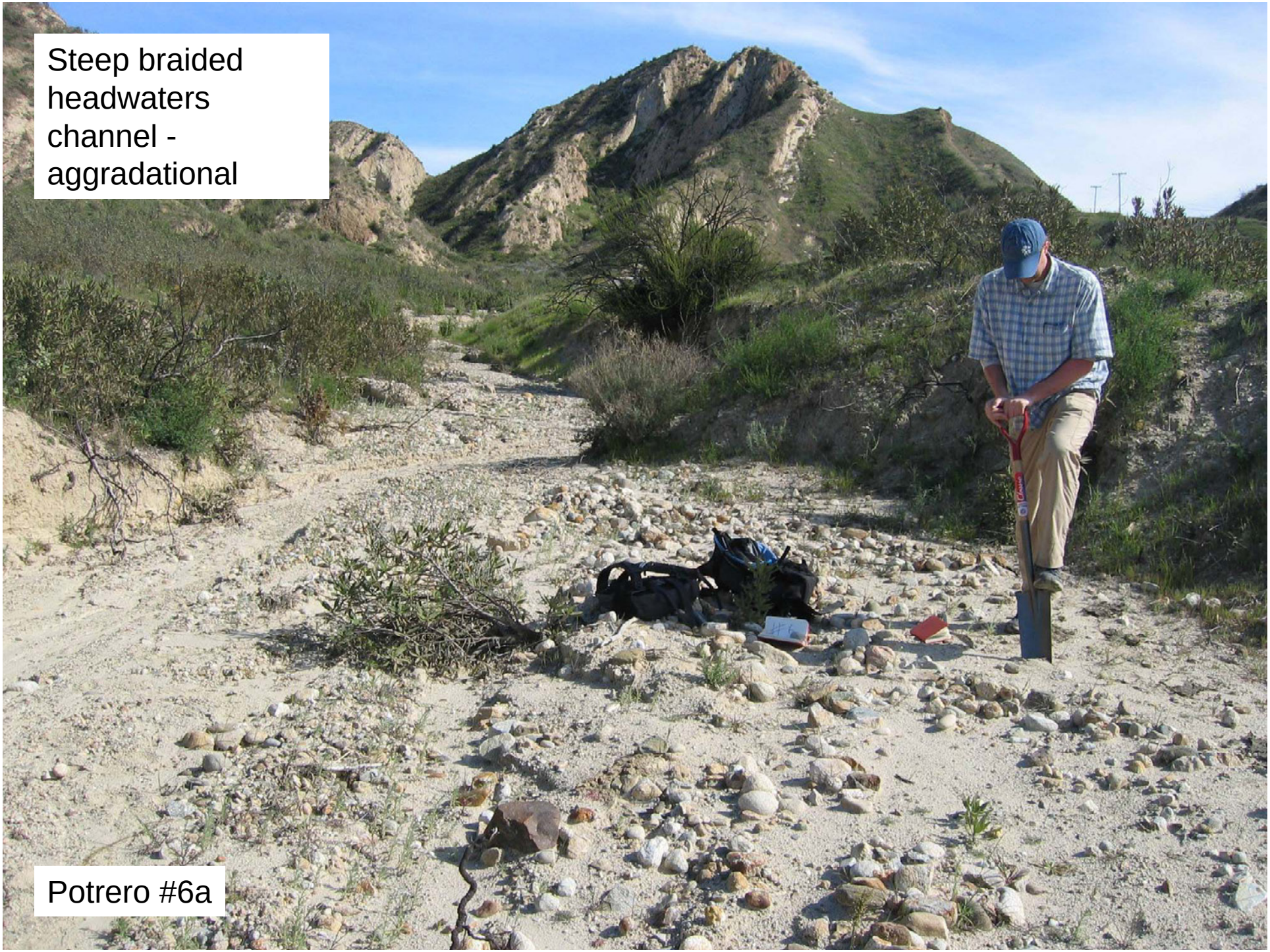
Steep, incised headwaters channel

Potrero #1

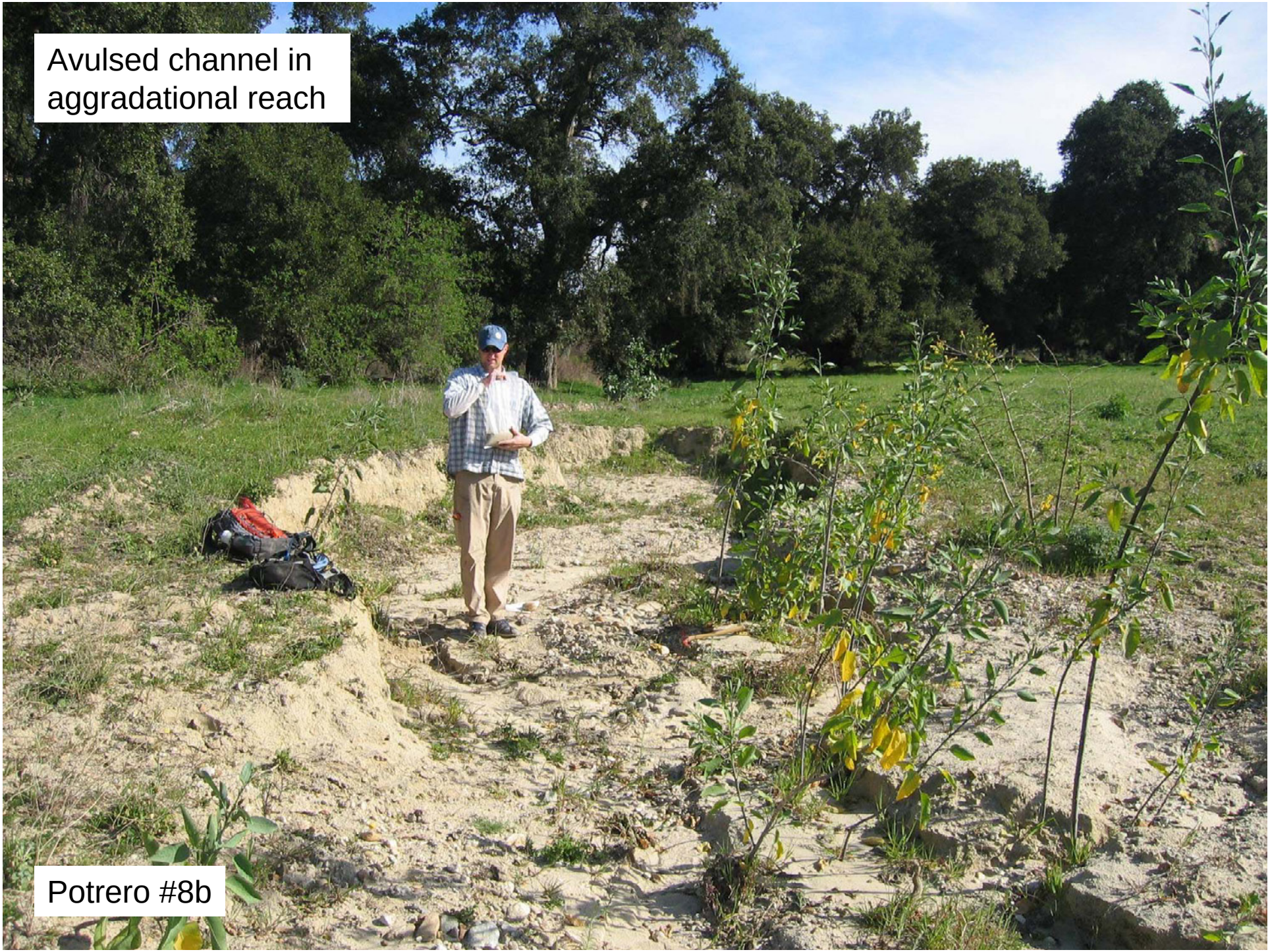
Steep braided headwaters channel - aggradational
Potrero #3

Steep braided headwaters channel - aggradational
Potrero #4a


Steep braided headwaters channel – aggradational
Potrero #5


Steep braided headwaters channel - aggradational
Potrero #6a

Steep braided headwaters channel – strongly aggradational
Potrero #7


Avulsed channel in aggradational reach
Potrero #8b

Strongly aggradational channel
Potrero #9

Strongly aggradational channel
Potrero #10

Deeply incised channel
Potrero #11

Aggradation in formerly incised channel
Potrero #12-14

Incision into aggraded sediments
Potrero #23

Heavily aggradational channel
Potrero #22

Mesic meadow
stable swale
Potrero #20

Mesic meadow
stable channel
Potrero #19

Mesic meadow currently stable swale (unstable migrating knickpoint in foreground)
Potrero #18c

Steep, unstable reach
with knickpoints

Potrero #17c

Pacific Advanced Civil Engineering, Inc., "Newhall Ranch River Fluvial Study Phase 1, Final Draft" (March 2006; 2006a)

Newhall Ranch

River Fluvial Study

PHASE 1 | FINAL DRAFT

SANTA CLARA RIVER

Prepared for:

NEWHALL LAND
A LENNAR/LNR COMPANY

Prepared by:

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

March 9, 2006 Revised
December 9, 2005 Revised
September 19, 2005 Revised
July14, 2005
#8197E

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

17520 Newhope Street, Suite 200 ▪ Fountain Valley, California 92708 ▪ 714.481.7300 ▪ fax: 714.481.7299

March 6, 2006

Ben Willardson
LACDPW
Water Resources Division
900 South Fremont, 3rd Floor
Alhambra, CA 91803
(626) 458-6117

Re: Santa Clara River Fluvial Study, January 2006 #8197E

Dear Mr. Willardson;

Pacific Advanced Civil Engineering, Inc. (PACE) is pleased to provide the following responses to the Los Angeles County Department of Public Works for the above-referenced project. The responses from PACE are as follows:

General Comments

1. *The HEC-RAS models approved by the separate hydraulic model review should be the only models used in this study. The only exception will be the data used for SAM, which is converted from the approved HEC-RAS data. The SAM data however must also be based on the approved HEC-RAS models. The calculations should be carried consistently through all tables, charts, text, and figures. All referenced models should be included in the report and on the CD in Appendix 4.3. The models must include the Existing and Proposed Conditions for the n=0.025 and n=0.085 models using the Capital Flood in the mixed flow regime. The two-year Proposed Condition, n=0.085 should also be included in the report and CD to verify the bottom width column of Appendix Ch 6.2.*

   PACE Response:
   Calculations in the present draft of the report are based on the approved HEC-RAS model. SAM numerical modeling is converted from the approved model. All models utilized in this report are included in the CD-ROM in the Appendix.

2. *All relevant general comments from the Castaic Creek review that affect the body of text need to be included in the Santa Clara River report.*

   PACE Response:
   Comments from the previously reviewed Castaic Creek First Phase Fluvial Study were reviewed and comments that pertained to the present report were included here.

Technical Comments

1. *PACE response to Comment 3 from the previous review, no changes were observed in the text on page 2. The comment still applies. All of the other previous comments have been adequately addressed.*

   PACE Response:
   The text has been updated to include the previous response.

2. *Page ii, the third sentence of the second paragraph states that the 2004 Sikand study relied on previous work conducted by SLA. PACE response to previous Comment 4 states that the "HEC-6 Sediment Transport Analysis..." was conducted by Sikand not SLA. Then in Section 2.1 the last sentence of the first paragraph states that the [2004] Sikand study relied on previous work conducted by Sikand. Rectify the apparent discrepancy.*

   PACE Response:
   The text has been updated to adequately differentiate the Sikand and SLA studies.

3. *Page ii, the ninth line of the third paragraph states that the average D50 value for all the SCR samples was 1.12 mm. This is not correct, the average of the D50 values is 1.18 for the 18 SCR samples or 1.09 mm for all 23 samples. According to Figure 3.2B the D50 of the average gradation is more like 0.79 mm by observation. Please note that an average of the individual D50 values will not give a valid D50 for the average gradation. The average of individual D50's and the D50 of the average gradation do not represent the same value. Calculating the D50 of the average gradation requires a geometric mean since the values are averaged on a logarithmic scale.*

   PACE Response:
   Based on conversations with LACDPW personnel (B. Willardson, February 22, 2006) Geometric mean calculations were determined not to be the appropriate method for determining average D_{50} values. In previous versions of this report, D_{50} was determined by averaging the values provided by Seward Engineering Geology. In this draft of the report, D_{50} is read directly from the semi-log plots presented in Chapter 3. The values in the text and tables have been updated to reflect change in methodology. It is important to note that the change in values was small in every case and did not require changing the transport function selected to determine transport potential.

4. *Page iii, the thirteenth line of the second paragraph states that the County approved the Sikand project. As stated previously, the County did not approve the Sikand project and models. The models have been significantly altered by PACE and are under final review for approval.*

   PACE Response:
   The text has been updated as per instructions given in the Castaic Creek Fluvial Study Phase 1 Final Draft.

5. *Page 4, last sentence of the first paragraph, clarify according to Comment 2 above.*

PACE Response:
The text has been updated to adequately differentiate the Sikand and SLA studies.

6. *Page 7, Table 3.1, update the D50 values according to Comment 3 above. According to the SAM output data the D50 values for the reaches are as follows: A,B 0.523; C 0.976; D 1.042; E 1.072. Also add another column called "Used for SAM Reach" that will show for which reach the sediment data was applied to in the SAM analysis.*

PACE Response:
The D_{50} values have been updated based upon the response to Comment 3. Additionally, Table 3.1 indicates the reaches where the respective gradation data is applied.

7. *Page 17, Table 4.3, SRB2, for Delta (ft) does not add up, see General Comment 4 above.*

PACE Response:
The table has been updated to resolve any round-off issues. Please see response to general Comment 4.

8. *Page 19, Table 4.4, the 1/11/06 submittal did not include any of the recent changes in calculations either for SAM on 1/6/06 or EC n=0.025 on 1/11/06. Update Existing Conditions LACH&SM column according to changes submitted on 1/11/06. Update SAM columns according to changes submitted on 1/6/06.*

PACE Response:
The table has been updated according to the latest SAM data.

9. *Page 21, Tables 5.1A-B, include the 1963 Area in the 1947 column with footnote for SRA1 according to previous discussions.*

PACE Response:
The table has been updated to reflect this comment.

10. *Page 22, eighth line of the first paragraph, replace "overbanks" with "sides" or similar wording because the left bank is 35' high and cannot be overtopped. Also add discussion about the loss of significant bank material in 2005 of the Magic Mountain parking area as shown in Figure 5.2A (150' lateral migration). If there is other bank armoring besides the treatment plant, please add the information.*

PACE Response:
Based on phone conversations with LACDPW (B. Willardson, February 22, 2006) the developed area is now referred to as banks. Additional information is provided discussing the loss of parking area at the theme park.

11. *Page 23, first sentence of the second paragraph, the "spike at station 200" is not evident to the reviewer. Please add more discussion to clarify.*

    PACE Response:
    A spike in the1999 topography is present from station 200 to station 300. Because the spike is in the 1999 topography, the reference has been removed. As noted in personal communication with County personnel (B. Willardson, February 22, 2006) the radar sampling technique used in creating the 1999 topography has difficulty in discerning the difference between dense woody brush and solid ground. The feature addressed in this comment, as well as similar comments, are a result of the surveying technique. The text has been updated in several locations to address where dense vegetation has been misinterpreted in the sampling.

12. *Page 23, the fourteenth line of the second paragraph states that the poor quality of the 1930 topography "renders a direct comparison difficult." If the topography is too poor to make a comparison it should not be included. If it does contribute some value, then the inaccuracies or shortcomings must be discussed further to show the reader what confidence is given to the data. This is true for any questionable data.*

    PACE Response:
    This data is included in the report based on a previous request by the County to include the complete record. Based on personal commutation with County personnel (B. Willardson, February 22, 2006) the text has been updated to improve readability.

13. *Page 24, second paragraph, discuss the presence of berms in the 2004 and 2005 data and the problems with the 1930 data for section 23000. More discussion is needed on how the canyon tributaries "may have played a role."*

    PACE Response:
    The text has been updated to the following:

    > **Sections 23000 (SRC4) and 20845 (SRD1) are the first historically aggradational sections analyzed (Figure 5.2J and 5.2K, respectively). Section 23000 is adjacent to the Chiquito Canyon Creek and Long Canyon Creek tributaries at the west end of the proposed Landmark development and between two historic agricultural production areas. Section 20845 is downstream of the proposed Landmark site and the left overbank has historically been used for agriculture. Both banks of section 20885 are tree-lined. Both sections are relatively wide and straight with braided channel beds. Both sections have aggraded over the period of historic record: 1.9 and 1.4 feet, respectively. In the most recent short term, however, section 23000 has aggraded 0.7 feet while section 20845 has degraded 0.5 feet. Section 23000 shows some incising below the 1930 historical bed although the average bed elevation is higher now than in the past. The dominant change in bed elevation between 2004 and 2005 at section 20845 occurred to the left of station 2600, while**

the remaining portion remained stable. It is not clear why this occurred, although agricultural practices or high discharges from the Chiquito and Long tributaries may have played a role. Agricultural practices may have stabilized the bank position and height while the creeks may influence the bed by discharging high volumes of water and sediments that have the dual ability to erode or deposit at this location. It should be noted that the topographic artifact between station 2600 and 3000 in the 1999 topography is a function of topographic sampling. As noted above, the dense brush in this and other woody sections may make the topography appear to be at a higher elevation than is actually present and results from the aerial survey technology used to create the topography.

14. *Page 24, last sentence of the second paragraph, the large inaccuracy in the 1999 data for section 20845 cannot be left as-is and explained only as a function of topographic conversion. This data appears inconsistent with the cross-section used in the HEC-RAS analysis. Similar to Comment 12 above, if the data is bad it should be thrown out or fixed. If it is good, the presence of this mound only in the 1999 topography needs to be explained. If an assumed cross-section was used it should be explained why this value should be accepted as reliable.*

PACE Response:
The text has been updated to reflect this comment. Please see response to Comment 13.

15. *Page 24, third paragraph, more discussion is needed on the four cross-sections. Section 14315 appears very active over the period of record. Sections 16305 &12195 both show a 1.1 foot average degradation between 2004 and 2005 as mentioned; only two other subreaches degrade more. The first sentence makes it sound like the general trend is for an inactive area, but it is observed to have pretty dramatic oscillations and rearrangements of sediment up to 8-feet plus of elevation difference. Mention should also be made of the diversion through sections 16305 and 14315 to the north near the 126 highway.*

PACE Response:
The text has been updated to the following:

Sections 18650 (SRD2), 16305 (SRD3), 14315 (SRE1), and 12195 (SRE2) all exhibit very mild long-term degradation (one foot or less) between 1947 and 2005 (Table 5.1). Additionally, short-term adjustment for all of these sections ranges between -0.6 and -1.2 feet between 2004 and 2005. Sections 16305 and 12195 exhibit 1.2 and 1.1 feet of degradation, respectively, and are among the five highest single season changes in bed elevation of the sections examined. Sections in SRA3 and SRB1 degrade significantly more with -2.3 and -1.7 feet, respectively. All of the sections from 18650 to 12195 are recovering from the 1928 dam break event, the sections low elevations, and all sections exhibit oscillations in bed elevation over the historic record (Figure 5.2L though 5.2O, respectively). These sections have in common a relatively wide, straight and braided bed. Grande Canyon Creek and Potrero Canyon Creek confluence with the River at near section 17000. The influence of the confluences is not immediately evident but may include some of the observed fluctuations in bed elevation as well as affecting the wide historic meandering

between the north and south bank (Figure 5.1). The observed features in the 1999 and 2004 topographies in section 16305 at stations 425 and 850 appear to be the south and north low-flow banks, respectively. Several of the features in the 1999 bed at section 14315 appear to correlate to the presence of vegetation on the bank and relate to surveying methodology, as noted above.

16. *Figure 5.2B, add more discussion of the 800' of bank migration from 1963 to1999.*

PACE Response:
The text has been updated to the following:

Section 42215 (SRA2) appears to have greatly down cut and widened since 1947, degrading an average 8.1 feet along the section. Some of the observed long-term change may be related to the presence of the theme park and water treatment facility on the bank at this location. In recent years (1999-2005), the creek appears to have become relatively stable: area has increased from 17946 to 17101 over the period (Figure 5.2B). The River is relatively wide at this location although a bend is present. Development has occurred on both banks with agricultural development on the north bank and the Magic Mountain theme park on the south bank. Historical development may have led to the observed degradation, although at present the bed appears to be stable or degrading only slightly. The impacts of woody vegetation in this section may have played a role in the recent degradation. Finally, the 2004-2005 winter was very wet and high flows were present on the River. During the heavy storms of December 2004 and January 2005, approximately 4.4 acres of the south bank was lost to the Santa Clara River. Some of the single-season degradation may possibly be attributed to this event. The features located at station 775 and 1325 in the 1999 topography are expected to be related the aerial surveying methodology, as noted above.

17. *Figure 5.2C, discuss the apparent berms/hills at stations 775 and 1325 in the 1999 topography, and the movement of the thalweg adjacent to the south bank.*

PACE Response:
The text has been updated to the following:

Similar to the other sections in Reach A, section 40825 (SRA3) is also degrading. The section has degraded 5.2 feet on average over the period of record (Table 5.1B). The 1963 data is insufficient in this section as indicated by the flat portions of the section, although the other years sufficiently indicate the trend. The 2005 thalweg is at the approximate elevation of the 1930 thalweg, although the present channel is more incised than the historic channel. The presently observed channel widening may possibly be attributed to recent high discharges, and migration of the channel may be related to these discharges. Features in the 1999 topography at stations 775 and 1325 are expected to be related to the aerial surveying methodology, as noted above.

18. *Figure 5.2E, correct the stationing between 0 and 200. Include discussion of any existing bank stabilization for the trailer park in this reach.*

    PACE Response:
    The figure has been updated to reflect this comment.

19. *Figure 5.2J, show assumptions for the northwest bank on all data sets. If there is a defined bank beyond the limit of the viewport expand the view to include it. The area for 2004 should end at the berm at station 1325, if there is a reason for not doing this state it, similarly with the berm in the 2005 data. The 1930 data does not show a thalweg, it continues to decline out–of-sight. It needs to be removed if the data is bad.*

    PACE Response:
    The viewport has been expanded to show a greater portion of the section.

20. *Figure 5.2M, discuss apparent berms in 1999 and 2004 data at stations 425 and 850.*

    PACE Response:
    The text has been updated to reflect this comment. Please see response to Comment 13.

21. *Figure 5.2N, discuss large migrations and sediment depositions according to Comment 14 above.*

    PACE Response:
    The text has been updated to reflect this comment. Please see response to Comment 13.

22. *Figure 5.2P, discuss the apparent berms in the 1999 and 2004 data at station 625.*

    PACE Response:
    The text has been updated to reflect this comment.

23. *Page 27, the twenty-fifth line makes a comparison between the existing and proposed conditions for total adjustment. This needs to be presented in tabular format as a new table or an addition to 7.1B & D.*

    PACE Response:
    As per personal communication with County personnel (B. Willardson, March 3, 2006) a reference has been added to refer to Appendix 6.1 and Table 8.

24. *Page 30-32, Tables 7.2A-D, add another column to show the difference between the two methodologies, a negative value corresponding to LACH&SM governance.*

PACE Response:
The table has been updated to reflect this comment.

25. *Page 30, second to last line, clarify the "existing" minimum bed elevation. It is assumed this is not the "Existing Conditions" bed which is based on the 1999 topography, but rather the 2005 topography.*

    PACE Response:
    The text has been updated to reflect this comment.

26. *Figures 7.2A-D, currently the downstream end of the toe-down elevation data is shown as ascending to meet the model bed at the county line. Since Newhall Ranch is responsible for levees all the way to the county line, the toe-down should continue at the depth of the final cross section and parallel to the model bed.*

    PACE Response:
    The figure has been updated to reflect this comment.

27. *Figures 7.3A-D, the 1999 minimum model bed does not match the same for Figures 7.2A-D near section 31000. Also, change to design toe-down as discussed in the January meeting.*

    PACE Response:
    Both figures employ the same data to create the model bed representation. The line types have been changed in an attempt to have the figures represent the bed data in a more uniform manner.

28. *Page 34-35, section 8, update section as previously discussed to include the more conservative method between the LACFCDDM and the LACH&SM with SAM calculations for general scour. Also include a new figure in Section 8 similar to Figure 7.3 that will show the most conservative toe-down, the 1999 minimum (model bed) and the 2005 minimum bed elevations.*

    PACE Response:
    The text has been updated so that the deeper of the LACFCDDM and the LACH&SM methodologies is used for total toe-down.

29. *Table 8, update toe-down depths and elevations to show the hydrology manual standard practice, including the LACFCDDM. This change is in accordance with discussions at Public Works between PACE, the County, and Newhall Land. Also as discussed move the old version to the appendices. The new Table 8 will be used to check levee elevations during the Tentative Tract Map review and possibly final design, depending on the Phase 2 study.*

    PACE Response:
    The table has been updated to reflect discussions between the County, PACE and Newhall Land.

Formatting Comments

1. *The memorandum should be proof-read for typographic errors that were not caught by this review.*

   PACE Response:
   Additional proof-reading has been completed for the text, tables and figures.

2. *Many small errors were observed in the tables, apparently as a result of rounding decimals not shown in the table. For example 13.1 – 5.1 = 8.1. As previously discussed with Ben Willardson of the County, figures should be truncated to the level of confidence. If the data is only good to the nearest tenth, then any calculations done with that data can only be good to the nearest tenth (and maybe less). All tables should be corrected to calculate and show significant figures. All values in a table should be consistently rounded to the same decimal place.*

   PACE Response:
   In previous drafts of this report, all tables used the appropriate number of decimal places. In the present draft, the tables have been edited to remove any rounding errors.

3. *Verify the measurement scale of all maps, even reduced maps must have a scale corrected for the reduction factor.*

   PACE Response:
   Previous map scales were applied correctly; however, some maps were printed at half scale. The present drafts include scales based on the print size.

4. *Where references are made to an appendix, use the full appendix designation. For example Appendix Chapter 3.2 not Appendix Chapter 3.*

   PACE Response:
   Appendix references have been updated.

5. *Fully justify the whole body of text.*

   PACE Response:
   The formatting of the report has been updated to reflect this comment.

6. *Figure 1, the Q_{cap} labels are of the old LADPW flow rate. Revise to show the new flow rates used to develop the mapped floodplain. (This error was also observed in the HEC-RAS study map).*

   PACE Response:
   The figure has been updated to reflect this comment.

7. *Page iii, a typo in the first line of the third paragraph, delete "form."*

   PACE Response:
   The formatting of the report has been updated to reflect this comment.

8. *Page iii, a typo in the third line of the fourth paragraph, delete "presented in," which occurs twice.*

   PACE Response:
   The formatting of the report has been updated to reflect this comment.

9. *Page iv, first through third lines of the page, all of the maximum and minimum adjustment values need to be updated to reflect changes in their respective tables (8 values in total).*

   PACE Response:
   The formatting of the report has been updated to reflect this comment.

10. *Page iv, fifth line of the second paragraph states that all of the cross sectional areas were used to calculate the average change in bed elevation over time. In fact, only the 1947, 2004 and 2005 areas were analyzed and only the 1947 and 2005 data were used to determine the long-term degradation.*

    PACE Response:
    The text has been updated to reflect this comment.

11. *Page v, the first paragraph lists the components of other scour but then presents the data in a confusing manner. Rearrange the sentences to follow the order that the subcategories are listed in. Include the results for the bend scour in existing conditions. Update the maximum value for bed form height to be consistent with the calculated values in Appendix 6.*

    PACE Response:
    The text has been updated to reflect this comment.

12. *Page v, last line of the first paragraph, replace "creek crossings" with "river crossings."*

    PACE Response:
    The text has been updated to reflect this comment.

13. *Page v, a typo in the second line of the second paragraph, "LACH&SM" is misspelled.*

    PACE Response:
    The text has been updated to reflect this comment.

14. *Page v, sixth through ninth lines of the second paragraph, reports the findings of the general bed adjustment. These figures need to be corrected for updates to Tables 7.2 A-D (8 values in total).*

    PACE Response:
    The text has been updated to reflect this comment.

15. Page v, a typo in the tenth line of the third paragraph, "adjustment" is misspelled.

    PACE Response:
    The text has been updated to reflect this comment.

16. *Page v, third sentence of the third paragraph, state whether the referenced calculations for SRC2 are proposed or existing conditions.*

    PACE Response:
    The text has been updated to reflect this comment.

17. *Page v, fifth line of the last paragraph, the freeboard values need to be corrected for updates to Tables 7.3A-D.*

    PACE Response:
    The text has been updated to reflect this comment.

18. *Page vi, third line, the toe-down values need to be corrected for updates to table 8.*

    PACE Response:
    The text has been updated to reflect this comment.

19. *Figure 1.1, clarify the subreach boundaries graphically, especially at the end of SRE3, the beginning of SRA1, and the SRA1/SRA2 interface. Use "SRA1" labels in place of "RA1." Graphically depict which cross-sections were used in the long term analysis. Graphically depict which cross sections were used in the SAM analysis. Show approximate locations of sediment samples. Fix the scale.*

    PACE Response:
    The figure has been updated to reflect this comment. Also, please see response to formatting Comment 3.

20. *Page 4, first sentence of the second paragraph, spell out "Simons, Li and Associates", (SLA).*

PACE Response:
The text has been updated to reflect this comment.

21. *Page 4, a typo in the second sentence of the second paragraph, should read "quantitative ~~and~~ analysis."*

PACE Response:
The text has been updated to reflect this comment.

22. *Page 5, delete last line of the first paragraph, "The text has been updated to reflect this."*

PACE Response:
The text has been updated to reflect this comment.

23. *Page 7, second line of the second paragraph, 18 samples were collected on the river and 23 total including the tributaries. Correct the text which says "17 samples."*

PACE Response:
The text has been updated to reflect this comment.

24. *Page 7, Table 3.1, the first station should read "37135 ~~8"~~.*

PACE Response:
The text has been updated to reflect this comment.

25. *Page 8, second paragraph, update all D50 values according to Technical Comment 3 above.*

PACE Response:
The text has been updated to reflect this comment.

26. *Page 8, a typo in the seventh line of the third paragraph, "…variation ~~of~~ in..."*

PACE Response:
The text has been updated to reflect this comment.

27. *Figures 3.1A-E, update D50 values according to Technical Comment 3 above. Also clean up stray lines near No. 4 line and between Nos. 8 & 16, and add dashed lines for Nos. 30 & 50.*

PACE Response:
The figure has been updated to reflect this comment.

28. *Figures 3.2A, clean up stray lines, label the same sieve sizes as Figure 3.1, cleanup the axes. Also make a reference to the fact that reaches A & B use exactly the same data.*

    PACE Response:
    The figure has been updated to reflect this comment. Also, please see response to technical Comment 6.

29. *Figure 3.2B, clean up stray lines as above, update D50 value according to Technical Comment 3.*

    PACE Response:
    The figure has been updated to reflect this comment.

30. *Page 17, second line of the second paragraph, update range of proposed conditions general adjustment.*

    PACE Response:
    The text has been updated to reflect this comment.

31. *Page 17, Tables 4.2A-B, a typo in the heading, "Conditions" is misspelled.*

    PACE Response:
    The table has been updated to reflect this comment.

32. *Figures 4.1A-B, delete "Outside Curved Reach" from the heading because there is no "inside" figure and the distinction is not necessary. Eliminate the first point of each series because it does not represent actual data. Change the symbol for one of the series to a filled, solid symbol making the two series easier to distinguish visually.*

    PACE Response:
    The figure has been updated to reflect this comment.

33. *Page 20, fifth line of the first paragraph, revise to say "…creating contour lines ~~of equal ground surface elevation~~…"*

    PACE Response:
    The text has been updated to reflect this comment.

34. *Page 20, a typo in the thirteenth line of the first paragraph, "STA 42215."*

    PACE Response:
    The text has been updated to reflect this comment.

35. *Page 21, Tables 5.1A-B, increase the font of the footnotes to make them more legible. Also fix the rounding errors according to Formatting Comment 2 above.*

    PACE Response:
    The table has been updated to reflect this comment.

36. *Pages 22-24, update the references to Figures 5.2 A-P according to their reordering. Also, as in the Castaic Creek study, a differentiation must be made between the longitudinal and cross-sectional stationing for all of Long-term Degradation, Section 5.*

    PACE Response:
    The text has been updated to reflect this comment.

37. *Page 23, first line of the second paragraph, update "SRB1" to "SRA4".*

    PACE Response:
    The text has been updated to reflect this comment. "As applied to…" is added.

38. *Page 23, fourth line of the second paragraph, insert "degraded" to read, "the section has degraded 3.2…"*

    PACE Response:
    The text has been updated to reflect this comment.

39. *Page 23, ninth line of the second paragraph, insert words to read, "single season degradation may be possibly attributed to the woody nature…"*

    PACE Response:
    The text has been updated to reflect this comment.

40. *Page 23, a typo in the sixteenth line of the second paragraph, "considered"*

    PACE Response:
    The text has been updated to reflect this comment.

41. *Page 24, a typo in the second line of the third paragraph, "less_between."*

    PACE Response:
    The text has been updated to reflect this comment.

42. *Page 24, second to last sentence of the third paragraph, Grande Canyon confluences with the River near Section 17000 not 15335 as stated.*

    PACE Response:
    The text has been updated to reflect this comment.

43. *Figure 5.1, use "SRA1" labels instead of "RA1." Correct the scale.*

    PACE Response:
    The figure has been updated to reflect this comment. Also, please see response to formatting Comment 3.

44. *Figure 5.2K, expand the viewport to include both banks (at least to the top width line) and the proposed levee. Correct the 1999 data as stated in Technical Comment 14 above.*

    PACE Response:
    The figure has been updated to reflect this comment.

45. *Page 25, seventeenth line, update the ranges of SAM aggradation and degradation.*

    PACE Response:
    The text has been updated to reflect this comment.

46. *Page 25, a typo in the twentieth line, "is observed to have the opposite trend <u>than</u> that predicted…"*

    PACE Response:
    The text has been updated to reflect this comment.

47. *Page 26, typos in the second to last sentence of the last paragraph, "height ranges from 0.5 <u>to</u> ~~and~~ 9.1…" and "from 0.5 <u>to</u> ~~and~~ 8.3…" Also update the values in the last paragraph according to the appropriate tables.*

    PACE Response:
    The text has been updated to reflect this comment.

48. *Page 27, the second sentence states that SAM analysis represents a long-term trend. SAM is not a long-term analysis tool since it only utilizes one storm flow for calculations. Correct the text accordingly.*

    PACE Response:
    The text has been updated to reflect this comment. Punctuation is added to clarify the

meaning of the text.

49. *Page 27, discussion of the content found in Tables 7.1 A-D needs to be presented in the order in which the tables are presented to avoid confusion. Also references made on page 27 to these and other tables need to be updated based on the final approved models.*

    PACE Response:
    The text has been updated to reflect this comment.

50. *Page 27, nineteenth line, references to stations do not use the STA designation. Add it for consistency.*

    PACE Response:
    The text has been updated to reflect this comment.

51. *Page 27, twenty-second line update the range of degradation depths, and include STA 24795 which also has the same depth as STA 13030.*

    PACE Response:
    The text has been updated to reflect this comment.

52. *Page 27, a typo in the twenty-ninth line, "components ~~are~~ differ significantly…"*

    PACE Response:
    The text has been updated to reflect this comment.

53. *Page 28, Table 7.1A, a new table was not included with the 1/11/06 .pdf files. Make sure it is updated according to the changes in Appendix Chapter 6.1A.*

    PACE Response:
    The table has been updated to reflect this comment.

54. *Figures 7.1A-D, use points instead of lines to depict adjustments. Use symbols that are easily distinguishable. Remove the first data point near STA 9000 because it does not represent a real data point. Also on Figure 7.1A correct the typo "Bed Adjustment" on the Y-axis.*

    PACE Response:
    The figure has been updated to reflect this comment.

55. *Page 30, Table 7.1A, update the LACFCDDM values to reflect the most recent changes, especially SRA3, SRC1, SRD2, and SRE1.*

PACE Response:
The table has been updated to reflect this comment.

56. *Page 31, Table 7.1C, update the LACFCDDM values to reflect the most recent changes, especially SRC1, SRD2, and SRE1.*

PACE Response:
The table has been updated to reflect this comment.

57. *Page 32, fourth line of the first paragraph, update the range of values for LACFCDDM, from "8 ~~10~~ to 21," or as necessary according to the approved, updated models.*

PACE Response:
The text has been updated to reflect this comment.

58. *Figure 7.3C, The calculated toe-down including SAM needs to be updated according to the latest figures.*

PACE Response:
The text has been updated to reflect this comment.

59. *Page 34, sixth line of the second paragraph, specify the trend of general adjustment, aggradation or degradation.*

PACE Response:
The text has been updated to reflect this comment.

60. *Page 34, a typo in the tenth line of the second paragraph, "aggradation ~~iton.~~"*

PACE Response:
The text has been updated to reflect this comment.

61. *Page 34, sixth line of the third paragraph, update the range of general adjustment. Also, seventh line of the third paragraph, update the range of other adjustment to include the straight and inside curve values (4.9 minimum). Also, tenth line of the third paragraph, update the range of total toe-down to include the straight and inside curve values (7.5 minimum).*

PACE Response:
The text has been updated to reflect this comment.

62. *Page 34, a typo in the first line of the fourth paragraph, "four ~~three~~ subreaches."*

    PACE Response:
    The text has been updated to reflect this comment.

63. *Page 35, fifth line of the first paragraph, update the range of general adjustment. Also, eighth line of the first paragraph, update the range of other adjustment to include straight and inside curve values (3.9 minimum). Also, tenth line of the first paragraph, update the range of total toe-down to include the straight and inside curve values (4.5 minimum).*

    PACE Response:
    The text has been updated to reflect this comment.

64. *Page 35, eighth line of the second paragraph, update the range of other adjustment (-4.6 minimum). In the tenth line of the second paragraph, update the local scour of the bridge piers at section 15335, "12.7 ~~12.5~~ feet." Also, last line of the second paragraph, include section 18830 which has the maximum freeboard of 4.2 feet as well as section 19050.*

    PACE Response:
    The text has been updated to reflect this comment.

65. *Page 35, seventh line of the third paragraph, update the other adjustment to include straight and inside curve values (-4.7 minimum).*

    PACE Response:
    The text has been updated to reflect this comment.

66. *Appendix 4.1, include the most current and approved HEC-RAS output for the Existing Conditions model with n=0.085 and n=0.025.*

    PACE Response:
    The appendix has been updated to reflect this comment.

67. *Appendix 4.2, include the most current and approved HEC-RAS output for the Proposed Conditions model with n=0.085 and n=0.025.*

    PACE Response:
    The appendix has been updated to reflect this comment.

68. *Appendix 4.3, include the most current and approved HEC-RAS models for all relevant 'n-values'.*

PACE Response:
The appendix has been updated to reflect this comment.

69. *Appendix 4.4, update using the most current and approved HEC-RAS model and output. Also state which 'n-value' is being used for the output.*

PACE Response:
The appendix has been updated to reflect this comment.

70. *Appendix 4.6, Figures A4.6A and B update using the most current and approved HEC-RAS model and output. Convert this output again to HEC-2 and SAM input. Use comma delimiting for transport volumes to emphasize differences in magnitude. Make rounding consistent in the width column.*

PACE Response:
The appendix has been updated to reflect this comment.

71. *Appendix 6.1, Figures A6.1A-F, update according to the most current and approved HEC-RAS model and output. Include changes made to pier width for the proposed conditions. Revise the text under "general" heading which states that the maximum velocity allowed by the table is 20-fps. Many velocities are higher than 20. Also revise the typo "LACDPW ~~DWP~~". Also update the pier widths and locations according to the approved proposed models.*

PACE Response:
The appendix has been updated to reflect this comment.

72. *Appendix 6.2, Figures A6.2A-B, update according to the most current and approved HEC-RAS model and output.*

PACE Response:
The appendix has been updated to reflect this comment.

If you have any questions regarding the above responses, please do not hesitate to contact us at (714) 481-7300.

Sincerely,
PACIFIC ADVANCED CIVIL ENGINEERING, INC. (PACE)

David A. Jaffe, Ph.D., P.E.
Project Engineer – Stormwater Division

DAJ/as

P:\8197E\5-Administrative\Letters\Out\Response Letter 3-06-06.doc

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

17520 Newhope Street, Suite 200 ▪ Fountain Valley, California 92708 ▪ 714.481.7300 ▪ fax: 714.481.7299

December 9, 2005

Ben Willardson
LACDPW
Water Resources Division
900 South Fremont, 3rd Floor
Alhambra, CA 91803
(626) 458-4974

Re: Newhall Ranch -- Santa Clara River Fluvial Study #8197E

Dear Mr. Willardson,

Pacific Advanced Civil Engineering, Inc. (PACE) is pleased to provide the following responses to the Los Angeles County Department of Public Works comment letter dated October 13, 2005, for the above-referenced project. The responses from PACE are as follows:

Previous Comments

4. *Page 7, discussion of sediment gradation size is included in both paragraphs. The bore logs from the Simons, Li, and Associates study show cobbles at certain depths. However, no cobbles are found in any of the gradations used for this study. Many of the cobbles were found below the depths sampled by Seward Engineering Geology. Large flow rates will carry cobbles and the reasons for not including cobbles in the gradations should be included in the discussion. (The upper foot of sediment is most likely not the active bed in the Santa Clara River as shown by Table 5.1. The bed elevation changed by 1 to 2 feet in the period from 2004 to 2005. The portion of the bed moving during peak flows may actually be much deeper. Although the second sampling set collected by Seward may be adequate for SAM analysis, there is some uncertainty in the gradation and distribution as shown by other studies. See comment 6 below.)*

   PACE Response:
   The County has noted that cobbles are present in the SLA study boring logs, which is true. Cobbles are not present in any of the grain size distribution curves in the SLA study (particularly in the Landmark study reach), however, and a careful review of the boring logs down to approximately 10 feet (approximately five times the SAM single event depth) notes only sporadic cobble observances, generally less than 5% and rarely as much as 10%. More importantly, is the fact that at sample location 11 (in the Landmark Village study reach), p. B.5, not until 8.5 feet are any cobbles observed. Because of the lack of cobble occurrence in the

both the boring logs and their depth below the SAM single event depth, taken here as the active depth, PACE believes that the sampling data collected by Seward is representative of the active bed. The text has been updated to reflect this comment.

Present Comments

1. *Page 2, the second set of bullets, number 1, indicates that field investigations were performed for the Santa Clara River. Were other field investigations conducted besides the bed sample collection? If so, the investigation needs to be added.*

   PACE Response:
   Photos of a previous field investigation are included in Appendix Chapter 3.

2. *Page 2, the second set of bullets, number 2, indicates cross-sections were determined to provide adequate representation of channel geometry. Was this done by PACE, or were the cross-sections based on the Sikand study and model?*

   PACE Response:
   An RMS file was provided by Sikand, which was exported to HEC-RAS. In addition to review of the Sikand base line HEC-RAS model, PACE prepared the proposed condition model geometry file modification to model the proposed bridges and bank protection associated with the proposed Newhall Ranch Project.

3. *Page 2, the second set of bullets, number 3, indicates a baseline hydraulic model. The year for the baseline needs to be specified.*

   PACE Response:
   The base topography is from 1999. The text has been updated to reflect this response.

4. *Page 4, the first paragraph states that Sikand relied on previous work conducted by Simons, Li, and Associates and submitted June 1998. Who was the SLA study submitted to?*

   PACE Response:
   The study in question, *HEC-6 Sediment Transport Analysis for ACOE General Permit on Santa Clara River (from Castaic Creek to Cottonwood Avenue) and San Francisquito Creek (from Santa Clara River to 15000' Northerly,* was prepared by Sikand Engineering, not by SLA. The text does not mention to whom the report was submitted. The text has been updated to reflect this comment.

5. *Page 4, the second to last paragraph states that 1500 cfs was required to generate sediment transport. This number is too high since sediment transport has been observed at much lower flow rates. This number should be compared to measured sediment transport data from the USGS. Sediment transport at lower rates may affect braiding and low flow channel armoring.*

   PACE Response:
   USGS data (*Sediment Discharge in The Santa Clara River Basin, Ventura and Los Angeles Counties, California*) notes in Table 3 that in 1971 at 1470 cfs 99% of the transport was silt at the County Line. It is important to note that PACE is citing the SLA study and not making the claim. PACE does not model silt in the present study since it is generally transported as wash load and is not pertinent to the present study's goals. The text has been updated to reflect this.

6. *Page 6, the sediment data represented in Section 3 are not the same as the data submitted in the previous version of the Santa Clara River Fluvial Study. As discussed in previous comment 4 from the previous review, the active bed is not one foot deep. The previous study from Seward, dated January 25, 2005, had sediment taken at depths of 25 feet below the surface. No discussion is made on why the February 25, 2005, sampling by Seward replaced the January 25, 2005, sampling. Both sets of data may be valuable and provide insight into the river behavior. More discussion needs to be added to the report on why the previous set of data was discarded if it was found to be inadequate. If not, both sets of data should be compared and analyzed.*

   PACE Response:
   A careful review of the data reveals that most of the sampling for the January report provided by Seward was for upland and tributary locations. Some of the samples in that report included River sample sites, however, only including single grabs. The February report includes multiple grabs at each sample location providing a much greater degree of confidence in the data in the form of being able to spot outliers (here in the statistical sense), and at several locations within the River bed. Because there is no way to independently determine the efficacy of the samples in the January report, the values were replaced with more verifiable data.

7. *Page 7, Section 3.3 discusses sediment characterization. The current study uses the same sediment gradation for both existing and proposed conditions. Modeling with HEC-6 will require that changes in sediment production also be considered. Some of these changes should be discussed in Section 5 that is looking at long-term historical trends.*

   PACE Response:
   As per a personal communication of 10/17/05 with Ben Willardson of the County, any and all HEC-6 related comments and responses will be delayed

until the second phase of the fluvial analysis following the approval of the Tentative Tract Map(s).

8. *Page 8, the reference to HEC-6 in this section should be removed as discussed in the response to comments from Castaic Creek. Other typographical errors in general sections of the fluvial studies can be corrected as discussed in the Castaic Creek comments from 08/23/05.*

   PACE Response:
   The text has been updated to reflect this comment.

9. *Page 10, the Sikand models discussed were modified significantly since they were developed. The reference should indicate that PACE has updated these models to meet Public Works standards.*

   PACE Response:
   The text has been updated to reflect this comment.

10. *Page 13, the second paragraph discusses outliers for sediment transport capacity calculations. More discussion needs to be added on how outliers are determined. The entire section should be updated as discussed in the Castaic Creek comments.*

    PACE Response:
    Outliers are values under analysis in a data set that reside far outside most other values in a data set. In this case, when the one of the results of a SAM.SED calculation that is three orders of magnitude or more different from the median, the data is excluded from analysis and noted as an outlier. The raw data is presented in Appendix Chapter 4.6. The text has been updated to reflect this response.

11. *Page 18, The HEC-6 study outlines for both Castaic Creek and the Santa Clara River should be similar. There are some differences in available data. These can be discussed once the SAM and long-term historic data are analyzed correctly and the tentative map approval is moving forward.*

    PACE Response:
    Please see PACE Response to Present Comment 7, above.

12. *Page 18, information needs to be provided regarding changes to sediment inflow based on the development of the watershed for the proposed conditions.*

    PACE Response:
    Please see PACE Response to Present Comment 7, above.

13. *The HEC-6 studies need to include historic cross-sections for comparison during the model calibration phase.*

    PACE Response:
    Please see PACE Response to Present Comment 7, above.

14. *Table 5.1 is not the same in the Santa Clara River and Castaic Creek studies. The same methodology should be used for both. More analysis and discussion of the river system needs to be added. An example of this type of analysis is provided as a guide: Station 11015 mean elevations from 1930, 1947, 1960, 1999, 2004, and 2005 are respectively 827.8, 831.3, 828.4, 832.1, 832.8, and 832.3. This cross-section appears to be fairly stable over time. Station 25000 mean elevations from 1930, 1947, 1960, 1999, 2004, and 2005 are respectively 915.1, 912.7, 912.1, 911.8, 910.3, and 909.5. This cross-section appears to be degrading over time. The cause of this long-term degradation may be the installation of the dam on Castaic Creek in 1971. More of this type of analysis is required. Some portions of the river fluctuate over the time period studied, while others aggrade or degrade. The trends in the river are shown by the mean elevations. These trends may be impacted as sediment production from some of the major tributaries are restricted by development. These issues need to be analyzed and discussed. The analysis and discussions can be validated using the HEC-6 model during the next phase. An understanding of the river system and changes must be portrayed and related to the top-of-levee heights and toe-down depths determined for the tentative map.*

    PACE Response:
    In the current draft of the report the historic thalweg analysis has been replaced with a historic cross-section analysis. The sections provide a more clear and complete picture of the trends of the creek bed in a given section. An analysis of the trends of the various sections is included in Chapter 5. This analysis separately considers the periods immediately following (1930) and later following (1947 and after) the failure of the St. Francis Dam in 1928. The data from the thalweg analysis is included for completeness in Appendix Chapter 5.

15. *Page 21, the comments in the second paragraph should be checked against Table 5.1. These assumptions do not appear to be correct now that the calculation procedures have been corrected.*

    PACE Response:
    Please see PACE Response to Present Comment 14, above.

16. *Figure 5.4 and Table 5.5 should use mean bed elevations for comparison of changes in the time period between 2004 and 2005. Comparison of the 1999, 2004, and 2005 data may provide more information. All tables should have the same station order as the to facilitate comparison, i.e., 9042 to 46195 or 46195 to*

9042. Again, general sections and comments in the fluvial studies for Castaic Creek and the Santa Clara River should be consistent. Both studies need to provide more analysis of data provided by the models. The analysis should include discussion on how the model results relate to toe-down, top-of-levee, and protection of other property owners.

PACE Response:
The purpose of the '04-'05 single season analysis is to illustrate bed changes that occur over a single season or single event. Including the 1999 data in this section does not offer any insight into the kinds of changes that occur during the '04-'05 rainy season or any other single event or season. Also, please see PACE Response to Present Comment 14, above.

If you have any questions regarding the above responses, please do not hesitate to contact us.

Sincerely,
PACIFIC ADVANCED CIVIL ENGINEERING, INC. (PACE)

David A. Jaffe, Ph.D., P.E.
Project Engineer – Stormwater Division

CC: Steve Sheridan/LACDPW
Mo Kajbaf/ LACDPW
Mark Subbotin/NLF
Glen Adamick/NLF

P:\8197E\5-Administrative\Letters\Out\Response to Comments 12-9-05.doc

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

17520 Newhope Street, Suite 200 ▪ Fountain Valley, California 92708 ▪ 714.481.7300 ▪ fax: 714.481.729

August 10, 2005

Mo Kajbaf
LACDPW
Land Development
900 South Fremont, 3rd Floor
Alhambra, CA 91803
(626) 458-4974

Re: Santa Clara River Fluvial Study

Dear: Mr. Kajbaf

Pacific Advanced Civil Engineering, Inc. (PACE) is pleased to provide the following responses to the Los Angeles County Department of Public Works for the above-referenced project. The responses from PACE are as follows:

1. *Page 4, the reference to the Sikand Study for the Santa Clara River should indicate that the results were not accepted by Public Works. The comments on the last review of the study in 2004 were not addressed.*

   PACE Response:

   The text was updated to reflect this comment in a previous partial draft sent to Public Works.

2. *Page 5, the Simons, Li, and Associates study references sediment gradation data and boring logs that are available in the copy of the report provided to PACE and available at LADPW Headquarters Technical Library.*

   PACE Response:

   The text has been updated to reflect the D_{50} for the two gradation curves in the SLA study and in the present study reach. While the boring logs are present, no map of the location of the borings is present in the PACE copy of the study. If a map showing the locations of the borings becomes available, PACE will further update the report to account for the boring data.

3. *Page 7, the second paragraph refers to Figures 3.2A-E, but only 3.2A and 3.2B are included in the report.*

   PACE Response:

   The text should refer to Figures 3.2A-B. The text has been updated to reflect this correction.

4. *Page 7, discussion of sediment gradation size is included in both paragraphs. The bore logs from the Simons, Li, and Associates study show cobbles at certain depths. However, no cobbles are found in any of the gradations used for this study. Many of the cobbles were found below the depths sampled by Seward Engineering Geology. Large flow rates will carry cobbles and the reasons for not including cobbles in the gradations should be included in the discussion.*

   PACE Response:

   Seward sampling was conducted on approximately the upper foot (recently active layer) of the bed. To be conservative no armoring layer (cobble layer) depth is assumed in sampling which allows the bed to fluctuate freely in numerical modeling. Additionally, the true armoring layer has not been observed in field measurements including Seward field studies and SLA boring logs. This study assumes that the grab sampling at the surface represents the below-surface bed. While the SLA boring logs do show vertical variation of in grain size distribution, a consistent grain size vertical distribution is not evident.

   The text has been revised to reflect this comment.

5. *Page 10, section 4.1.2, discusses correlation between hydraulic parameters and location along the channel. River stationing does not necessarily determine hydraulic parameters. Correlation between flow or velocity at a location, and the parameters such as depth, width, and slopes is more reasonable. Several different relationships were used for the reaches (A-F) to determine sub-reaches. Correlation of one hydraulic variable with a fairly constant correlation variable would make more sense. A few of the correlation calculations show velocity versus hydraulic parameters, but this is only done for approximately 20% of the analyzed reaches. No explanation is provided on why either of these methods was used.*

   PACE Response:

   SAM modeling is based on channel subreaches determined by correlating hydraulic characteristics with longitudinal cross-section location to preserve the along-stream character of the flow. The hydraulic parameters examined are discharge, energy slope, bed slope, Froude number, top width, hydraulic velocity and flow area based on the 100-year discharge. First, correlation coefficients are calculated for each station against the hydraulic parameters. The hydraulic parameter that produces the greatest correlation is plotted against cross-section location. Subreaches are then selected in a manner that preserves the trend of the hydraulic parameter as well as produces approximately equal subreach lengths, which are generally 1000 feet long. This methodology seeks to maintain continuity of analysis by producing similar length subreachs while analyzing the hydraulic parameters that largely control sediment transport.

   The text was updated to reflect this comment in a previous partial draft sent to Public Works. The correlation calculations for velocity versus hydraulic parameters produced low correlation relative to channel position and have been removed from the text.

6. Pages 11-13, references to the MPM method that are spelled out should be written as Meyer-Peter and Muller, rather than Meyer, Peter, and Muller.

PACE Response:

This typographical error has been corrected in the text.

7. *Pages 11-14, more discussion needs to be added on why the MPM method was chosen for modeling sediment transport in the study area. MPM is a gravel transport equation. Although the sediment transport capacity appears reasonable for a zero dimension model, the measured transport through the downstream reach exceeds the transport specified by MPM at lower flows.*

PACE Response:

The MPM equation was found to be the representative transport equation for all subreaches for the existing and proposed conditions. This is because transport estimates based on other transport equations (i.e. Yang), when used to estimate general adjustment and transport, produced values in excess of both historical values of general adjustment (as much as approximately 15 feet) and values of general adjustment that might be physically expected during a single event (over approximately 20 feet). In other cases some transport equations (i.e. Brownlie D_{50}) estimated sediment transport that produced general adjustment calculations much smaller than expected (as little as approximately 1 foot).

The text was updated to reflect this comment in a previous partial draft sent to Public Works.

8. *Pages 21-22, these pages discuss the long-term trends in the river. The earliest topography is 1930, two years after the St. Francis Dam failure. This event released a flood wave with a peak flow of 1.3 million cfs measured 1.4 miles downstream of the dam. This flow made its way down San Francisquito Canyon and into the Santa Clara River. It seems that this flow may have created the river channel shown in the 1930 topography. The scour from this flood wave may have resulted in the lower elevations in 1930. It appears that areas with 1930 elevations higher than the elevations shown in other years are near the outlets of major watersheds, such as Castaic Creek. The channel in the last 50-years may be reworking itself to reach a more stable state than that caused by the dam failure. Inclusion of the 2005 topographic data will provide valuable insight into the channel response since the events of the last storm year were very significant for sediment transport.*

PACE Response:

It is important to note that the failure of the St. Francis Dam in March, 1928, is likely captured in Figure 5.3. The 1930 thalweg generally represents the lowest bed elevation over the period of record except between STA 30000 to STA 32000 (Castaic Creek confluence). The scour resulting from the flood wave progression is believed account for the lower than average bed elevations observed in the historical topography. The high point at Castaic Creek may represent the sediment transport from the Creek into the River in the period following the Dam failure.

The text was updated to reflect this comment. Topography from 2005 had become available to PACE within the last week. Analysis of the 2004-2005 water year

events bed change and a continued historical evaluation with this data will be included in the final draft of the report once the data has been analyzed.

9. *In general, most of the technical background work is in place. More discussion needs to be added on the methods followed so that future readers can understand the processes and procedures used to develop the results for this study.*

   PACE Response:

   PACE will continue to work closely with Public Works to update the discussion in the text. These updates will be available in the final draft of the report.

Items Completed After Meetings and Phone Conversations

1. The SAM sediment input gradation data was incorrect for several sub-reaches due to a data conversion process error. The data have been corrected and the models have been re-run to provide correct information and figures.

2. Calculations for whether the channel was aggrading or degrading were reversed. The previous calculations showed that if transport capacity upstream was more than the transport in the reach downstream, the bed degraded. This is backwards based on the volume continuity equation $I - O = \Delta S$. If inflow (sediment transport capacity from upstream) is greater than the outflow (transport capacity in the reach downstream) the change in storage is positive. Positive storage is aggradation, negative storage is degradation. These calculations have been updated by PACE.

3. Reach D of the proposed conditions from HEC-2 did not match the data in SAM. This was corrected when the model was run with the sediment gradation corrections.

If you have any questions regarding the above responses, please do not hesitate to contact us at (714) 481-7300.

Sincerely,
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

David A. Jaffe, Ph.D., P.E.
Project Engineer – Stormwater Division

DAJ

P:\8197E\5-Administrative\Letters\Out\Response Letter 8-22-05.doc

River Fluvial Study – Phase 1 Final Draft

Newhall Ranch
Santa Clara River

DRAFT

March 6, 2006

Prepared For Submittal to:

LADPW
900 South Fremont Ave.
Alhambra, CA 91803-8197

On Behalf of:

Newhall Land/Lennar
23823 Valencia Blvd
Valencia, CA 91355

REGISTERED PROFESSIONAL ENGINEER
MARK EDWARD KREBS
No. 049292
Exp. 9-30-06
CIVIL
STATE OF CALIFORNIA

Prepared By:

Pacific Advanced Civil Engineering, Inc. (PACE)
17520 Newhope Street, Suite 200
Fountain Valley, CA 92708

REGISTERED PROFESSIONAL ENGINEER
DAVID A. JAFFE
No. 68321
Exp. 9/30/07
CIVIL
STATE OF CALIFORNIA

Contact Person:
Mark Krebs, P.E.
Bruce Phillips, P.E.
David Jaffe, Ph.D., P.E.

#8197E

Table of Contents

1 Introduction 1
1.1 Types of Adjustment 1
1.1.1 Study Objectives 1
2 Previous Fluvial Analyses for Study Reach 4
2.1 Introduction 4
2.2 Sikand Engineering Associates, 2004 4
2.3 Simons, Li & Associates, 1990 5
2.4 USGS, 1979 6
3 Sediment Characterization and Analysis 7
3.1 Sediment Data Collection 7
3.2 Sediment Gradation Analysis 7
3.3 Sediment Characterization 8
4 General Adjustment 10
4.1 SAM Model 10
4.1.1.a SAM Model Theory and Limitations 10
4.1.1.b SAM Model Assembly 11
4.1.2 Reach-by-Reach Channel Hydraulic Characterization 12
4.1.3 Input Data and Selection of Transport Functions 14
4.1.3.a SAM.AID Application and Theory 14
4.1.4 SAM Bed Stability 16
4.2 HEC-6 19
5 Long-Term Adjustment 20
5.1 Single Season Bed Adjustment 25
6 Other Scour 26
7 Total Scour 27
7.1 Freeboard Elevation 32
8 Summary 34
9 References 36

Executive Summary

This technical study provides an evaluation of the existing and proposed fluvial characteristics and long-term stability of Santa Clara River between Interstate 5 and an area generally west of the Los Angeles/Ventura County line in the vicinity of the Newhall Ranch Specific Plan. Development along the River within the study area has the potential to modify the fluvial mechanics of the River. The proposed buried soil cement bank protection on both the north and south banks of the River is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. This analysis evaluates impacts from build-out of Newhall Ranch from (1) fluvial modifications of the river bed from single hypothetical storm events, and (2) changes in the floodplain fluvial operation over the long-term.

Three sediment transport studies were previously conducted within the study reach in the last 25 years. The first study conducted by Sikand Engineering (June 2000, and revised November 2004) was to provide HEC-6 sediment transport analysis for the Santa Clara River and to determine the possible effects of the Newhall Ranch Development on river bed stability. The study relied on previous work conducted by Simons, Li & Associates (SLA) (June 1998). The second study, produced by SLA (November 1990), sought to provide information for flood and fluvial process management in the Santa Clara River. The SLA report was reviewed in detail by LADPW and response to comments made, however, the report was not revised to obtain final LADPW approval. The final study was conducted by USGS, whereby the study collected sediment data from 1967 to 1975 at three sites in the Santa Clara River basin including the Los Angeles-Ventura County line. The study estimated long-term sediment discharge by applying the sediment and water discharge relationship observed from 1967 to 1975 to long-term records of water discharge (1928-1975).

Sediment data collection for the Santa Clara River along the study reach was conducted by Allan E. Seward Engineering Geology Inc. Eighteen samples were collected at six different locations positioned along River subreaches. All sampling was conducted using grab samples of the upper foot of the active or recently active portion of the bed. No fine material is included in the sediment analysis because fine material is generally transported as wash load. A review of the raw gradation curves indicates that most samples are comprised of poorly graded sands with gravels and silts. The D_{50} values for all samples ranged from 0.25 to 4.67 mm with an average of 0.8 mm. Additionally, previous studies noted above also found similar sandy characteristics. No cobbles are present in the Seward study and sampling was not conducted for cobble grain sizes. Cobbles are not present in any of the grain size distribution curves in the heretofore discussed SLA study (particularly in the Landmark study reach), and a careful review of the boring logs down to approximately 10 feet (approximately five times the SAM single event depth) notes only sporadic cobble observances, generally less than 5% and rarely as much as 10%. More important is the fact that at sample location 11 (in the Landmark Village study reach), p. B.5, not until 8.5 feet are any cobbles observed. Because of the paucity of cobble occurrence in the both the boring logs and their depth below the SAM single event depth, taken here as the active depth, PACE believes that the sampling data collected by Seward is representative of the active bed.

Modifications to the river bed are measured as bed adjustment in feet. Positive adjustment indicates aggradation and negative adjustment indicates degradation. Several types of adjustment are considered in this study including general adjustment, long-term adjustment, and other scour. General adjustment is scour that occurs in an individual discharge event and is calculated as the difference between sediment inflow and outflow of a given River reach. Long-term adjustment consists of fluvial processes that occur over several years. Other scour is made up of local scour, bend scour, low-flow incisement, and bedform formation.

General adjustment was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state zero-dimensional numerical model. SAM is utilized to provide a first approximation of sediment transport potential for subreaches within Santa Clara River. The SAM numerical model is built upon hydraulic and fluvial representations of the study bed. The hydraulic component includes representations of bed characteristics and discharge. The fluvial component includes representation of bed gradation and sediment transport functions. SAM's hydraulic component utilized average cross-section data imported from HEC-2 numerical models of the river converted from HEC-RAS numerical models. The conversion process modifies the original numerical model, as discussed in Chapter 4, so some differences in numerical models are created. Both the existing and proposed conditions HEC-RAS models were originally developed by Sikand Engineering in the *Newhall Ranch Santa Clara River HEC-RAS Study* (June 2000) and submitted as part of the Newhall Ranch Specific Plan. The HEC-RAS model that is the basis of the SAM modeling, and will be the basis for the HEC-6 model, has been refined by PACE and has been submitted (concurrently with this Fluvial Study) to LADPW for review and approval. The current model resembles the Sikand model but has been refined to address current LACDPW modeling standards and updated proposed project conditions. River subreaches that make up the SAM model are determined by examining the hydraulic parameters of the individual HEC-RAS cross-sections and identifying correlations between those hydraulic parameters and the longitudinal position in the channel.

Representation of sediment grain size distribution in SAM is percent finer data obtained from sieve analysis of channel sediment samples. At each sample location, multiple samples are collected and the average data is input into the model. Sediment transport equations used in all SAM modeling were chosen with the assistance of the Army Corps' SAM.AID subroutine. The SAM.AID subroutine determines the most representative transport function based on the hydraulic parameters and percent finer data by comparing model data with peer-reviewed sediment transport studies. The study found that Meyer-Peter and Muller (MPM) was the representative transport function for all subreaches for both existing and proposed conditions because it produced adjustment values within physical reason.

SAM was run for all River reaches and bed stability was estimated based on the change in potential transport between adjacent channel subreaches for the Q_{CAP} discharge. General adjustment based on SAM modeling is presented in Chapter 4. General adjustment was also calculated using the equation specified in the Los Angeles County Hydrology and Sedimentation Manual (LACH&SM). The LACH&SM general adjustment calculation is based only on flow mean velocity. In most circumstances, adjustment predicted by the LACH&SM is greater (more scour) than that predicted by SAM for both the existing and proposed conditions. SAM results

predict general adjustment from -2.9 to +2.3 feet for the existing condition, and -1.6 and +2.1 feet for the proposed condition. LACH&SM methodology predicts general adjustment from -2.1 to -8.1 feet for the existing and -1.8 to -7.6 feet for the proposed condition, both outside of curves (Table 4.4). In this report the outside of the curve values and inside of curve values are considered separately, as per LACDPW criteria, since outsides of curves tend to degrade while insides of curves tend to aggrade. It is not presently clear if the changes in general adjustment result from the alteration of the hydrology caused by full build-out, or from changes in the velocity in the River associated with specific individual project improvements. It is expected that various Newhall related impacts will be localized, and, with respect to implementation of the proposed improvements, that the River will continue to behave fluvially as it did prior to construction of these proposed improvements. Long-term changes to hydrology and sediment production are not addressed in the first phase report, but may be addressed in the second phase HEC-6 numerical modeling. Finally, the general trend in general adjustment for the study reach as indicated by SAM modeling is not apparent for either the existing or proposed condition.

Long-term adjustment was calculated based on historical records in the form of topographic data. Topographic data dating from 1930, 1947, 1963, 1999, 2004 and 2005, was digitized. Cross-sections were cut at the locations of select HEC-RAS sections for each historical topography. At least one cross-section was chosen for each subreach established in Chapter 4. Areas of the 1947, 1963, 1999, 2004 and 2005 sections are calculated and the areas of the 1947, 2004 and 2005 bed are used to calculate the average change in bed elevation over time. The 1930 topography is not used to calculate average change in bed because the trends in bed change that occurred during this year occurred immediately following the failure of the St. Francis Dam upstream of the project site. Several events within the available historical record (1930 to present) have had an impact on the River bed and fluvial mechanics. These events include failure of the upstream dam, construction of bridges spanning the River, agricultural infill along the River banks, and periodic burning of surrounding vegetation during forest fires. The most significant historical event in the formation of the present bed condition was the failure of the Dam. Within the project reach, the failure of the Dam appears to have resulted in the abrupt scour of the bed. The sectional analysis finds that some historical sections (SRD2, SRD3, SRE1, SRE2) show little change between 1947 and 2005 suggesting an approximate equilibrium state for these subreaches. Between 1947 and 2005, 0.5, 0.7, 1.0, and 0.8 feet, respectively, of cumulative degradation appears to have occurred on these sections. Upstream sections SRA1 to SRC3 show continuous degradation over the period of record from 1947 to the present. Three sections, SRC4, SRD1 and SRE3 aggraded cumulatively between 1947 and 2005 by 1.9, 1.4, and 3.1 feet on average, respectively. While it is unclear why the observed aggradation occurred, it is presently believed to be the result of the fires of the Summer of 2004 and the heavy rains of the 2004/2005 rainy season. This combination had the potential to produce high sediment runoff loading into the River. Degradation seems to be more prevalent on the upper half of the study reach while mild fluctuations about a mean are more apparent on the lower half. This appears to result from the relatively steep, narrow, winding upper portion of the study reach versus the relatively flat, wide, braided channel in the lower portion of the study reach of the River. Agricultural activities occurred, primarily in downstream sections but in upstream sections as well, so some of the observed channelization may have resulted from these activities.

Other scour considered in this study is comprised of four sub-categories: local scour, bend scour, low-flow incisement, and bedform height. Local scour occurs in the vicinity of flow obstructions including piers and abutments. Bend scour occurs because of velocity gradients around curves in fluvial systems. Three distinct bends are located in the study reach. Low flow incisement is included to represent thalweg or low flow channel depth. On-site inspection and review of historic data of this feature suggest a thalweg depth of approximately two feet. Finally, bedform height represents the dunes and anti-dunes that develop in active soft-bottomed channels during flow events. In this study, bedform height has been limited after Kennedy (1963). Local scour ranges from 0.0 to 17.4 feet in the proposed conditions at the various river crossings. Results of calculations of bend scour vary from 0.0 to 11.3 feet for the existing condition and 0.0 to 8.9 feet for the proposed condition. For both the existing condition and the proposed condition, the bedform height ranges from 0.5 to 8.3 feet. Changes between the existing and proposed conditions are a reflection primarily of the change in velocity brought about by the proposed condition.

General adjustment, long-term adjustment, and other scour are summed to determine total potential bed adjustment following LACH&SM methodology. For cross-sections where SAM modeling predicts aggradation, the general adjustment contribution to total bed adjustment is not included for degradation calculations. The existing condition is predicted to have a combined bed adjustment of approximately -6.9 to -19.7 feet for the outside of curved reaches and -6.2 to -15.4 feet for the inside of curved and straight reaches. Calculations in the proposed condition predict that the combined bed adjustment ranges from approximately -6.7 to -26.2 feet for both the outside of curved reaches and for the inside of curved and straight reaches.

A comparison of total bed adjustment estimated by both the summed methodology and the LACFCDDM methodology shows that the more intensive LACH&SM methodology using SAM for general adjustment and historical analysis for long-term adjustment predicts a shallower toe-down for both the existing and proposed conditions than does the LACFCDDM methodology except for sections in the vicinity of subreach SRA2, SRB1, SRC2, and SRE1. In subreach SRA2 section 43820, very high long-term adjustment causes LACH&SM calculations of this section to exceed LACFCDDM calculations by 1.4 feet for both outside of curved reaches and straight or inside of curved reaches in the existing and proposed conditions. In SRC2 section 29140, higher general adjustment and higher bedform height cause LACH&SM calculations of this section to exceed LACFCDDM calculations by 0.6 feet in outside curved reaches and 1.2 feet in straight and inside of curved reaches for the existing condition. In SRB1 section 36080 and SRE1 section 15125, the presence of proposed bridges causes LACH&SM calculations of this section to greatly exceed LACFCDDM calculations, by more than 10 feet. LACH&SM methodology utilizing SAM calculations predicts a deeper toe-down than does the LACFCDDM at these locations methodology because the LACFCDDM does not account for the effects of local degradation as effectively.

Freeboard is considered for the purposes of this report to be the additional height required above the top of a levee or other bank protection to prevent overtopping. Freeboard elevation is calculated in this study based on LACH&SM Chapter 5A-3, and includes LACFCDDM calculations. The freeboard for the River ranges from

approximately 2.5 to 5.2 feet for both outside of curved and straight or inside of curved reaches in the proposed condition. Maximum total toe-down, total freeboard, toe-down elevation and freeboard elevation are presented in Table 8.

Previous studies estimated that a toe-down of 12.5 feet would be required for adequate protection. The results of this study, however, suggest that a variable toe-down from approximately 5 to 27 feet based on SAM modeling, or 8 to 21 feet based on LACFCDDM. A large portion of this difference can be attributed to the difference in general adjustment. It is expected that HEC-6 modeling will be on the order of 1 to 5 feet general adjustment.

1 Introduction

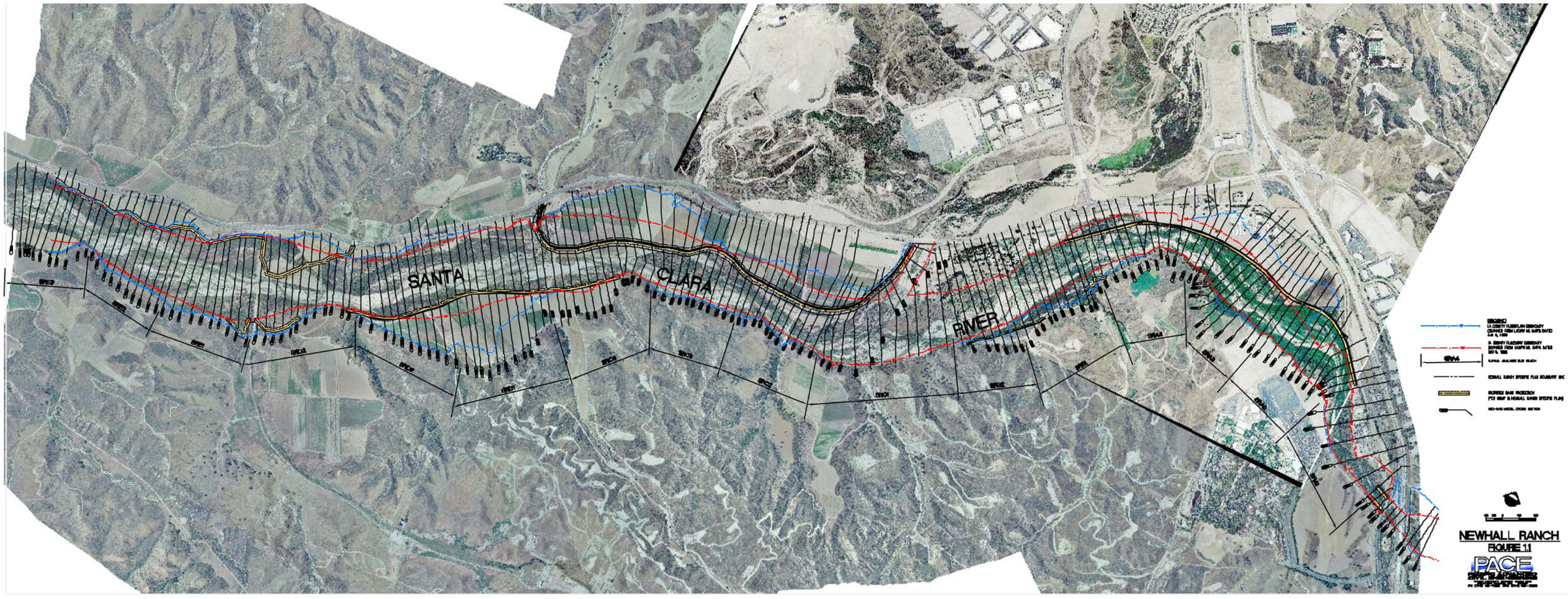
The following technical investigation provides a detailed and focused evaluation of the fluvial characteristics and long-term stability of the Santa Clara River for the reach including all of Newhall Lands' proposed Newhall Ranch and Phase 1 Landmark Village development. The River study reach is located from Interstate 5 on the east and to a point directly downstream of the Ventura County/Los Angeles County line (Figure 1.1). This reach includes the Newhall Ranch Specific Plan and the proposed Entrada project. The first phase of the Newhall Ranch Specific Plan (Landmark Village) is bounded by the River on the south, State Highway 126 on the north, Castaic Creek on the east, and Grande Canyon on the west (Figure 1.1). The Santa Clara River fluvial system extends from Acton, California in the east to the Pacific Ocean, the River's natural terminus, in the west. Adjacent development along the River within the study reach has the potential to modify the fluvial response of the watershed through changes in the runoff and reduction in the sediment supply from the developed areas. The proposed buried soil cement bank protection on both the north and south banks of the River within the study reach is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. These modifications to the river system have the potential to modify the fluvial operation of the floodplain and cause changes to the stream mechanics. The intent of this analysis is to evaluate these impacts from (1) fluvial modifications of the river bed from single hypothetical storm events, (2) changes in the floodplain fluvial operation over the long-term; and, (3) to determine the top and toe of the proposed bank protection.

1.1 Types of Adjustment

Modifications to the river system are measured as bed adjustment in feet. Positive adjustment indicates bed aggradation while negative adjustment indicates bed degradation. Several types of adjustment are considered in this study including general adjustment, long-term adjustment, and other scour. General adjustment consists of scour that occurs in an individual discharge event, and may be considered as the difference between sediment inflow and outflow. That is, if sediment inflow into a given reach is higher than sediment outflow for the same reach, aggradation will occur. In contrast, if sediment outflow exceeds inflow for a given reach, degradation in the form of scour will occur in the reach. Long-term adjustment consists of fluvial processes that occur over many rainy seasons and contribute fluctuation of bed elevation of a river or creek. Other scour is comprised of local scour, bend scour, low-flow incisement, and bedform formation. These are discussed in detail, below.

1.1.1 Study Objectives

The primary objective of this report is to develop the technical engineering analysis to assess river bed impacts from potential modifications of fluvial operation from proposed development west of Interstate 5, including the Newhall Ranch Specific Plan. The intent is to provide a comprehensive assessment of short- and long-term bed adjustment. This report provides technical analysis for (1) general adjustment, (2) long-term adjustment, (3) other scour, (4) study reach gradation, (5) SAM modeling and analysis, (6) HEC-6 modeling and



A full-size reproduction of this figure can be found at Impact Sciences.

analysis, and (7) total soil cement bank protection toe-down design. The objectives of the fluvial assessment for the proposed development project include the following:

1. Quantify the fluvial parameters that are representative of the river bed characteristics.
2. Model the existing and proposed conditions river bed and fluvial processes.
3. Provide preliminary assessment of the streambed stability through determination of the sediment transport capacities within different reaches of the floodplain.
4. Provide toe-down depth assessment throughout the study reach.
5. Provide freeboard height assessment throughout the study reach.
6. Determine any impacts to off-site properties.

A variety of engineering analysis and tasks were associated with both the different aspects of the watershed hydrology and floodplain hydraulics. A technical framework was developed to guide the analysis of the system. These major task areas of study reflected the various objectives of the study and included the following:

1. Floodplain field investigations – Perform field reconnaissance of the existing watershed conditions as well as ground photo survey along the entire existing creek system within the fluvial study boundary.
2. Baseline digital floodplain cross-section geometry – Layout appropriate spacing and location of cross-sections to establish the representative channel geometry. Digitally develop extremely accurate cross-section coordinate points using topographic digital terrain models (DTM) and CAD subroutines suitable for hydraulic model format. Adjust cross-section data to include horizontal variation of roughness and other attributes.
3. Baseline HEC-RAS hydraulic model – Prepare floodplain model in HEC-RAS based on the 1999 digital geometry and existing condition flowrates. Evaluation based on single storm event and steady flow conditions.
4. HEC-2 model creation – Conversion of HEC model formats for use in SAM and HEC-6 modeling.
5. Floodplain reach characterization and parameter estimation – Prepare an assessment of the hydraulic parameters and evaluate the statistics. Determine hydraulic subreaches based on hydraulic statistics. The analysis involves determining the average hydraulic properties for each reach and then applying the appropriate sediment transport relationship to each grain size fraction.
6. Sediment transport capacity analysis – Prepare steady state sediment transport capacity analysis through dividing the channel system into different reaches and comparing the capacity within each reach.

7. Analyze historic trends in river bed adjustment – Consider available historic data to gain insight into changes in bed characteristics throughout the period of record.
8. Analysis of local bed adjustment components – Study of the individual components of local bed adjustment.
9. Calculate toe-down depth – Calculate the total toe-down depth of proposed soil cement bank protection based on the analysis of individual bed adjustment components.

2 Previous Fluvial Analyses for Study Reach

2.1 Introduction

Three sediment transport studies have been conducted within the study reach between Interstate 5 and the Los Angeles/Ventura County line in the last 25 years. The first study conducted by Sikand Engineering was submitted in June 2000, and revised November 2004. The purpose of the Sikand study was to provide HEC-6 sediment transport analysis for the Santa Clara River to determine the possible effects of the Newhall Ranch Development on river bed stability. The Sikand study relied on previous work conducted by SLA which was submitted June 1998 in *HEC-6 Sediment Transport Analysis for ACOE General Permit on Santa Clara River (from Castaic Creek to Cottonwood Avenue) and San Francisquito Creek (from Santa Clara River to 15000' Northerly)*.

The second study produced by Simons, Li, and Associates and submitted November 1990, sought to provide information for flood and fluvial process management in the Santa Clara River from Soledad Canyon to Castaic Creek. The study included multiple tasks including data collection, quantitative analysis and mathematical modeling, alternatives evaluation and other assignments.

The final study was conducted by the United States Geological Survey and completed in August 1979. The study sought to determine the sediment discharge in the Santa Clara River Basin in Los Angeles and Ventura Counties using sediment trap (1968-1975) and historical data (1928-1975). Sediment data was collected for the period 1967 to 1975 at the Los Angeles/Ventura County line.

2.2 Sikand Engineering Associates, 2004

The Sikand study covers the portion of Santa Clara River from Interstate 5 to the Los Angeles/Ventura County line. The study utilized the ACOE HEC-6 model to assess how improvements in the River as part of the Newhall Ranch Development will alter sediment transport. The primary focus of the study was the long-term degradation of the river bed and the toe-down depth required for proposed improvements. Both the existing and proposed model conditions were developed in HEC-RAS and the only differences between the models was the incorporation of proposed levees. Soils data was taken from the SLA study in Chapter 4 of the Interim Report, Existing Conditions Data Collection. Grain size distribution plots indicate poorly graded sand with gravel and a D_{50} of approximately 1 mm in the vicinity of the Castaic Creek confluence. Only HEC-6 input files offer sediment information. The inflow sediment boundary condition and grain size distribution was also taken from the SLA study. Conversions from tons sediment per day to feet of scour was calculated by assuming a four day duration and sediment specific gravity of 2.65. Several discharges were run in the numerical modeling including the Capital and 100-year storm events. The report does not specifically note the discharge of either event.

The study found that for seven subreaches in the present condition, the bed is in steady state, but that the proposed conditions are expected to cause minimal degradation (an average of one foot) in some subreaches and minimal aggradation (an average of three feet) in some subreaches. The study also analyzed the historical record of gage data at the county line from 1953 to 1993, and determined that a 1500 cfs minimum discharge was required to generate sediment transport. By comparison, USGS data (*Sediment Discharge in The Santa Clara River Basin, Ventura and Los Angeles Counties, California*) notes in Table 3 that in 1971 at 1470 cfs, 99% of the transport was silt at the county line. It is important to note that PACE is citing the SLA study and not making the claim. PACE does not model silt in the present study since it is generally transported as wash load and is not pertinent to the present study's goals.

It is important to note that the results of this study were not accepted by Los Angeles County Department of Public Works, and the comments on the last review of the study in 2004 were not addressed.

2.3 Simons, Li & Associates, 1990

The SLA study is broad in reach and included use of the proprietary QUASED numerical model for fluvial analysis. At present, it is not clear if this model is still applicable or how it compares to other fluvial modeling software such as HEC-6. The study included a large volume of data analysis including flood flow frequency analysis, HEC-2 numerical modeling, historic photograph analysis, and sediment yield calculation. Supplemental design criteria are provided for subsequent studies. Sediment gradation data was presented in an interim report that indicates an average D_{50} of approximately 1.3 mm below Interstate 5. Boring logs are present in the SLA study. There is no apparent consistent vertical distribution of sediment grain size between boring logs.

The study suggests a 100-year return period discharge in the River of 47,100 cfs in the vicinity of the Interstate 5 bridge. For the portion of the River downstream of Interstate 5, the bed was found to be adjusting between -0.1 to +1.0 feet. The study notes that the River appears to be in "pseudo-equilibrium" and "shows no trend toward either aggradation or degradation and significant lateral migration of the channel is not apparent." QUASED modeling suggests that some reaches increase degradation potential as the result of encroachment by improvements as compared to the existing condition. For the portion of the River downstream of Interstate 5, some portions of the bed are expected to aggrade more, while others are expected to degrade more. Downstream of Mint Canyon on the River toe-down, design depth of 12.50 feet is recommended with a general scour of 2.68 feet, a bed form height of 4.92 feet, a low flow incisement of 2 feet, and a total scour of 7.14 feet (Table 3.20, p. 3-54).

The SLA report was reviewed in detail by LADPW and response to comments made, however, the report was not revised to obtain final LADPW approval.

2.4 USGS, 1979

The USGS study collected sediment data from 1967 to 1975 at three sites in the Santa Clara River basin including the Los Angeles-Ventura County line. The study estimated long-term sediment discharge by applying the sediment and water discharge relationship observed from 1967 to 1975 to long-term records of water discharge (1928-1975).

During the short-term period (1968-1975), total sediment discharge was 63.5 million tons, 59.5 million tons of which was carried in suspension. Coarse sediment accounted for 28% of the total sediment discharge (17.7 million tons). Transport of the majority of sediment occurred during only a few days of flood flow each year (55% of the total sediment within 2 days and 92% within 53 days).

Sediment deposited in reservoirs (Lake Piru and Pyramid Lake) resulted in a 6% reduction of sediment to the River basin during the historical period (1928-1975) and 12% during the period most affected by dams (1953-1975). Castaic Creek interception of sediment reduced the amount of sediment in the River by another 2% from 1928-1975 and 4% from 1953-1975. It is not clear how these reductions are directly related the completion of the Castaic Creek Dam because it was not completed until 1971.

3 Sediment Characterization and Analysis

3.1 Sediment Data Collection

To characterize the sediment of the river bed and by extension the possible bed load of sediment during discharge events, a sediment grain size analysis was conducted. The goal of the analysis is to gain a statistical representation of the size distribution of soil components of the river bed. Grain size distribution analysis is a powerful tool because the results can represent both a qualitative description of soil make up as well as quantitative input for further predictive measures, such as fluvial modeling.

Sediment collection for the Santa Clara River along the study reach was conducted by Allen Seward Engineering Geology, Inc. Eighteen samples were collected along the river with a total of 23 including samples taken at the tributaries. The relevant sampling locations are compiled in Table 3.1. All sampling was conducted using grab samples of the upper foot of the active or recently active portion of the bed. At least three samples at different locations within a sampling station were taken at each River sampling location. Sampling locations for the study are presented in a February 14, 2005 report, reproduced in Appendix Chapter 3.2.

Table 3.1: Santa Clara River Location and Average D_{50} of Sediment Samples

Reach	Station	Sample Number	Reach Average D_{50} (mm)[1]
A & B	37135	CB1	0.5
	37135	CB2	
	36515	CB3	
C	28500	HR1	0.95
	28500	HR2	
	28500	HR3	
	24115	LC1	
	24115	LC2	
	24115	LC3	
D	22195	AC1	1.0
	22195	AC2	
	22195	AC3	
D & E	15335	MC1	1.0
	15335	MC2	
	15335	MC3	

1: Reach average is the average of all samples I the reach.

3.2 Sediment Gradation Analysis

Generally, grain size distribution analysis is broken down into three distinct steps. The first step is to dry the samples. Drying is accomplished in a desiccator or similar apparatus. The second step is to sieve or otherwise

separate the sediment by particle size. Finally, fine material (smaller than standard mesh 200) is analyzed using hydrometric techniques. The sediment distributions are plotted on semi-log plots by percent finer for a given sample size. For this study, no fine material is included in analysis because fine material is generally transported as wash load, which is not of concern here. Distribution data has been averaged on a station by station basis. Averaging is accomplished by taking the mean of the three samples from a given station. Averaging provides a single representative sediment grain size distribution for a given station that can be used for numerical modeling or other analysis. Plots of the mean grain size distribution for each sampling station are presented in Figure 3.1A-E. Raw grain size distribution plots for the study are presented in the February 14, 2005 Seward report, reproduced in Appendix Chapter 3.2.

3.3 Sediment Characterization

A review of the raw gradation curves indicates that most samples are comprised of poorly graded sands with gravels and silts. The D_{50} values for all samples ranged from 0.25 to 4.67 mm with an average of 0.8 mm. A comparison with Figure 3.2A-B indicates that averaging retains the sandy character of the sampled soil. The averaged D_{50} values range from 0.5 to 1.0 mm. Additionally, previous SLA study noted above also found similar sandy characteristics, however, the average grain size was found to be approximately D_{50}=1.3 mm, somewhat more coarse that the current sampling.

Seward sampling was conducted on approximately the upper foot (recently active layer) of the bed, as noted above. To be conservative, no armoring layer (cobble layer) depth is assumed in sampling which allows the bed to fluctuate freely in numerical modeling. Additionally, the true armoring layer has not been observed in field measurements including Seward field studies and SLA boring logs. This study assumes that the grab sampling at the surface represents the below-surface bed. While the SLA boring logs do show vertical variation in grain size distribution, a consistent grain size vertical distribution is not evident.

The County has noted that cobbles are present in the SLA study boring logs, which is true. Cobbles are not present in any of the grain size distribution curves in the SLA study (particularly in the Landmark study reach), however, careful review of the boring logs down to approximately 10 feet (approximately five times the SAM single event depth) notes only sporadic cobble observances, generally less than 5% and rarely as much as 10%. More importantly, is the fact that at sample location 11 (in the Landmark Village study reach, p. B.5) no cobbles are observed until 8.5 feet. Because of the paucity of cobble occurrence in both the boring logs and their depth below the SAM single event depth, taken as the active depth, PACE believes that the sampling data collected by Seward is representative of the active bed.

LACDPW has noted that previous versions of this report included different sediment gradation data than is present currently. Careful review of the data reveals that most of the sampling for the January 2005 PACE draft report, compiled by Seward, was for upland and tributary locations, many at the proposed Landmark site. Some of the samples in that report included River

sample sites; however, only single grabs were included. The February 2005 PACE draft report includes multiple grabs by Seward at each River sample location providing a much greater degree of confidence in the data by being able to spot outliers (here in the statistical sense). Because there is no way to independently determine the efficacy of the samples in the January 2005 report, the gradation data was replaced with more verifiable data. The January 2005 data is not included in this draft.

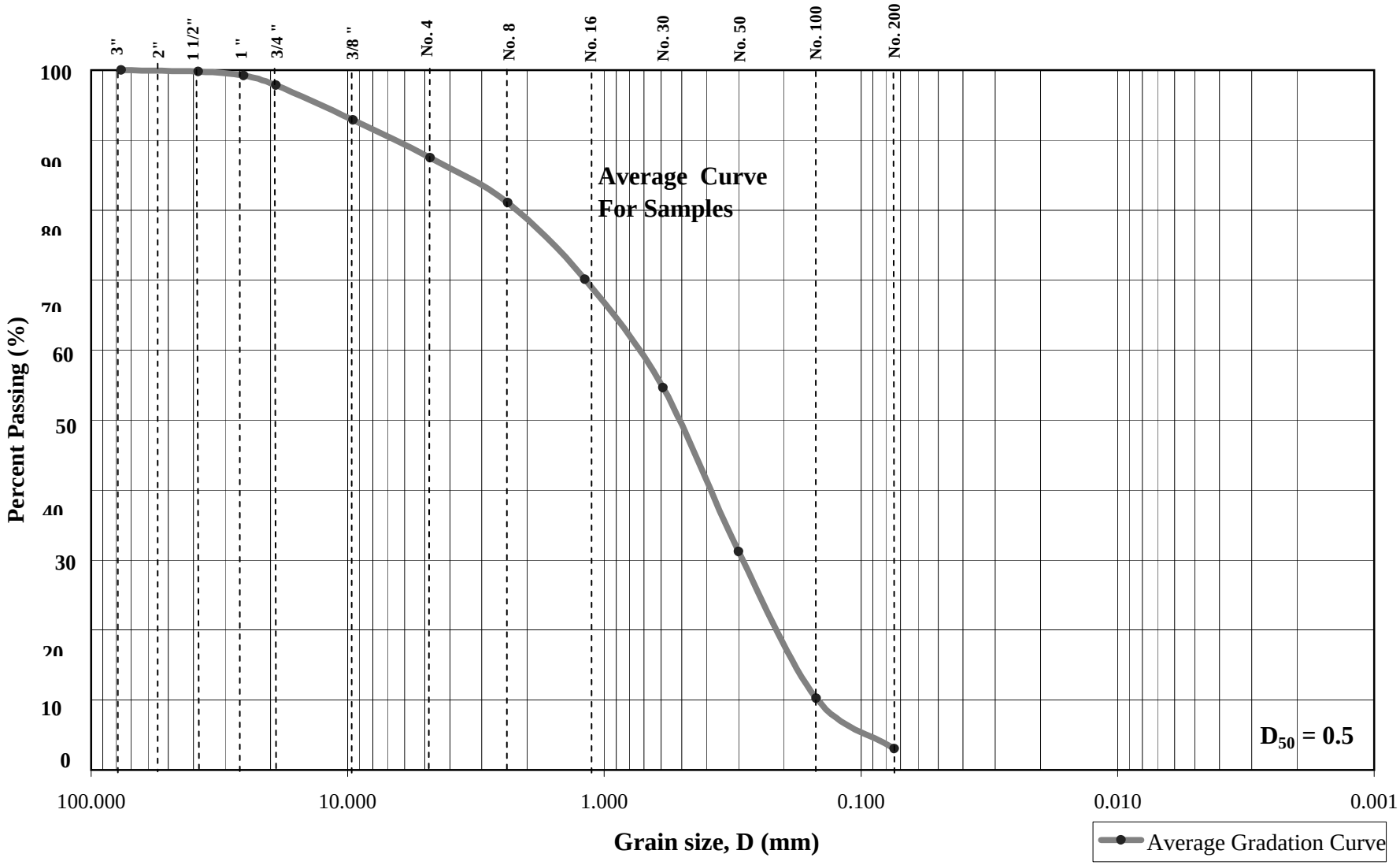


Figure 3.1A. Santa Clara River Reach A Average Gradation Curve

P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\scrgrainsize - new reach a (cb 1, 2, 3) 10-02-05

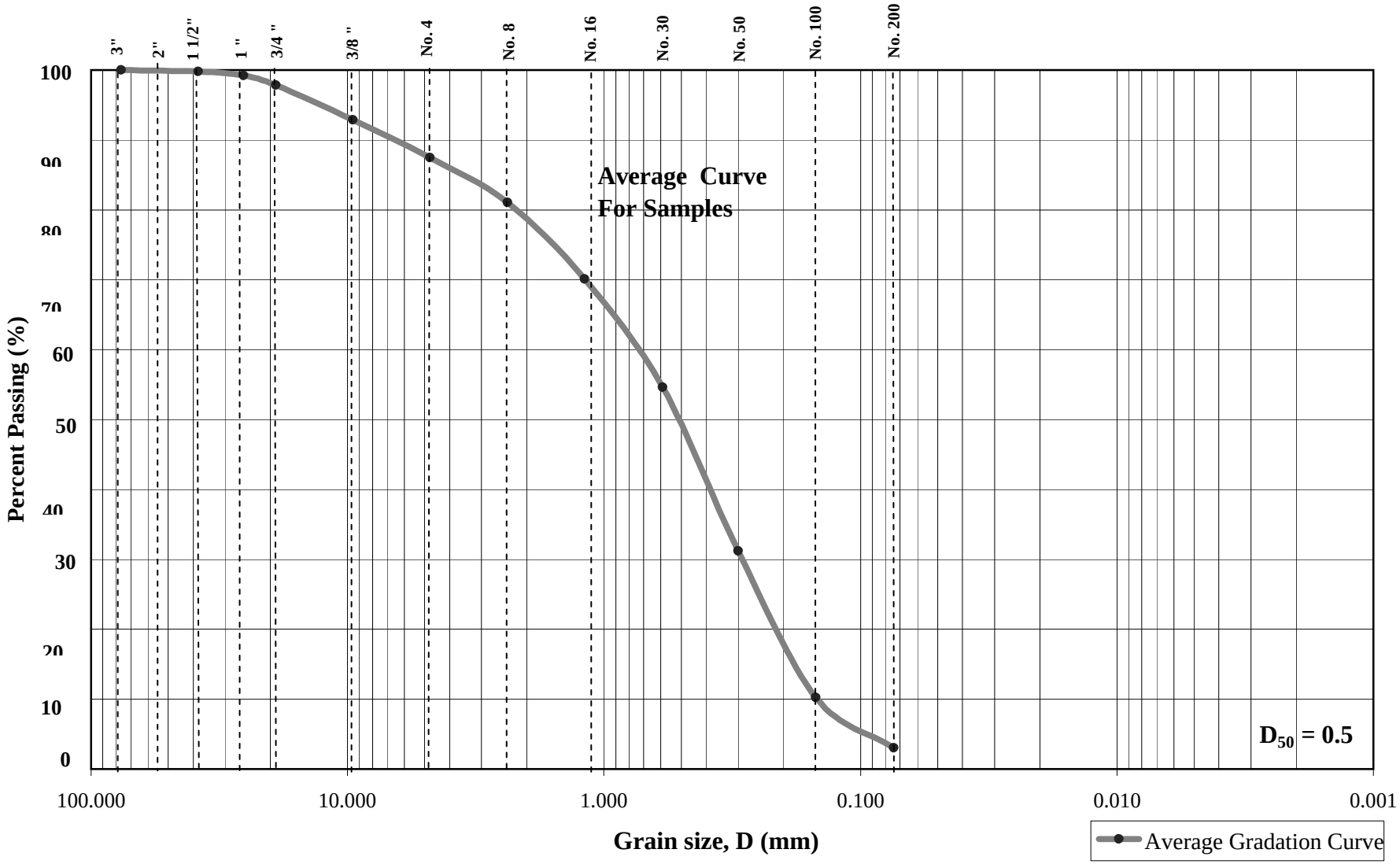


Figure 3.1B. Santa Clara River Reach B Average Gradation Curve

P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\scrgrainsize - new reach b (cb 1, 2, 3) 10-02-05

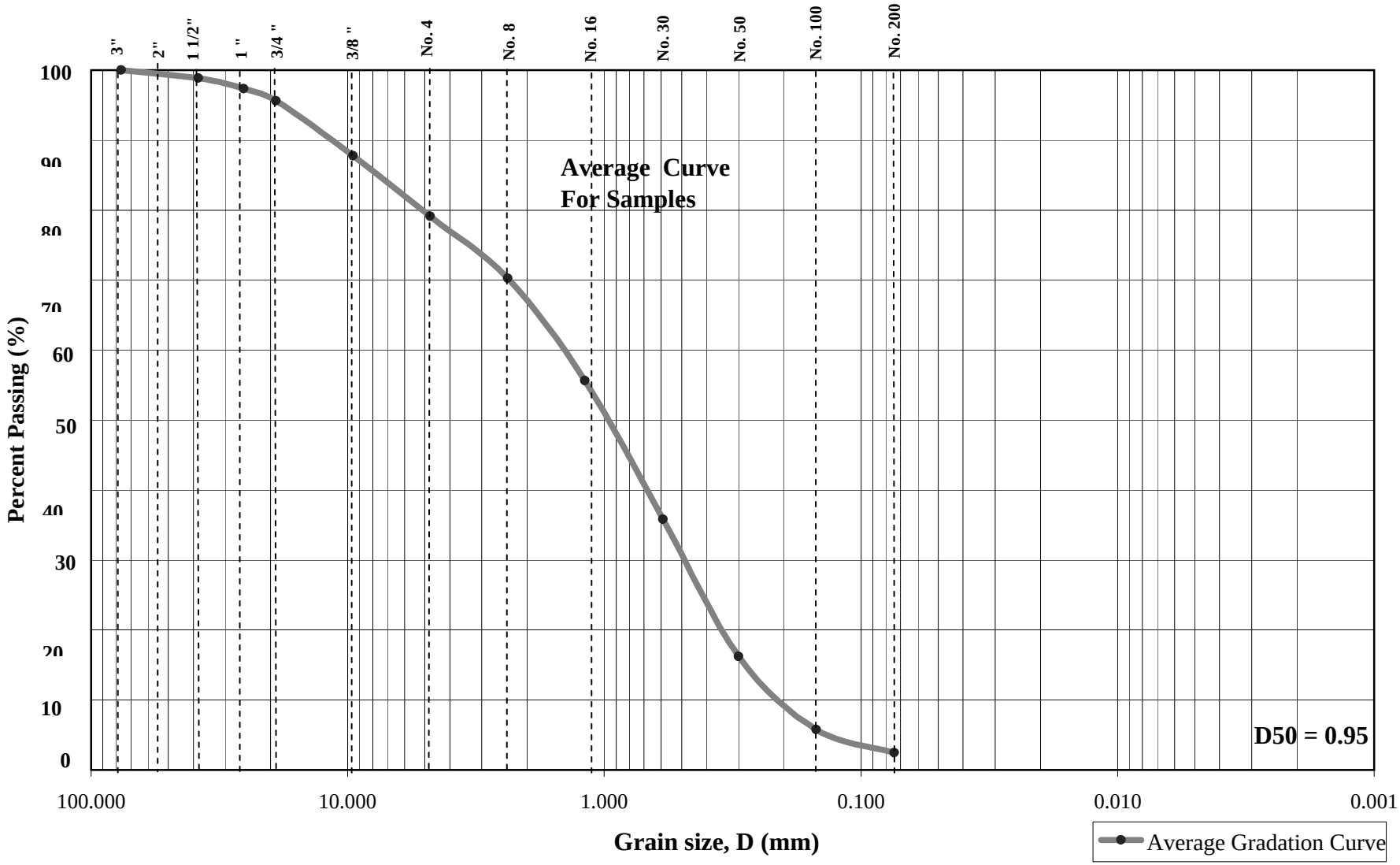


Figure 3.1C. Santa Clara River Reach C Average Gradation Curve

P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\scrgrainsize - new reach c (hr 1, 2, 3 & lc 1, 2, 3)

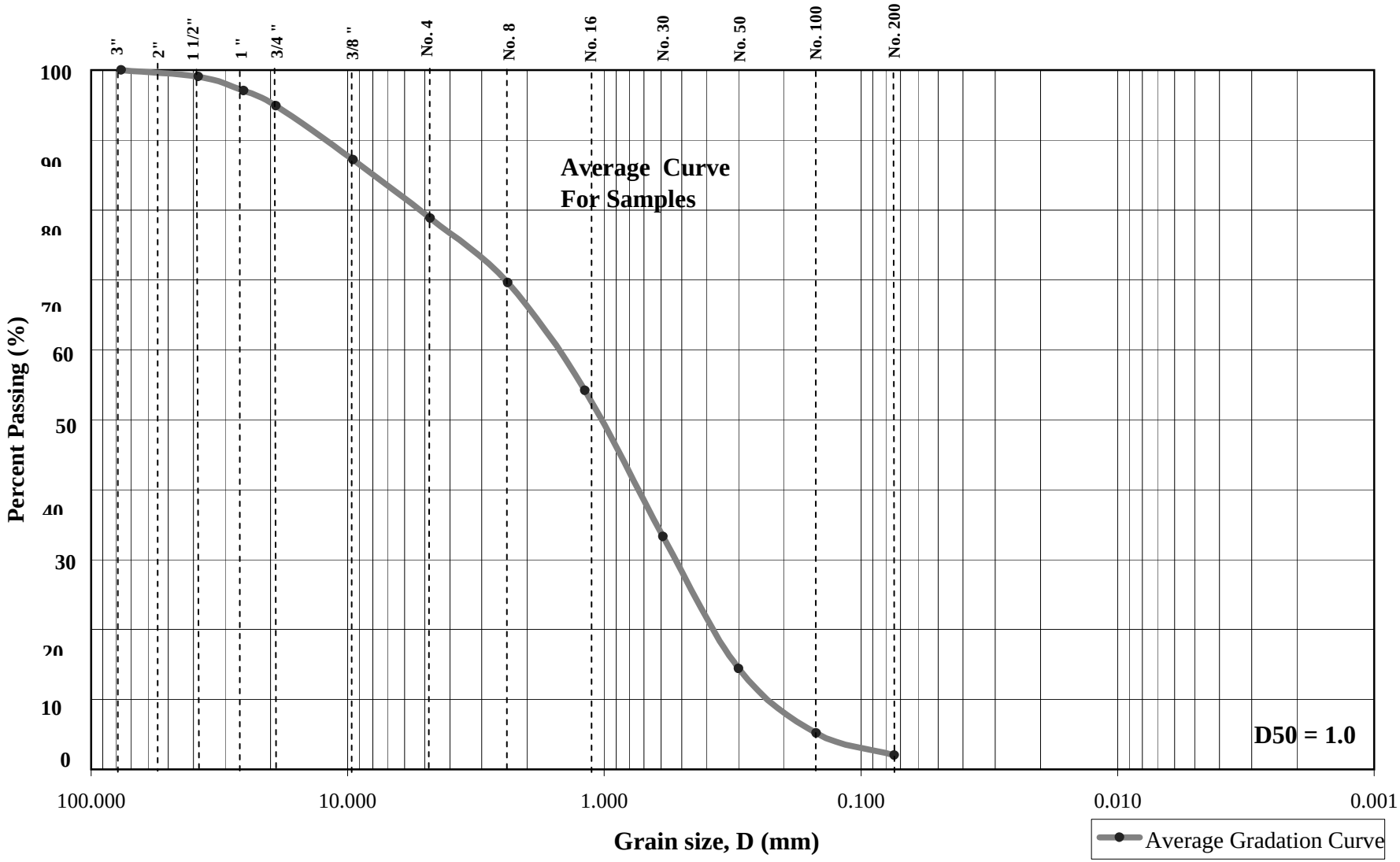


Figure 3.1D. Santa Clara River Reach D Average Gradation Curve

P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\scrgrainsize - new reach d (ac 1, 2, 3 & mc 1, 2, 3) 9-19-05

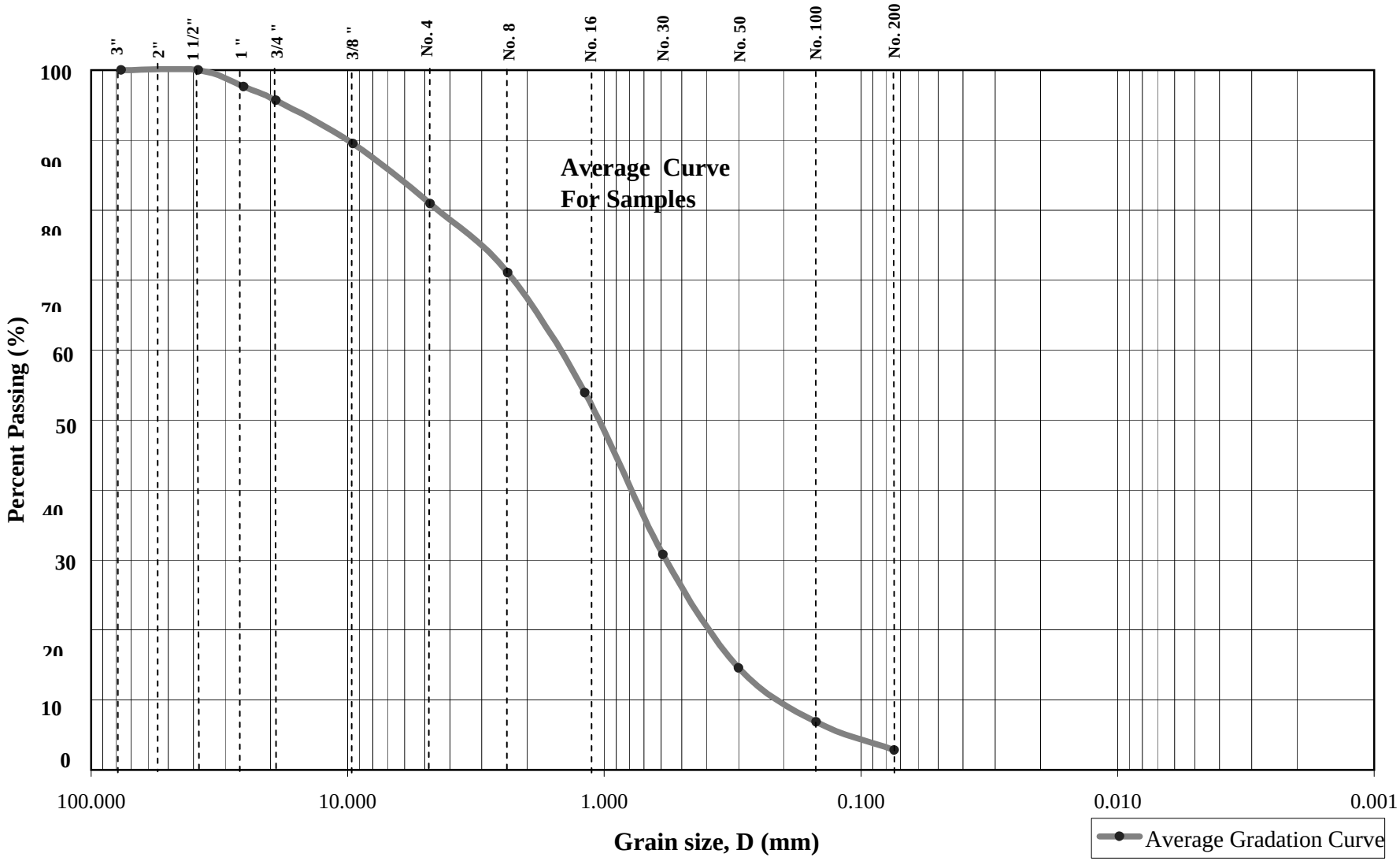


Figure 3.1E. Santa Clara River Reach E Average Gradation Curve

P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\scrgrainsize - new reach e (mc 1, 2, 3) 9-19-05

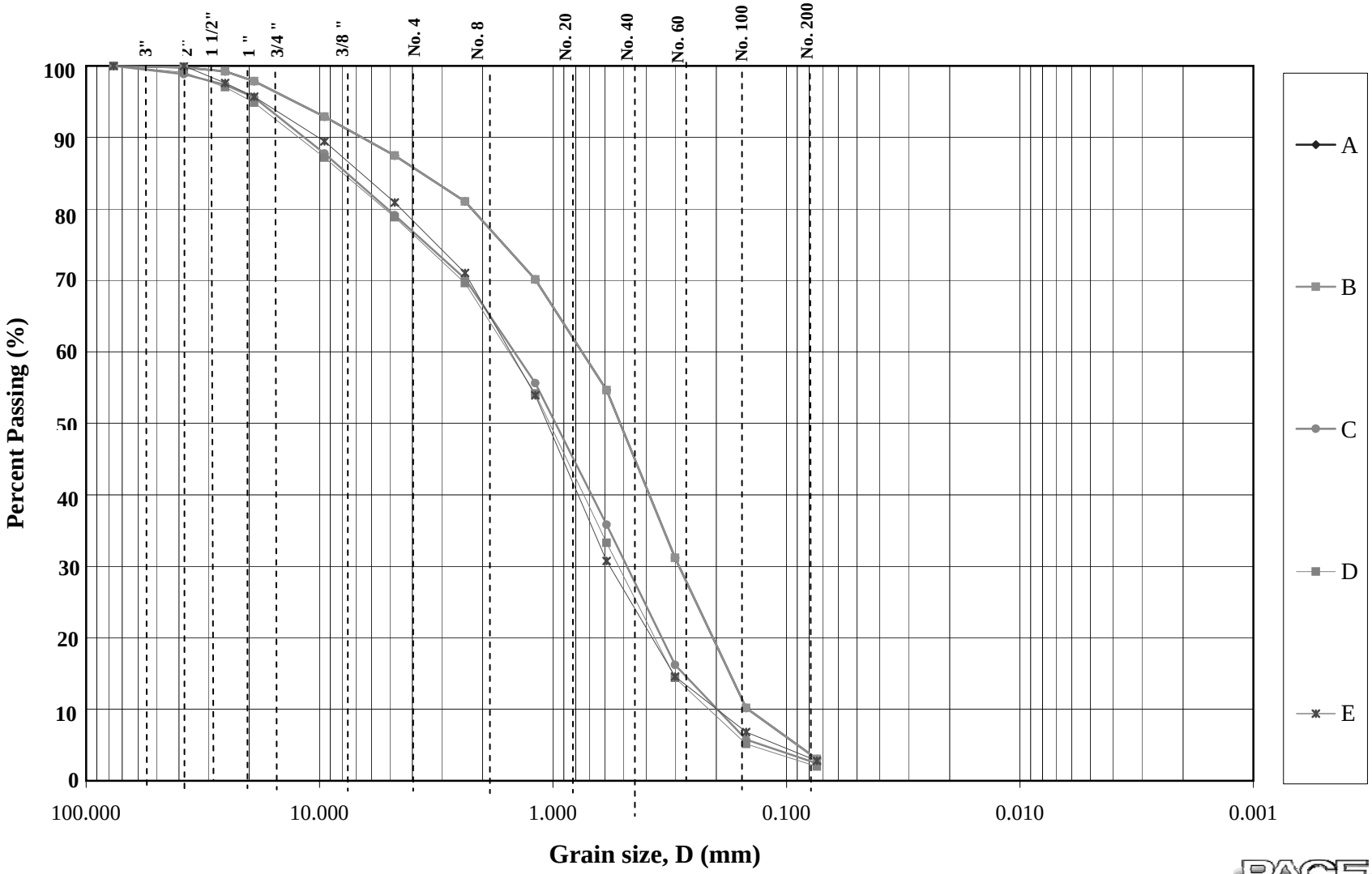


Figure 3.2A. Santa Clara River Streambed Grain Size

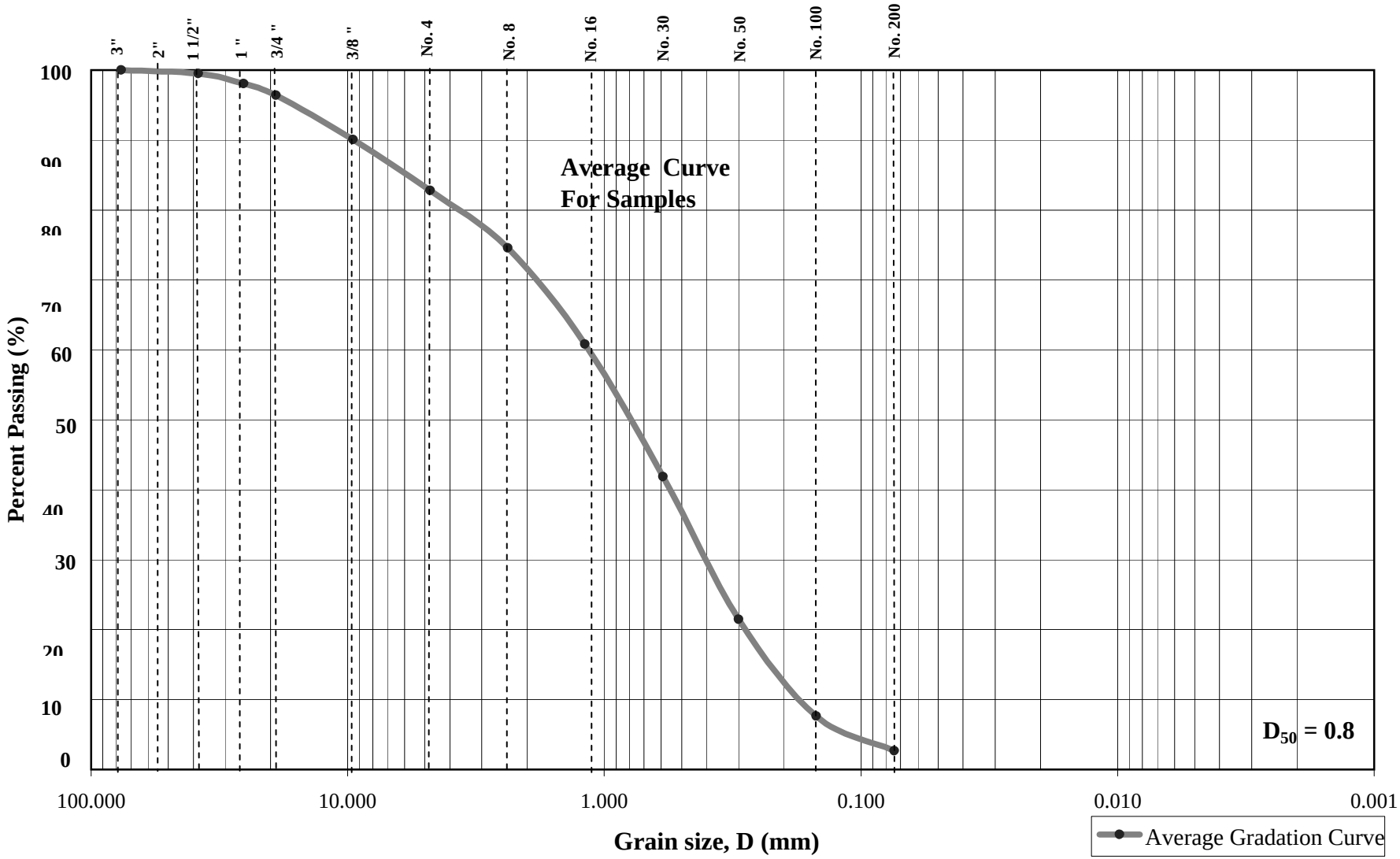


Figure 3.2B. Santa Clara River Average Gradation Curve

4 General Adjustment

4.1 SAM Model

General adjustment was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a first calculation of sediment transport potential for multiple subreaches within the Santa Clara River (SCR). The SAM Sediment Hydraulic Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity for a given channel or floodplain hydraulic cross-section for a given discharge at a single point in time. A number of sediment transport functions are available for this analysis and SAM has the ability to assist in selecting the most appropriate sediment transport equation.

The three primary fluvial components of SAM are SAM.HYD, SAM.SED and SAM.AID. SAM.HYD provides a steady state, normal-depth, one-dimensional representation of channel hydraulics. The SAM.SED module combines the hydraulic parameters with the bed material gradation curve to compute bed material discharge rating curves by size classification. The SAM.AID module provides the user with recommended sediment transport equations based on the best matches between hydraulic parameters and grain size distribution of the study reach with parameters of from widely accepted and published research.

4.1.1.a SAM Model Theory and Limitations

The SAM numerical model is built upon hydraulic and fluvial components. The hydraulic components include representations of river bed characteristics that are input into an analytical procedure. The fluvial component includes representation of bed gradation as percent finer statistics and a selection of up to twenty sediment transport equations. SAM's hydraulic component will accept either average reach parameters or cross-section data imported from HEC-2/HEC-6 models. Hydraulic modeling is based on a uniform flow equation where discharge is the dependent variable such that,

$$Q = f(D, n, W, z, S)$$

where Q is discharge in cfs, D is flow depth in feet, n is the Manning's number, W is bottom width in feet, z is the channel side slope, and S is the energy slope. The bottom width is representative of the total moveable bed width of the channel and Manning's number is a composite value. Normal depth is calculated using Manning's equation, and effective values of width and depth are calculated following normal depth calculations. In cases where HEC-2 cross-sections are used for modeling, as in this study, the

effective depth and width are calculated from the cross-section data based on the channel hydraulics.

The fluvial component is based on sediment transport functions to calculate the bed portion of the sediment discharge-rating curve.

The sediment transport equations are of the form,

$$GS_i=f(V, D, S_e, B_e, d_e, \rho_s, G_{sf}, d_s, i_b, \rho_f, T)$$

where GS_i is the transport rate for sediment size class i; the hydraulic terms V, D, S_e, and B_e, are the average velocity, effective flow depth, energy slope, and effective flow width, respectively; the sediment particle parameters d_e, ρ_s, and G_{sf} are the effective particle size, particle density, and grain size shape factor, respectively; the sediment mixture properties, d_s and i_b are the geometric mean particle size of sediment class i and fraction of class i in the bed, respectively; and the fluid properties ρ_f, and T, the water density and temperature, respectively. Twenty well known, published, peer-reviewed transport equations are available including Ackers-White, Colby, Laursen-Copeland, Laursen–Madden, MPM, Toffaleti, Yang, Van Rijn and others. Once the data assembly is complete, the SAM.SED module can be used to create a sediment discharge-rating curve based on grain size distribution. The reader is referred to the SAM user's documentation for further reference.

It is important to note that the SAM model is a zero-dimensional computational package that is only based on a single cross-section at a particular point in time. As such, SAM simulations can only represent a reach average during a steady state discharge. Because SAM applies sediment transport to a point, no variability in size distribution in either space or time is calculated. With these limitations in mind, in this study SAM is intended to provide a first approximation to sediment transport to which other more sensitive calculations can be compared.

4.1.1.b SAM Model Assembly

In this study, hydraulic representation of the river bed is accomplished in several distinct steps. First, the HEC-RAS numerical model (1999 base topography) is thinned to no more than 100 stations per cross-section using HEC-RAS's cross-section points filter. Second, the HEC-RAS geometry is converted to HEC-2 format using the Army Corps RAS2UNET software. Next, the HEC-2 model deck is arranged to run in sub critical mode and all features, such as ineffective flow areas and levees, are added. Once the HEC-2 model is complete, it is re-imported into HEC-RAS and compared to the original model. Any cross-sectional differences between the RAS and 2 models are resolved. Once the original and re-imported models match, the HEC-2 model is run to

produce the Army Corps' T95 binary hydraulic simulation output file. Next, the T95 file is then read directly into SAM using the SAM model's M95 subroutine using the reach length option. Sections are chosen based on the reach characterization described below. A comparison of output and discussion is presented in Appendix Chapter 4.4.

This conversion methodology is powerful because it ensures that data created for, and analyzed using HEC-RAS and HEC-2 hydraulic software, is fully compatible with, and implemented in, SAM fluvial analyses. Copies of the HEC-RAS and HEC-2 models for both the existing and proposed conditions are included in Appendix Chapter 4.3. A table comparing the velocity and depth of the different models used in each phase of the project described previously is also included in Appendix Chapter 4.4. Both the existing and proposed conditions HEC-RAS model were originally developed by Sikand Engineering in *Newhall Ranch Santa Clara River HEC-RAS Study* (June 2000) and submitted as part of the Newhall Ranch Specific Plan. The Sikand model was further modified by PACE to create a model that was reviewed and accepted by LACDPW. The newest model Q_{CAP} discharge was approved by LACDPW for this study in 2005. Slight differences exist between the PACE and Sikand models in terms of discharge and stationing and have been made to meet LACDPW criteria, otherwise the models are the same. Otherwise, the only changes made to the HEC-RAS model occur in the proposed condition where the alignment of soil cement bank protection was revised to reflect the most current proposed condition, and the afore mentioned Q_{CAP} discharge. The current position of the bank protection avoids River jurisdictional areas and is further outside the River than the bank protection originally proposed in the Sikand model. The HEC-RAS model discharges in the present models were originally included in the Sikand model, except for the revised Q_{CAP} discharge, which was provided by LACDPW, as noted above. Finally, subreaches within the SAM model are specified and average hydraulic parameters are calculated for those subreaches. Subreaches are determined by examining the hydraulic parameters of the individual HEC-RAS cross-sections and identifying correlations between those hydraulic parameters and the longitudinal position in the channel of the individual cross-section. This process is presented in Appendix Chapter 4.5.

4.1.2 Reach-by-Reach Channel Hydraulic Characterization

Reaches are defined by changes in discharge within Santa Clara River. These changes occur at HEC-RAS sections STA 46195, STA 36080, STA 32265, STA 22195, and STA 15125, as shown in Figure 1.1. As noted above, SAM modeling is based on channel subreaches determined by correlating hydraulic characteristics with longitudinal cross-section location to preserve the along-stream character of the flow. The hydraulic parameters examined are discharge, energy slope,

bed slope, Froude number, top width, hydraulic velocity, and flow area based on the Q_{CAP} discharge. First, correlation coefficients are calculated for each section against the hydraulic parameters. The hydraulic parameter that produces the greatest correlation is plotted against cross-section location. Subreaches are then selected in a manner that preserves the trend of the hydraulic parameter as well as produces approximately equal subreach lengths, which are generally 1000 feet long. This methodology seeks to maintain continuity of analysis by producing similar length subreaches while analyzing the hydraulic parameters that largely control sediment transport. Correlation values typically vary from r=±0.25 to r=±0.82. In the case of the Santa Clara River, all subreaches have been defined based on locations of trend changes within the River. Subreaches are defined in Table 4.1A-B and shown in Figure 1.1. Both the existing and proposed conditions models employ identical subreach lengths and locations. However, because the HEC-RAS models were created separately by Sikand, slight differences in the model hydrology occur. These minor differences are not expected to significantly alter comparisons between the two models. The use of identical subreaches was employed for two reasons: to ensure consistency between existing and proposed conditions analysis, and because correlation values between sections and various hydraulic parameters for both the existing and proposed conditions are similar. Statistical analysis of the reaches for both the existing and proposed conditions is shown in Appendix Chapter 4.5.

Table 4.1A: Santa Clara River Existing Conditions Sub-Reach Stationing

Subreach	US Sta	DS Sta	Transport Equation[1]
SRA1	46195	44210	MPM
SRA2	43820	41460	MPM
SRA3	41280	38925	MPM
SRA4	33880	36265	MPM
SRB1	36080	29385	MPM
SRB2	33880	32605	MPM
SRC1	32265	29385	MPM
SRC2	29140	27155	MPM
SRC3	26990	25000	MPM
SRC4	24795	22415	MPM
SRD1	22195	20070	MPM
SRD2	19855	17785	MPM
SRD3	17510	15335	MPM
SRE1	15125	13190	MPM
SRE2	13030	11180	MPM
SRE3	11015	9025	MPM

1: MPM - Meyer, Peter and Muller, 1948

Table 4.1B: Santa Clara River Proposed Conditions Sub-Reach Stationing			
Subreach	US Sta	DS Sta	Transport Equation[1]
SRA1	46195	44210	MPM
SRA2	43820	41460	MPM
SRA3	41280	38925	MPM
SRA4	38710	36265	MPM
SRB1	36080	34090	MPM
SRB2	33880	32605	MPM
SRC1	32265	29385	MPM
SRC2	29140	27155	MPM
SRC3	26990	25000	MPM
SRC4	24795	22415	MPM
SRD1	22195	20070	MPM
SRD2	19855	17785	MPM
SRD3	17510	15335	MPM
SRE1	15125	13190	MPM
SRE2	13030	11180	MPM
SRE3	11015	9025	MPM

1: MPM - Meyer, Peter and Muller, 1948

4.1.3 Input Data and Selection of Transport Functions

Representation of sediment grain size distribution in SAM takes the form of percent finer data obtained from sieve analysis of channel sediment grab samples. At each sampling location, multiple samples are collected and analyzed, and the average data is input into the model. All sampling and sieve analysis was conducted by Seward Engineering Geology, and sample locations were chosen based on either the presence of recently active alluvium or the presence of adjacent/underlying older alluvium commonly incorporated into stream sediment load during major events. Environmental constraints on subsurface investigations in active drainages limited sampling locations in some instances, and in these cases the most representative, obtainable data is used as previously described in Chapter 3.

4.1.3.a SAM.AID Application and Theory

Sediment transport equations used in all SAM modeling were chosen with the assistance of the Army Corps' SAM.AID subroutine. The SAM.AID subroutine determines the most representative transport function based on the hydraulic parameters and percent finer data for each subreach by comparing model data with the results of 20 peer-reviewed and widely acknowledged sediment transport studies. This case-by-case transport equation selection is more likely to provide a robust representation of channel sediment transport than choosing an individual transport equation for all reaches.

Application of different transport functions to an individual channel reach may provide significantly differing model output. This is

because the parameters of a given study from which the function is derived, vary greatly. To accomplish the task of guiding the user in selecting an appropriate transport function, SAM.AID assumes that the function that best represents sediment transport in a gauged stream would also best represent transport in an ungauged stream with similar sediment and hydraulic characteristics. SAM.AID begins by comparing study parameters (V, D, S_e, B_e, D_{50}) with parameters in the transport function database. Comparison begins by determining if D_{50} falls within one of the ranges identified in the database. Once the initial matches have been made in the database, the three best-matched sediment transport functions for the study reach are listed along with the parameters that matched the data set.

Once the best transport equation matches have been determined by SAM.AID, the most representative equations are run in SAM.SED for each subreach. Yang (Yang, 1984) and MPM (Meyer-Peter and Muller, 1948) equations are added to all simulations where they are not explicitly matched by SAM.AID so that there is a continuity of comparison between subreaches. Following SAM.SED computations sediment transport potential for each subreach can then be estimated by reviewing the calculations from each equation and analyzing the results. Any SAM.SED calculation outliers are excluded and calculations of bed adjustment are made using mean estimate of transport potential. Outliers are values under analysis in a data set that reside far outside most other values in a data set. In this case, when one of the results of a SAM.SED calculation is three orders of magnitude or more different from the median, the data is excluded from analysis and noted as an outlier. The raw data is presented in Appendix Chapter 4.6.

The MPM equation was found to be the representative transport equation for all subreaches for the existing and proposed conditions. This is because transport estimates based on other transport equations (i.e. Yang), when used to estimate general adjustment and transport, produced degradation values in excess of both historical values of general adjustment (as much as approximately 15 feet) and values of general adjustment that might be physically expected during a single event (over approximately 20 feet). In other cases, some transport equations (i.e. Brownlie D_{50}) estimated sediment transport that produced general adjustment calculations much smaller than expected (as little as approximately 0.1 feet). The full summary of transport potential by subreach for the various transport equations for both existing and proposed conditions is provided in Appendix Chapter 4.6. Since the D_{50} for a given reach is the same for both the existing and proposed conditions models, the differences in transport function applicability is related to hydraulic differences between the two conditions.

4.1.4 SAM Bed Stability

Bed stability can be examined based on the change in potential transport between channel subreaches. Subreaches are readily determined from changes in hydraulic parameters, and frequently the most significant hydraulic parameter in terms of impact on stream stability is discharge (volume per unit time). If a channel subreach has equal potential transport both entering and exiting the reach, then the subreach is said to be in equilibrium. Frequently, however, channel subreaches are either in an aggrading or degrading condition. For the purposes of this study, aggrading reaches are those whereby the potential transport entering the reach (the potential transport of the subreach upstream of that under immediate consideration) is higher than the potential transport leaving the subreach (the potential transport of the subreach under immediate consideration). In degrading subreaches, the opposite is true and potential transport entering the reach is lower than that leaving the subreach. While it would appear that downstream subreaches would degrade constantly because discharge generally increases in downstream subreaches and in turn increases the transport potential as one moves downstream, other factors such as hydraulic depth, mean subreach velocity, hydraulic top width, and bed slope contribute significantly to potential transport.

Bed stability was determined by calculating the difference between subreach upstream and downstream sediment potential transport for the Q_{CAP} discharge. Transport potential for each reach is shown in Table 4.2A-B. The table shows no clear trend in transport potential as a function of subreach. The difference in transport potential, ΔTP (ton/day) between two cross-sections, was converted to bed adjustment, *GA* (feet), as:

$$GA = \frac{\Delta TP}{\rho bRL} day$$

where ρ is density in tons per cubic feet, *b* is channel width in feet, *day* denotes one day's time, and *RL* is reach length in feet. Density has been taken as 165.36 lb/ft^3. A summary of the adjustment for each reach is shown in Table 4.3.

General adjustment is based on SAM modeling presented in Figure 4.1A-B and Table 4.4A-B for the existing and proposed conditions, respectively. It is important to note that no apparent pattern of aggradation/degradation is apparent between cross-sections in the figure. General adjustment calculated using the equation presented in the Los Angeles County Hydrology and Sedimentation Manual (LACH&SM) is also shown in the figures. This latter calculation methodology is only based on flow mean velocity at a given channel section as computed by the HEC-RAS model of the system. In most circumstances, scour predicted by the LACH&SM is greater than that predicted by SAM for both the existing and proposed conditions except

at Commerce Center Bridge. It should be noted that scour predicted by the ACOE HEC-6 numerical model is expected to be approximately the same as or shallower than SAM predictions in terms of depth, although some longitudinal deviation from SAM results is expected.

The tables and figures indicate the general adjustment ranges from -2.9 to +2.3 feet for the existing condition, and -1.6 to +2.1 for the proposed condition. In Reach A (SRA1 to SRA4), the general adjustment does not vary by more than ±0.2 feet between the existing and proposed condition. SRA1 is predicted to have no change in general adjustment between the two conditions, and only SRA3 is expected to decrease degradation. The remaining sections are expected to decrease aggradation. In Reach B, either a minor increase in degradation between the existing and proposed general adjustment (0.1 feet ,SRB1) or minor increase in aggradation (0.2 feet, SRB2), is expected. In Reach C, no change between the existing and proposed condition is expected in SRC1 or SRC4, while SRC2 and SRC3 have 1.3 and 0.9 feet of decreased and increased degradation, respectively. No pattern of aggradation or degradation change in Reach D is observable. The subreaches in Reach D decrease degradation, increase aggradation, and increase degradation in subreaches SRD1 to SRD3 respectively. Reach E also has no pattern of aggradation or degradation change between the existing and proposed conditions ranging from 0.2 feet of decreased aggradation in SRE2 to 0.1 feet of increased degradation in SRE3. Finally, the general trend in general adjustment for the study reach as indicated by SAM modeling is not apparent for either the existing condition or proposed condition. It is not expected that short reaches (on the order of 500 feet) with minor lateral changes (on the order of 100 feet) in the positions of the proposed conditions improvements will affect these results significantly except where velocity changes are greater than approximately 25 percent.

Table 4.2A: Santa Clara River Existing Conditions Bed Stability

Subreach	US Sta	DS Sta	Trans Eq	Transport (ton)	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRA1	46195	44210	MPM	403,938	525.6	0.6		0.6
SRA2	43820	41460	MPM	330,678	977.0	0.4	AGGRADE	0.4
SRA3	41280	38925	MPM	401,167	1,242.2	0.3	DEGRADE	-0.3
SRA4	38710	36265	MPM	343,735	952.0	0.3	AGGRADE	0.3
SRB1	36080	34090	MPM	483,359	1,389.0	0.6	DEGRADE	-0.6
SRB2	33880	32605	MPM	488,063	1,650.3	0.0	DEGRADE	0.0
SRC1	32265	29385	MPM	101,035	1,965.8	0.8	AGGRADE	0.8
SRC2	29140	27155	MPM	470,866	780.8	2.9	DEGRADE	-2.9
SRC3	26990	25000	MPM	558,797	1,492.1	0.4	DEGRADE	-0.4
SRC4	24795	22415	MPM	468,697	2,008.5	0.2	AGGRADE	0.2
SRD1	22195	20070	MPM	675,434	2,009.0	0.6	DEGRADE	-0.6
SRD2	19855	17785	MPM	241,344	1,936.3	1.3	AGGRADE	1.3
SRD3	17510	15335	MPM	623,943	1,812.5	1.2	DEGRADE	-1.2
SRE1	15125	13190	MPM	796,646	1,878.9	0.6	DEGRADE	-0.6
SRE2	13030	11180	MPM	307,423	1,372.4	2.3	AGGRADE	2.3
SRE3	11015	9025	MPM	624,904	1,390.6	1.4	DEGRADE	-1.4

Table 4.2B: Santa Clara River Proposed Conditions Bed Stability								
Subreach	US Sta	DS Sta	Trans Eq	Transport (ton)	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRA1	46195	44210	MPM	403,938	525.6	0.6		0.6
SRA2	43820	41460	MPM	359,566	958.6	0.2	AGGRADE	0.2
SRA3	41280	38925	MPM	385,857	1,022.2	0.1	DEGRADE	-0.1
SRA4	38710	36265	MPM	370,217	797.6	0.1	AGGRADE	0.1
SRB1	36080	34090	MPM	534,683	1,376.0	0.7	DEGRADE	-0.7
SRB2	33880	32605	MPM	494,553	1,709.1	0.2	AGGRADE	0.2
SRC1	32265	29385	MPM	147,697	1,859.8	0.8	AGGRADE	0.8
SRC2	29140	27155	MPM	389,467	899.2	1.6	DEGRADE	-1.6
SRC3	26990	25000	MPM	633,550	1,159.3	1.3	DEGRADE	-1.3
SRC4	24795	22415	MPM	603,656	860.1	0.2	AGGRADE	0.2
SRD1	22195	20070	MPM	661,922	1,511.4	0.2	DEGRADE	-0.2
SRD2	19855	17785	MPM	319,200	1,431.8	1.4	AGGRADE	1.4
SRD3	17510	15335	MPM	620,768	1,274.3	1.3	DEGRADE	-1.3
SRE1	15125	13190	MPM	731,941	1,588.9	0.4	DEGRADE	-0.4
SRE2	13030	11180	MPM	291,031	1,375.5	2.1	AGGRADE	2.1
SRE3	11015	9025	MPM	635,705	1,399.4	1.5	DEGRADE	-1.5

Table 4.3: Santa Clara River SAM Existing vs Proposed Conditions Bed Stability					
Subreach	US Sta	Existing Conditions Grade Change (ft)	Proposed Conditions Grade Change (ft)	Delta (ft)	Result
SRA1	46195	0.6	0.6	0.0	NO CHANGE
SRA2	43820	0.4	0.2	0.2	DECREASE AGG
SRA3	41280	-0.3	-0.1	-0.2	DECREASE DEG
SRA4	38710	0.3	0.1	0.2	DECREASE AGG
SRB1	36080	-0.6	-0.7	0.1	INCREASE DEG
SRB2	33880	0.0	0.2	-0.2	INCREASE AGG
SRC1	32265	0.8	0.8	0.0	NO CHANGE
SRC2	29140	-2.9	-1.6	-1.3	DECREASE DEG
SRC3	26990	-0.4	-1.3	0.9	INCREASE DEG
SRC4	24795	0.2	0.2	0.0	NO CHANGE
SRD1	22195	-0.6	-0.2	-0.4	DECREASE DEG
SRD2	19855	1.3	1.4	-0.1	INCREASE AGG
SRD3	17510	-1.2	-1.3	0.1	INCREASE DEG
SRE1	15125	-0.6	-0.4	-0.2	DECREASE DEG
SRE2	13030	2.3	2.1	0.2	DECREASE AGG
SRE3	11015	-1.4	-1.5	0.1	INCREASE DEG

Figure 4.1A: Santa Clara River Existing Conditions General Adjustment

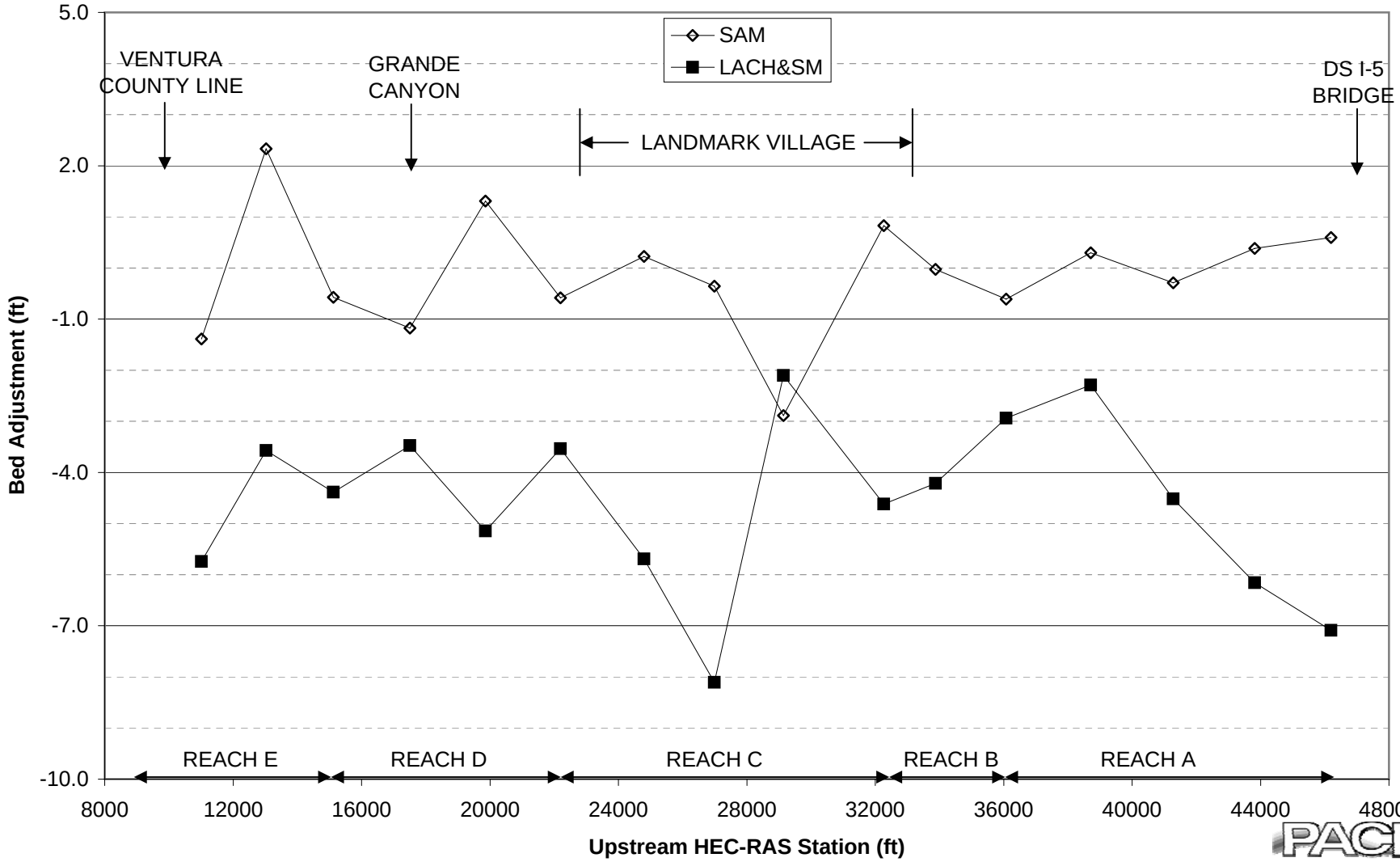


Figure 4.1B: Santa Clara River Proposed Conditions General Adjustment

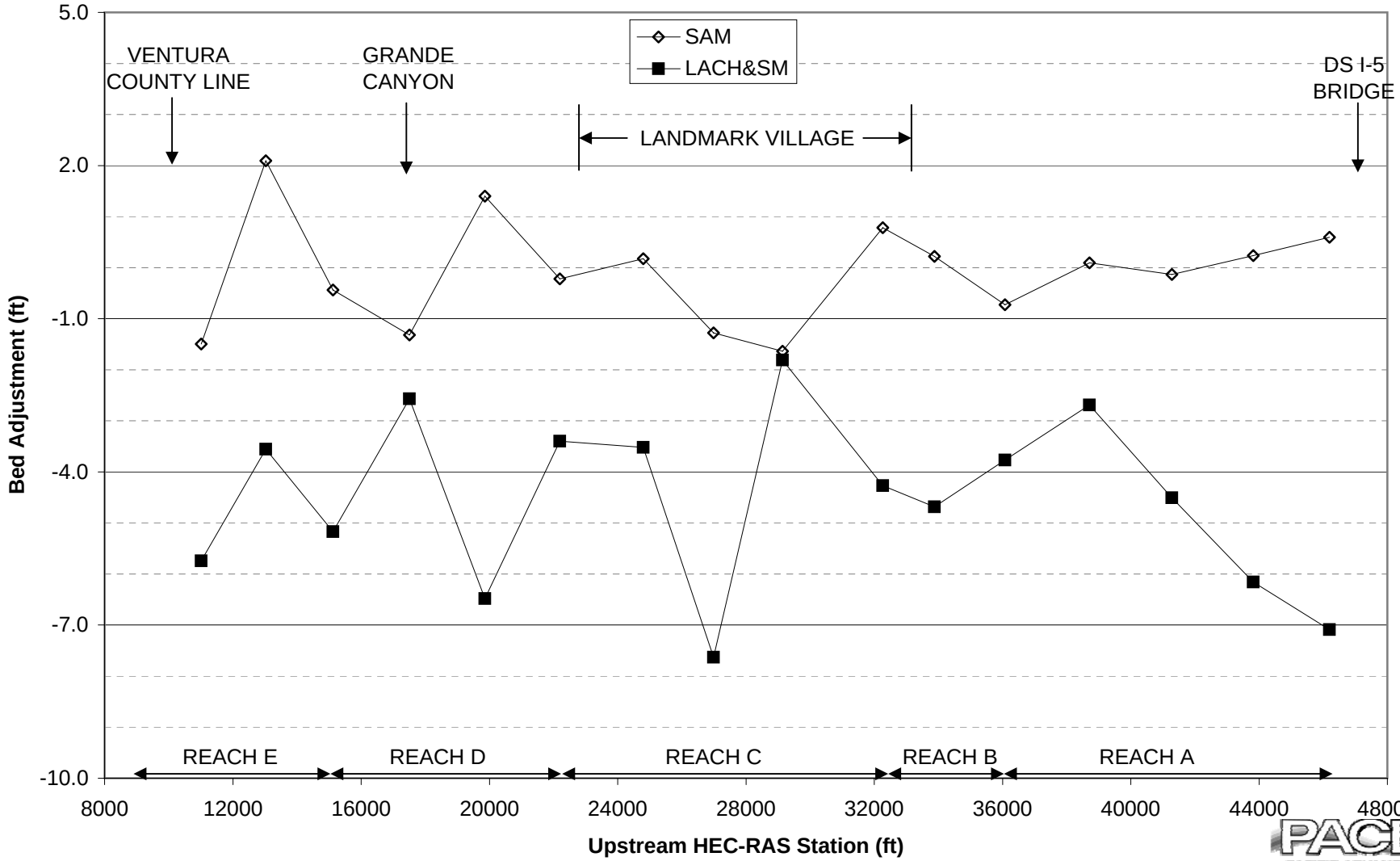


Table 4.4: Santa Clara River SAM & LACH&SM General Adjustment Comparison (ft)

Subreach	US Sta	Existing Conditions		Proposed Conditions	
		SAM[1]	LACH&SM[2]	SAM[1]	LACH&SM[2]
SRA1	46195	0.6	-7.1	0.6	-7.1
SRA2	43820	0.4	-6.2	0.2	-6.2
SRA3	41280	-0.3	-4.5	-0.1	-4.5
SRA4	38710	0.3	-2.3	0.1	-2.7
SRB1	36080	-0.6	-2.9	-0.7	-3.8
SRB2	33880	0.0	-4.2	0.2	-4.7
SRC1	32265	0.8	-4.6	0.8	-4.3
SRC2	29140	-2.9	-2.1	-1.6	-1.8
SRC3	26990	-0.4	-8.1	-1.3	-7.6
SRC4	24795	0.2	-5.7	0.2	-3.5
SRD1	22195	-0.6	-3.5	-0.2	-3.4
SRD2	19855	1.3	-5.1	1.4	-6.5
SRD3	17510	-1.2	-3.5	-1.3	-2.6
SRE1	15125	-0.6	-4.4	-0.4	-5.2
SRE2	13030	2.3	-3.6	2.1	-3.6
SRE3	11015	-1.4	-5.7	-1.5	-5.7

1: Sam calculations represent an entire subreach

2: LACH&SM calculations represent one cross-section

4.2 HEC-6

The ACOE HEC-6 model is a one-dimensional moveable bed open channel hydraulic and sediment transport model. The model was designed to simulate change in river bed profiles resulting from sediment scour and deposition over long periods of time. The model segments hydrograph data into a progression of steady flow events with varied discharge and duration. Every segment of flow is used to calculate a water surface profile and associated hydraulic parameters (e.g. velocity, depth, etc.). From the hydraulic parameters, potential sediment transport rates are estimated for each model reach and scour or deposition is next estimated so that cross-section shape can be updated. Sediment calculations are based on grain size distribution so that sorting and armoring can be considered.

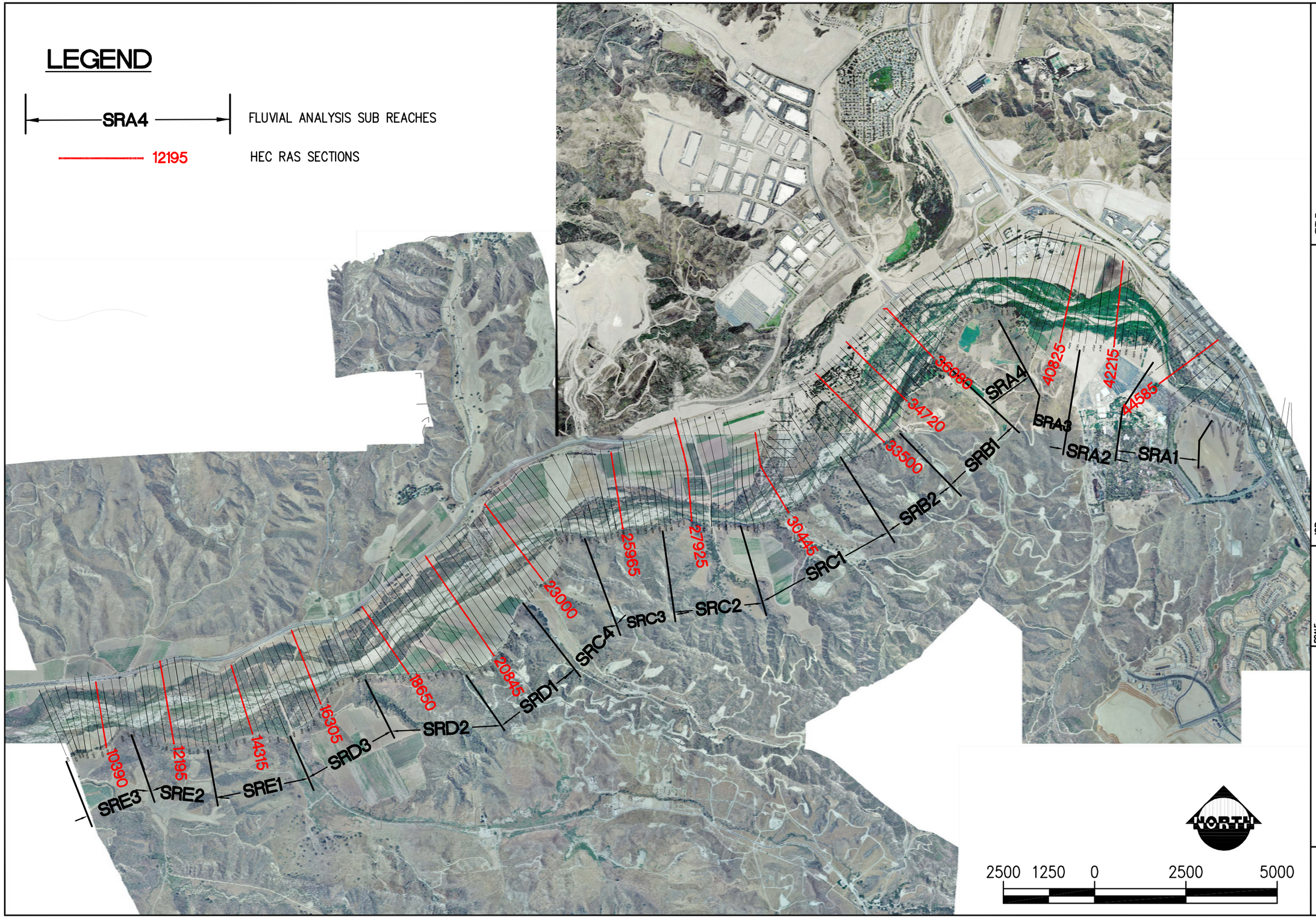
A one dimensional energy approximation to the equations of motion is used for hydraulic calculations in HEC-6. Manning's equation is utilized to incorporate bed friction. The model also uses both an up- and down-stream boundary condition with internal conditions optional. Krone's method is for deposition of fines and Ariathurai and Krone's method is used for scour. Sediment transport functions are user selectable and 13 different equations are possible. Colby's method is used to adjust transport potential and armoring is simulated using Gessler's method. Sediment boundary conditions operate such that inflowing sediment load is a function of inflow discharge.

At this date the "T" enhancement of the HEC-6 program, created by Mobile Boundary Hydraulics, is expected to be used.

5 Long-Term Adjustment

Long-term adjustment was calculated based on historical records in the form of topographic data. First, topographic data, provided by Allan E. Seward Engineering Geology dating from 1930, 1947, 1963, 1999, 2004 and 2005, was digitized (See Appendix Chapter 5.1). This was accomplished by determining a common coordinate system and creating contour lines within the study area. Topographic data was available in several formats including digital elevation maps (1999, 2004, 2005), topographic surveys (1963) and quad maps (1930, 1947). Digital elevation maps were only adjusted for horizontal location. Cross-sections were next cut at the locations of select HEC-RAS sections for each historical topography (shown in Figure 5.1). At least one cross-section was chosen for each subreach established in Chapter 4 based on engineering interest. The sections chosen are section 10390, section 12195, section 14315, section 16305, section 18650, section 20845, section 23000, section 25965, section 27925, section 30445, section 33500, section 34720, section 36080, section 40825, section 42215, and section 44585. Section 36080 is actually in SRB1 not SRA4, although it was chosen since it is directly upstream of a tributary and near the proposed Commerce Center Drive Bridge. Areas of the 1947, 1963, 1999, 2004 and 2005 sections are calculated and these areas are used to calculate the average change in bed elevation over time. The other topography (1930) is not used to calculate average change in bed because of the impacts of the failure of the St. Francis Dam in 1928, as discussed below. To calculate the area of a given cross-section the lowest historical point on the section is determined and the area of each vertical foot of the section in one-foot intervals is calculated, as shown in Figure 5.2A-P, for each topography. The area of a section is the sum of the one-foot area intervals, also shown in Figure 5.2A-P. All areas for a given section have a common toe and top from which the area is calculated. In cases where available topography ends abruptly, areas are calculated assuming a vertical wall at the end. The relative average change in depth for a given section and topography is calculated as the area divided by the top width, where the top width is taken as the width of the upper most one-foot area. The top width in this sense is not a hydraulic characteristic but a physical one, which along with the sectional area determines the maximum capacity of the section. Moreover, the calculated depth is a relative physical value based on the section area and represents an average physical characteristic of the section as a whole.

Several events within the available historical record (1930 to present) have had an impact on the River bed and fluvial mechanics. These events include failure of the upstream St. Francis Dam, construction of bridges spanning the River, agricultural infill along the River banks, and periodic burning of surrounding vegetation during forest fires. These different historical events can be placed into two categories: the St. Francis Dam failure in 1928, and those that occurred both prior to and following Dam failure. The most significant historical event in the formation of the present bed condition was the aforementioned failure of the Dam. The consequence of this event is tied to the River's recovery from the erosion caused by the extremely high flow of floodwater. Within the project reach, the failure of the Dam appears to have resulted in the severe scouring of the bed, detailed below. In its current state, the River bed appears to have mostly recovered from dam flood scour as evidenced by the cross-sections presented in this chapter. Placement of the bridges does not appear to have had a measurable impact on long-term bed characteristics, except for very local



TITLE
SANTA CLARA RIVER
HISTORIC SECTIONS
ANALYSIS LOCATION MAP

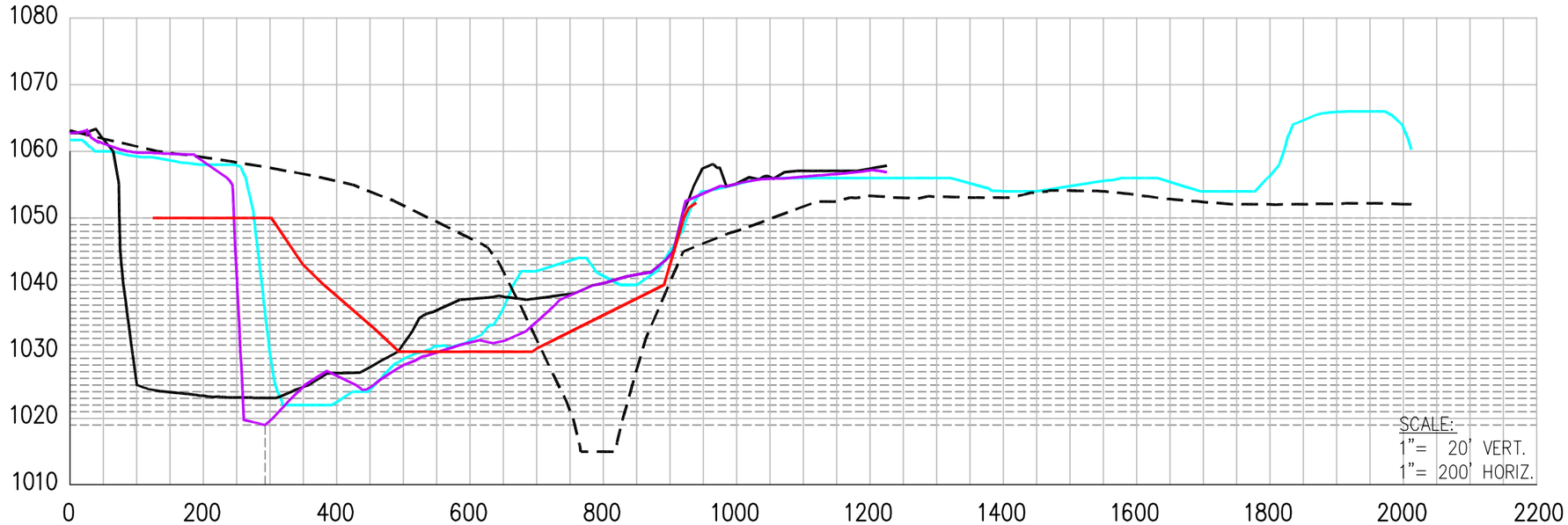
JOB
NEWHALL RANCH
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE	1"= 2500'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	D.J.
DATE	09/17/05
JOB NO.	8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17620 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA. 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.1

P:\8197E\Engineering\GlobalExhibits\8197-EXH--02.dwg - Tab: 11x17 By: ddrahn on Mar. 14, 2006 at 04:10 pm



SUBREACH SRA1 SECTION 44585

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 44585 (sf)					
ELEV	1947	1963	1999	2004	2005
1020.0	NA	0.0	0.0	25.2	0.0
1021.0	NA	0.0	0.0	48.3	0.0
1022.0	NA	0.0	0.0	58.2	0.0
1023.0	NA	0.0	83.5	68.1	0.0
1024.0	NA	0.0	102.1	78.5	124.2
1025.0	NA	0.0	141.9	100.6	228.6
1026.0	NA	0.0	154.8	146.6	266.3
1027.0	NA	0.0	165.8	197.4	293.6
1028.0	NA	0.0	176.8	234.9	350.0
1029.0	NA	0.0	191.6	257.0	369.4
1030.0	NA	0.0	213.6	282.0	388.9
1031.0	NA	212.3	248.9	313.8	402.9
1032.0	NA	243.0	298.2	370.3	411.2
1033.0	NA	274.0	318.5	417.1	419.4
1034.0	NA	304.8	329.7	435.2	427.0
1035.0	NA	336.3	344.1	446.8	433.5
1036.0	NA	368.0	351.4	458.4	446.7
1037.0	NA	399.7	357.9	469.9	471.9
1038.0	NA	431.4	363.6	480.9	500.6
1039.0	NA	463.1	369.0	500.5	645.2
1040.0	NA	494.8	374.5	523.6	693.5
1041.0	NA	517.3	422.7	558.1	728.9
1042.0	NA	530.4	463.2	598.0	769.2
1043.0	NA	543.6	528.6	628.9	800.6
1044.0	NA	555.1	568.3	641.8	813.9
1045.0	NA	564.8	613.8	652.1	824.5
1046.0	NA	574.6	621.8	658.1	830.6
1047.0	NA	584.3	629.2	661.0	833.3
1048.0	NA	594.1	636.3	663.9	836.0
1049.0	NA	603.8	642.2	666.8	838.6
1050.0	NA	613.6	646.7	669.6	841.2
Area	NA	9208.9	10358.4	12311.6	14989.6

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

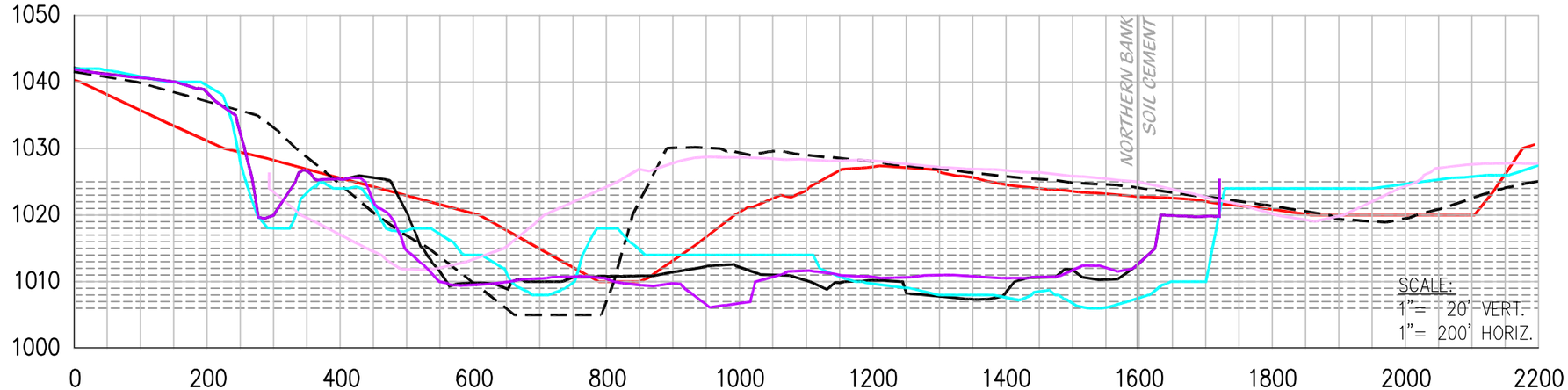
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE	AS NOTED
DESIGNED	DAJ
DRAWN	DEP
CHECKED	MEK
DATE	12/20/05
JOB NO.	8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2A

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 44585 – 5.2A By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRA2 SECTION 42215

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 42215 (sf)

ELEV	1947	1963	1999	2004	2005
1007.0	0.0	0.0	58.7	31.4	0.0
1008.0	0.0	0.0	112.6	79.5	95.4
1009.0	0.0	0.0	370.2	95.4	148.4
1010.0	0.0	0.0	502.0	183.9	223.1
1011.0	0.0	80.5	641.6	412.8	588.7
1012.0	7.2	114.1	679.1	920.5	898.3
1013.0	86.6	146.5	709.3	1055.3	1028.1
1014.0	136.6	178.9	736.3	1093.5	1073.1
1015.0	181.3	211.3	1041.4	1115.8	1090.6
1016.0	222.4	243.5	1067.9	1129.1	1104.3
1017.0	254.2	274.7	1099.1	1134.2	1110.1
1018.0	286.0	305.7	1143.3	1140.1	1115.7
1019.0	317.8	336.6	1284.1	1146.4	1121.9
1020.0	395.8	367.6	1309.9	1159.8	1133.8
1021.0	509.5	692.9	1326.8	1263.7	1245.8
1022.0	601.5	843.7	1341.2	1301.3	1260.7
1023.0	700.1	1008.7	1357.4	1315.9	1275.2
1024.0	802.4	1236.4	1380.0	1329.3	1289.6
1025.0	1107.8	1398.5	1697.5	1342.9	1304.2
Area	5609.2	7439.6	17858.4	17250.9	17107.1

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

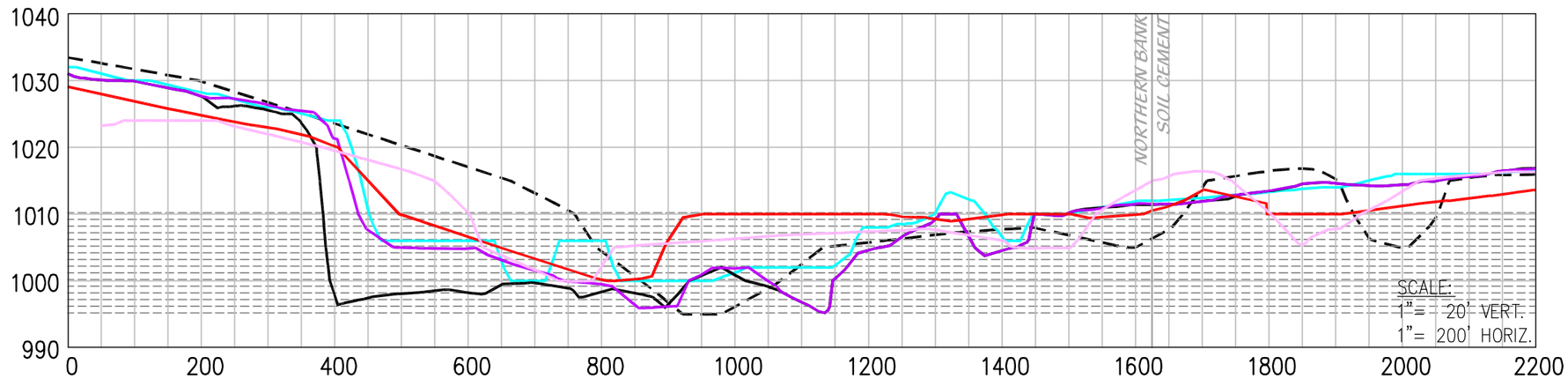
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2B

Xrefs: 8197 - 2004 CONTOURS.dwg; 8197 - 2005 CONTOURS.dwg; 8197 - 1999 CONTOURS.dwg; 8197 - 1930 CONTOURS.dwg; 8065-Lining.dwg; 8197-SANTA CLARA TITLE BLOCK.dwg; 7104E-COPY OF-7904-E-WRP soil cement bank (NEW 8-11-
Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg - Tab: HEC 42215 - 5.2B By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRA3 SECTION 40825

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 40825 (sf)					
ELEV	1947	1963	1999	2004	2005
996.2	0.0	0.0	0.0	9.7	12.9
997.2	0.0	0.0	0.0	69.9	67.0
998.2	0.0	0.0	0.0	86.7	188.6
999.2	0.0	0.0	0.0	103.3	456.3
1000.2	11.9	15.1	37.4	154.0	625.4
1001.2	70.2	98.4	217.6	218.8	708.1
1002.2	98.7	132.7	282.6	423.1	759.7
1003.2	128.3	167.0	414.0	510.9	783.1
1004.2	158.0	201.3	437.1	551.2	796.9
1005.2	214.6	235.7	454.0	674.5	863.0
1006.2	409.0	270.0	518.5	838.5	930.2
1007.2	639.8	304.0	749.3	880.3	958.5
1008.2	938.6	338.0	779.8	921.8	987.0
1009.2	1028.9	371.7	862.1	958.0	1016.8
1010.2	1063.6	695.0	918.3	1002.5	1056.7
Area	4761.4	2829.0	5670.9	7403.2	10210.2

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

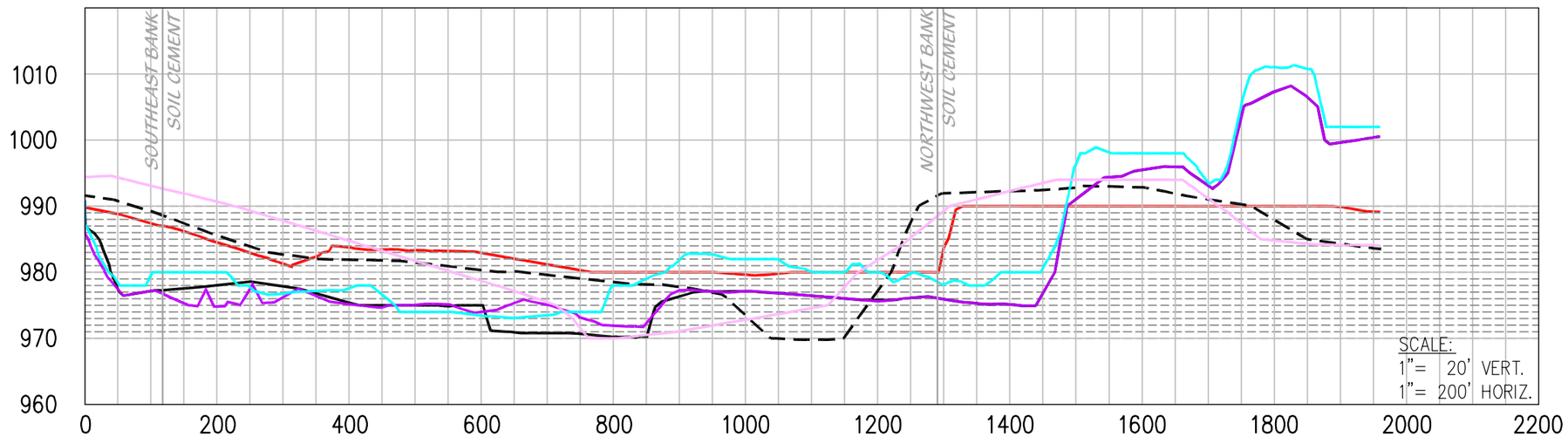
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2C

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 40825 – 5.2C By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRA4 SECTION 36080

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 36080 (sf)					
ELEV	1947	1963	1999	2004	2005
971.0	93.7	0.0	0.0	0.0	91.0
972.0	174.6	0.0	0.0	10.6	239.1
973.0	239.8	0.0	0.0	82.2	246.8
974.0	307.3	0.0	102.4	115.5	252.5
975.0	377.1	0.0	304.6	222.6	263.0
976.0	430.9	0.0	324.4	671.8	605.5
977.0	468.8	0.0	354.8	1056.6	910.2
978.0	508.6	0.0	494.3	1374.2	1221.1
979.0	550.5	0.0	716.4	1418.3	1387.9
980.0	592.7	31.1	856.6	1431.8	1423.4
981.0	638.7	556.0	1187.3	1440.9	1430.6
982.0	687.7	651.4	1265.1	1448.5	1435.4
983.0	736.8	762.1	1397.2	1456.8	1441.2
984.0	785.7	978.5	1448.0	1463.4	1447.0
985.0	833.2	1103.9	1456.6	1469.3	1452.5
986.0	878.1	1137.3	1465.1	1473.5	1460.6
987.0	923.4	1171.0	1472.8	1476.4	1467.8
988.0	968.8	1217.1	1477.5	1479.2	1472.7
989.0	1014.1	1254.0	1480.3	1482.1	1477.6
990.0	1059.5	1281.8	1483.1	1485.0	1482.5
Area	12270.0	10144.3	17286.2	21058.6	21208.4

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

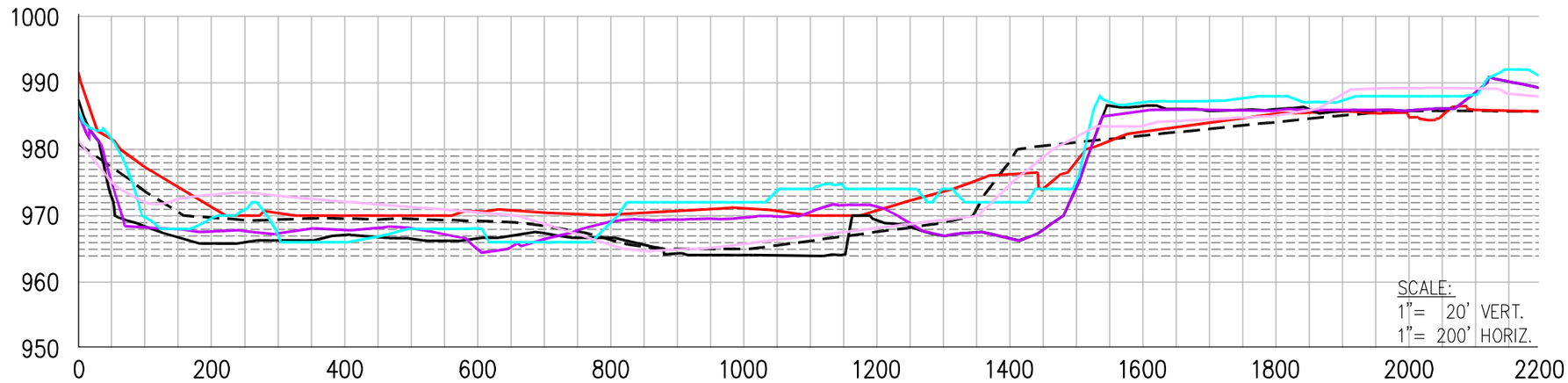
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2D

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 36080 – 5.2D By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRB1 SECTION 34720

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 34720 (sf)					
ELEV	1947	1963	1999	2004	2005
965.0	9.7	0.0	0.0	10.3	231.3
966.0	168.0	0.0	0.0	65.0	303.0
967.0	282.7	0.0	271.2	135.7	634.9
968.0	401.3	0.0	351.3	398.2	1136.8
969.0	514.8	0.0	551.0	863.0	1275.0
970.0	628.3	0.0	609.6	1066.6	1366.9
971.0	750.5	597.2	679.8	1291.9	1426.6
972.0	885.8	1013.8	712.6	1369.9	1433.7
973.0	1075.3	1075.4	1046.2	1433.9	1440.6
974.0	1275.9	1129.0	1106.4	1441.5	1448.6
975.0	1340.0	1190.1	1370.2	1449.0	1455.7
976.0	1361.8	1247.1	1421.8	1456.0	1462.2
977.0	1382.1	1349.4	1429.3	1462.3	1468.0
978.0	1402.4	1401.4	1435.1	1468.7	1473.5
979.0	1422.7	1421.1	1441.6	1474.9	1479.0
980.0	1443.0	1440.7	1448.8	1481.0	1484.6
Area	14344.4	11865.3	13874.8	16867.7	19520.2

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

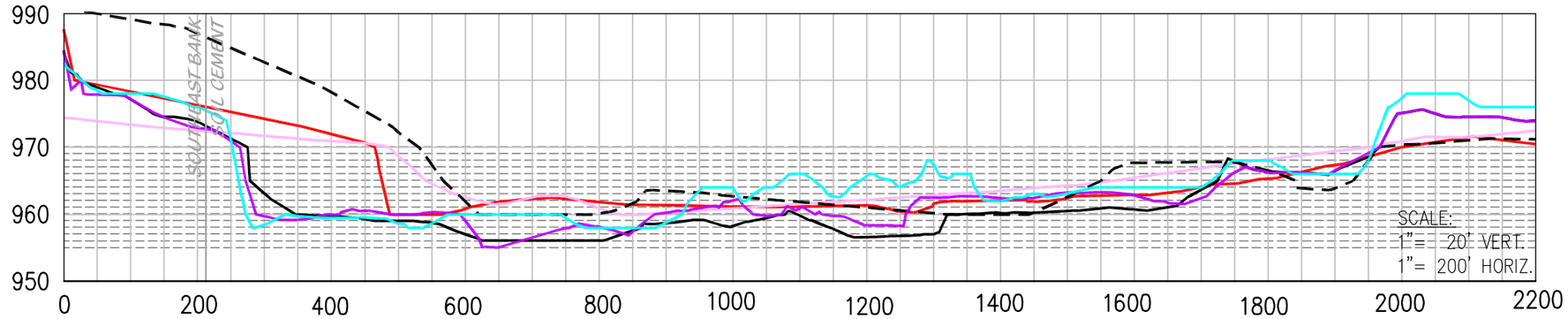
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2E

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 34720 – 5.2E By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRB2 SECTION 33500

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 33500 (sf)					
ELEV	1947	1963	1999	2004	2005
956.1	0.0	0.0	0.0	41.8	0.0
957.1	0.0	0.0	0.0	82.3	240.8
958.1	0.0	0.0	9.0	155.0	418.0
959.1	0.0	0.0	197.7	297.4	554.4
960.1	4.4	6.4	392.5	452.2	853.2
961.1	140.8	138.3	656.4	807.3	1176.6
962.1	341.9	580.7	666.0	956.7	1345.8
963.1	613.6	1022.2	767.1	1103.1	1374.8
964.1	831.7	1194.0	932.7	1424.0	1404.0
965.1	980.6	1263.3	1230.8	1454.8	1433.7
966.1	1074.3	1339.2	1352.6	1469.8	1449.3
967.1	1154.5	1388.8	1565.6	1593.4	1454.5
968.1	1236.3	1440.9	1618.0	1651.7	1459.8
969.1	1329.6	1481.3	1697.5	1673.1	1671.6
970.1	1424.1	1517.7	1702.9	1694.4	1686.9
Area	9131.9	11372.7	12788.7	14857.0	16523.3

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

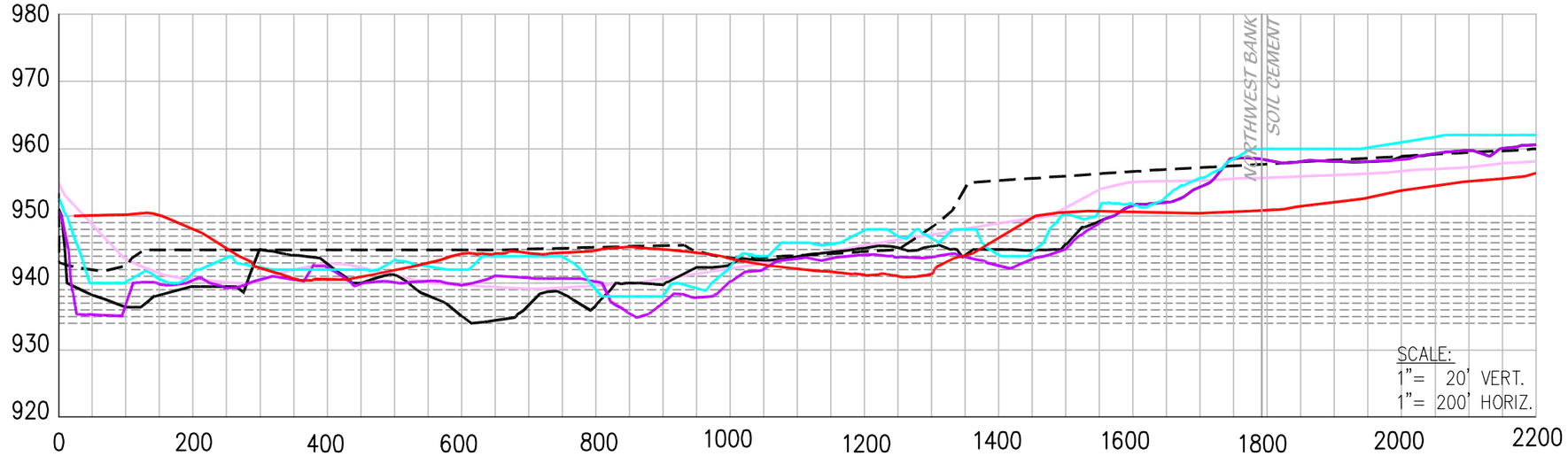
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY GA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2F

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 33500 – 5.2F By: ddrahn on Mar. 14, 2006 at 05:08 pm



SUBREACH SRC1 SECTION 30445

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 30445 (sf)					
ELEV	1947	1963	1999	2004	2005
935.0	0.0	0.0	0.0	0.0	43.9
936.0	0.0	0.0	0.0	82.0	90.9
937.0	0.0	0.0	0.0	133.4	149.9
938.0	0.0	0.0	97.2	166.4	247.4
939.0	0.0	0.0	142.4	241.3	367.5
940.0	139.1	0.0	190.2	313.7	518.4
941.0	399.9	46.1	303.6	707.6	703.1
942.0	551.9	274.3	146.9	964.2	785.1
943.0	712.0	473.6	667.1	1049.7	852.0
944.0	847.3	610.9	817.6	1187.7	943.5
945.0	916.0	849.6	1073.7	1450.1	1115.0
946.0	980.4	1114.6	1131.3	1490.5	1446.4
947.0	1048.6	1167.4	1261.1	1502.5	1499.6
948.0	1122.7	1201.3	1347.1	1518.1	1509.8
949.0	1189.5	1240.3	1461.8	1536.3	1526.3
950.0	1264.9	1280.2	1484.2	1554.1	1552.1
Area	9172.4	8258.3	10124.1	13897.6	13350.9

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

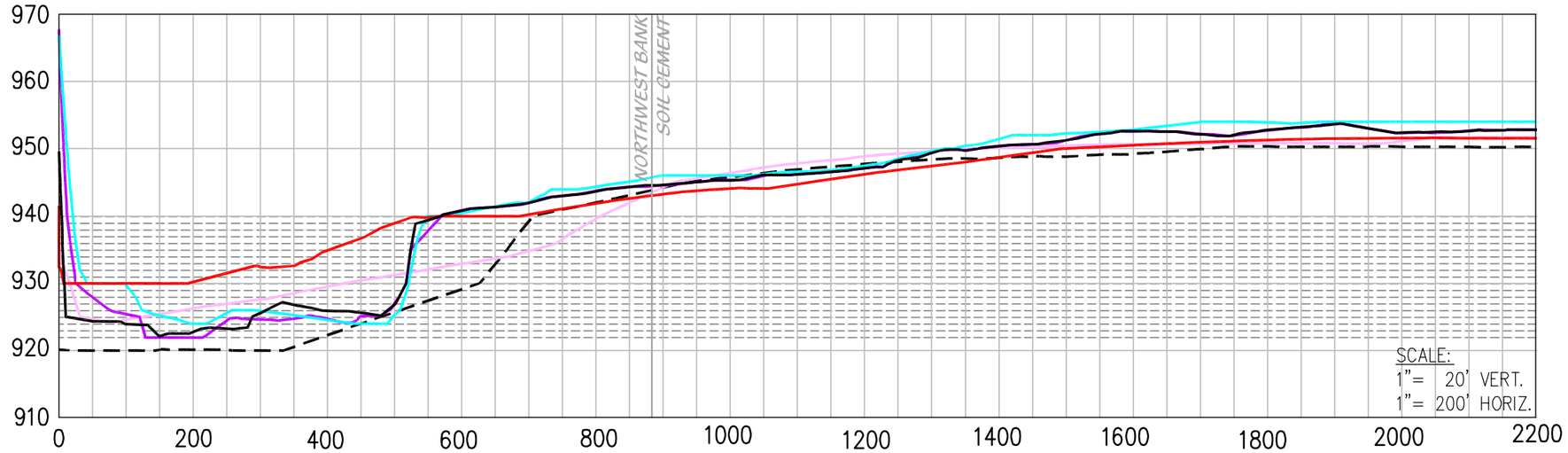
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE	AS NOTED
DESIGNED	DAJ
DRAWN	DEP
CHECKED	MEK
DATE	12/20/05
JOB NO.	8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2G

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 30445 – 5.2G By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRC2 SECTION 27925

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 27925 (sf)					
ELEV	1947	1963	1999	2004	2005
922.9	0.0	0.0	0.0	93.2	24.2
923.9	0.0	0.0	0.0	110.4	116.8
924.9	31.0	0.0	116.9	153.2	224.6
925.9	116.8	0.0	265.7	369.4	307.0
926.9	181.8	0.0	383.0	424.8	430.6
927.9	259.0	0.0	396.4	445.0	491.4
928.9	322.5	0.0	405.9	464.7	500.1
929.9	375.5	0.0	416.7	482.0	505.7
930.9	433.3	181.2	475.3	493.3	509.8
931.9	498.0	244.8	488.5	495.7	511.7
932.9	562.7	308.8	494.8	498.4	513.5
933.9	627.2	368.6	498.3	501.2	515.3
934.9	689.3	388.8	501.7	504.0	517.1
935.9	730.7	413.1	505.0	511.1	519.0
936.9	745.7	441.0	508.7	521.1	521.1
937.9	761.4	464.1	512.9	531.0	523.2
938.9	778.5	485.0	518.0	541.1	525.4
939.9	795.6	514.3	524.0	551.2	545.5
AREA	7908.8	3809.7	7011.7	7690.7	7801.9

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

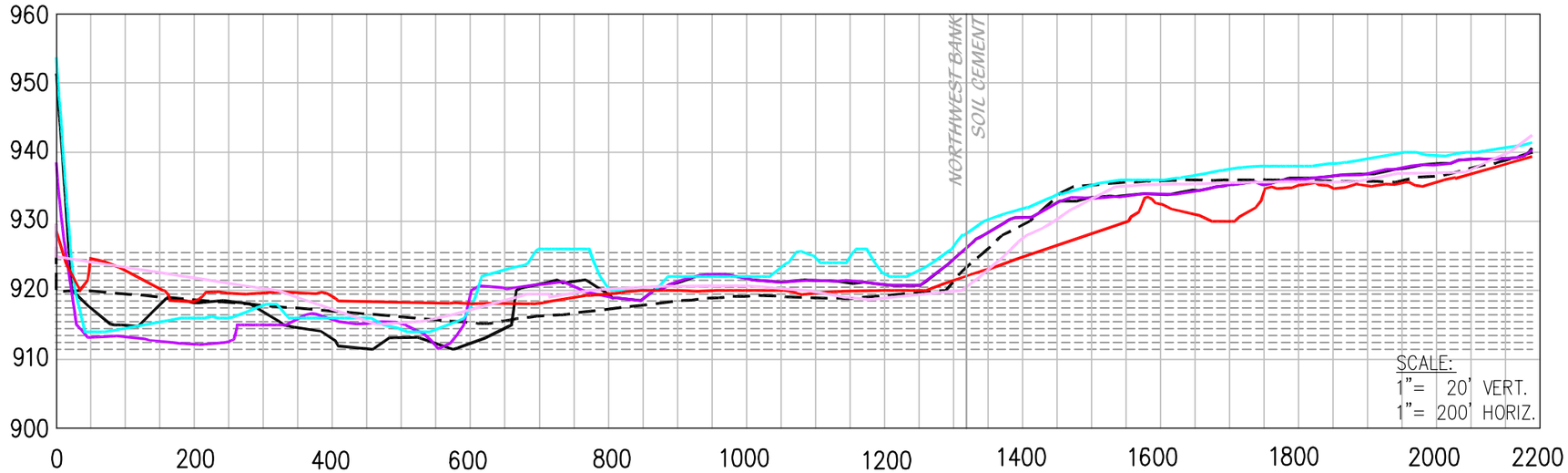
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2H

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 27925 – 5.2H By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRC3 SECTION 25965

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 25965 (sf)					
ELEV	1947	1963	1999	2004	2005
912.5	0.0	0.0	0.0	26.8	76.8
913.5	0.0	0.0	0.0	174.7	177.5
914.5	0.0	0.0	42.0	278.4	257.8
915.5	16.2	0.0	174.6	366.4	347.7
916.5	113.4	0.0	358.1	522.6	408.7
917.5	183.8	0.0	511.8	566.9	449.5
918.5	250.0	84.3	557.3	572.3	504.1
919.5	384.0	396.2	577.2	619.3	662.5
920.5	689.2	884.8	615.7	690.5	722.9
921.5	1050.0	1150.5	669.2	915.0	893.2
922.5	1149.7	1199.2	778.9	1191.1	1195.9
923.5	1226.4	1249.5	947.5	1263.7	1261.5
924.5	1303.6	1304.0	1043.2	1278.3	1274.7
925.5	1367.8	1394.3	1121.5	1291.0	1286.5
Area	7734.2	7662.7	7397.0	9757.0	9519.2

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

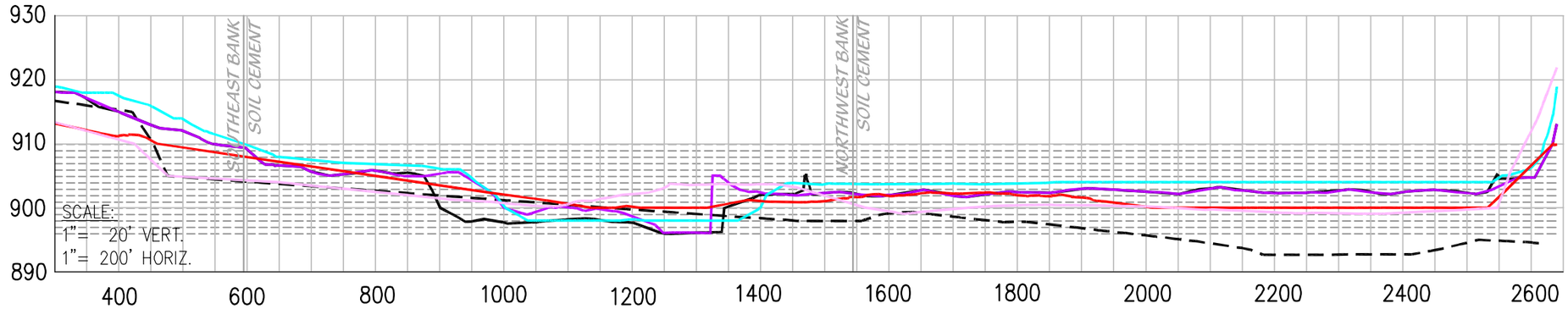
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.21

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 25965 – 5.21 By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRC4 SECTION 23000

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 23000 (sf)					
ELEV	1947	1963	1999	2004	2005
896.9	0.0	0.0	0.0	61.7	89.1
897.9	0.0	0.0	0.0	89.8	153.8
898.9	0.0	0.0	313.2	116.0	381.3
899.9	302.5	0.0	377.5	156.1	430.9
900.9	926.6	725.1	402.7	319.0	456.6
901.9	1278.1	1110.9	415.2	339.4	489.5
902.9	1487.7	1518.6	436.0	909.3	558.9
903.9	1706.5	1663.0	468.2	1544.6	582.8
904.9	1990.7	1740.8	1540.7	1609.7	589.5
905.9	2094.6	1818.6	1634.9	1814.1	1822.6
906.9	2110.3	1896.4	1732.9	1946.9	1946.9
907.9	2125.8	1974.1	1903.3	2000.1	2000.1
908.9	2141.4	2051.6	1979.2	2016.7	2016.7
909.9	2156.9	2129.0	2008.1	2044.7	2044.7
Area	18321.2	16628.1	13211.7	14968.1	13563.3

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

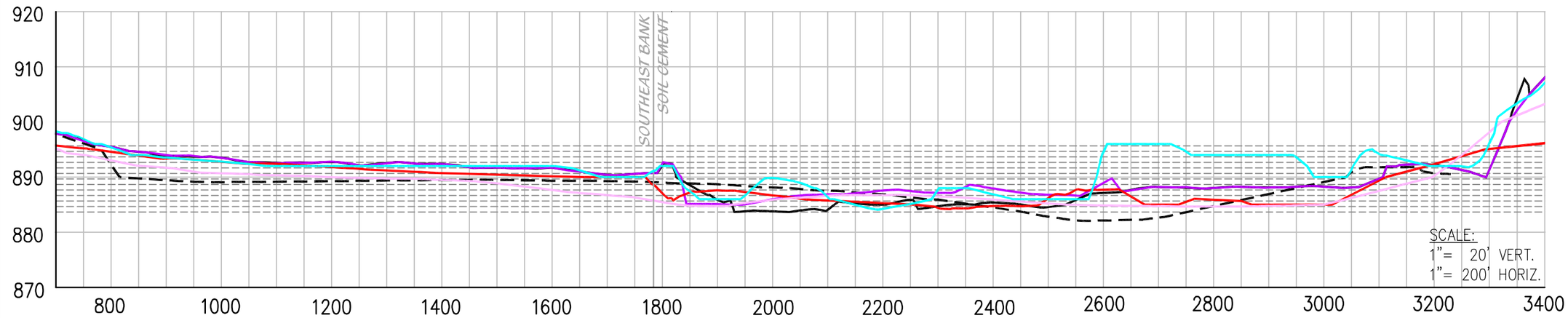
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2J

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 23000 – 5.2J By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRD1 SECTION 20845

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 20845 (sf)					
ELEV	1947	1963	1999	2004	2005
884.7	0.0	24.3	19.2	0.0	150.4
885.7	452.5	415.1	108.7	73.4	442.9
886.7	691.1	825.4	339.0	171.1	658.8
887.7	1429.9	1056.2	496.3	461.1	733.8
888.7	1566.1	1284.4	615.1	956.0	1015.0
889.7	1707.6	1319.7	689.2	1235.6	1247.2
890.7	2042.6	1505.0	861.5	1298.3	1289.4
891.7	2272.0	1843.3	974.7	1484.4	1486.8
892.7	2377.0	2063.6	1499.5	1854.8	1853.7
893.7	2445.9	2286.8	1891.4	2282.6	2283.6
894.7	2514.1	2433.1	2192.5	2417.1	2427.1
895.7	2569.9	2558.2	2348.7	2502.7	2502.7
Area	20068.6	17615.1	12035.8	14737.0	16091.2

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

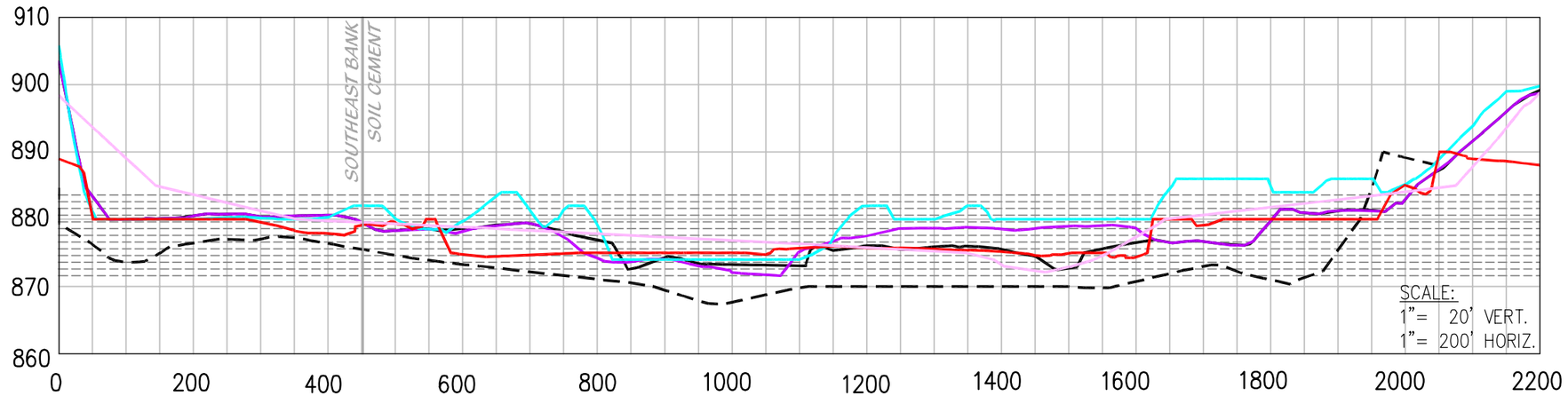
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2K

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 20845 – 5.2K By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRD2 SECTION 18650

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 18650 (sf)					
ELEV	1947	1963	1999	2004	2005
872.6	14.7	0.0	0.0	63.6	1.7
873.6	102.7	0.0	0.0	133.2	134.8
874.6	158.5	10.7	180.4	265.4	310.8
875.6	247.2	556.7	307.9	322.1	405.3
876.6	441.9	1011.6	328.6	386.3	694.8
877.6	654.2	1048.1	340.5	566.5	980.3
878.6	869.6	1120.0	359.9	726.4	1064.1
879.6	1094.1	1248.2	443.3	1236.2	1285.5
880.6	1300.2	1706.9	906.3	1457.7	1456.8
881.6	1437.6	1915.9	1293.2	1805.3	1802.1
882.6	1569.2	1923.4	1474.1	1925.6	1925.6
883.6	1699.4	1930.9	1556.6	1949.4	1949.4
Area	9589.2	12472.3	7190.7	10837.7	12011.1

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

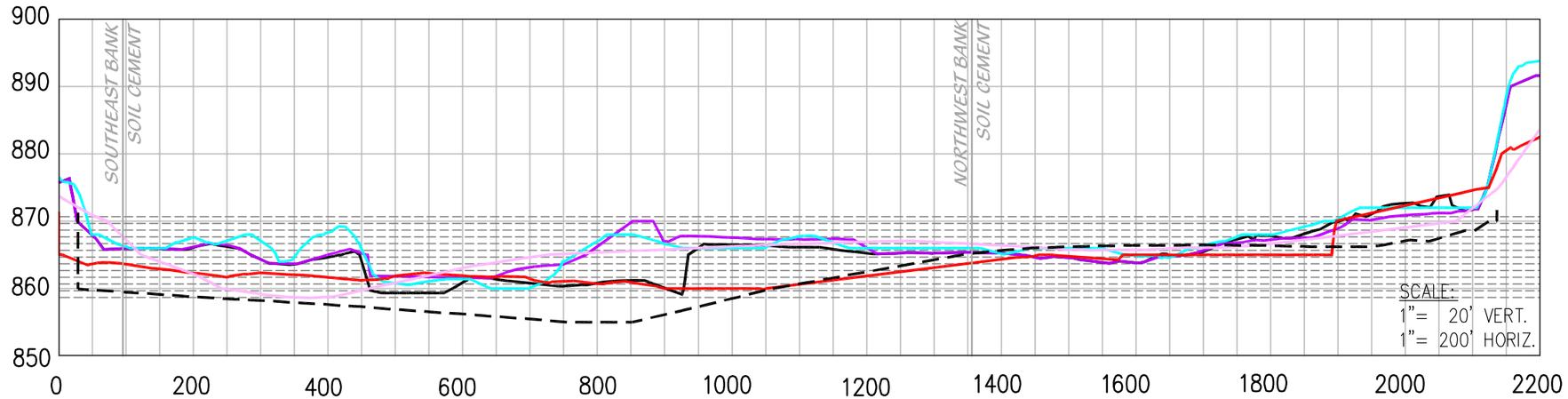
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2L

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 18650 – 5.2L By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH RD3 SECTION 16305

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 16305 (sf)					
ELEV	1947	1963	1999	2004	2005
859.6	116.8	0.0	0.0	0.0	36.9
860.6	225.0	121.1	44.8	0.0	170.0
861.6	293.0	414.5	183.6	0.0	369.2
862.6	358.9	892.9	268.2	180.1	475.4
863.6	432.1	1172.9	282.0	243.7	481.4
864.6	521.6	1363.3	307.5	444.6	628.8
865.6	643.2	1755.6	434.3	778.8	966.6
866.6	1122.9	1892.0	921.7	1157.1	1432.7
867.6	1681.2	1893.0	1359.0	1424.1	1691.5
868.6	1833.9	1894.1	1668.7	1759.2	1796.9
869.6	1924.7	1895.9	1793.3	1820.6	1842.8
870.6	2005.0	1906.3	1846.8	1896.1	1880.2
Area	11158.2	15201.5	9110.0	9704.3	11772.3

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

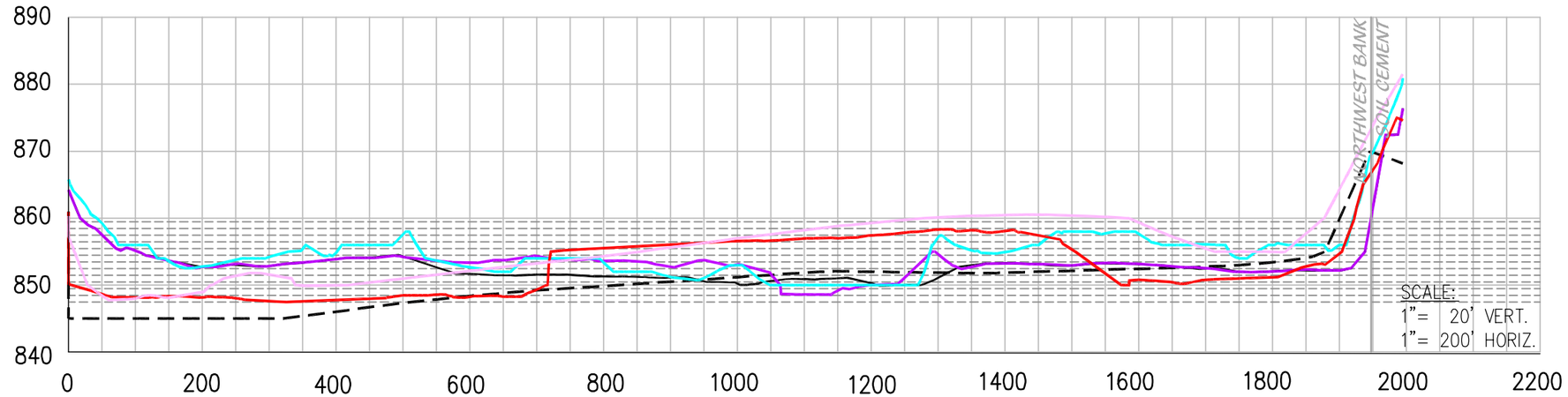
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2M

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 16305 – 5.2M By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRE1 SECTION 14315

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 14315 (sf)					
ELEV	1947	1963	1999	2004	2005
848.5	43.7	241.8	0.0	0.0	0.0
849.5	153.8	650.6	0.0	71.9	0.0
850.5	237.3	718.0	107.7	143.8	55.0
851.5	384.3	892.6	274.1	193.5	347.3
852.5	556.7	998.3	398.1	286.3	800.8
853.5	659.2	1047.6	604.4	807.3	1273.6
854.5	758.3	1090.6	828.5	1592.4	1703.6
855.5	899.6	1132.2	1081.0	1830.5	1835.8
856.5	1065.8	1302.0	1398.1	1873.9	1873.9
857.5	1183.6	1555.3	1662.9	1886.2	1886.2
858.5	1301.7	1798.4	1792.2	1898.3	1898.3
859.5	1425.5	1918.4	1865.8	1915.1	1915.1
Area	8669.5	13345.8	10012.7	12499.2	13589.6

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

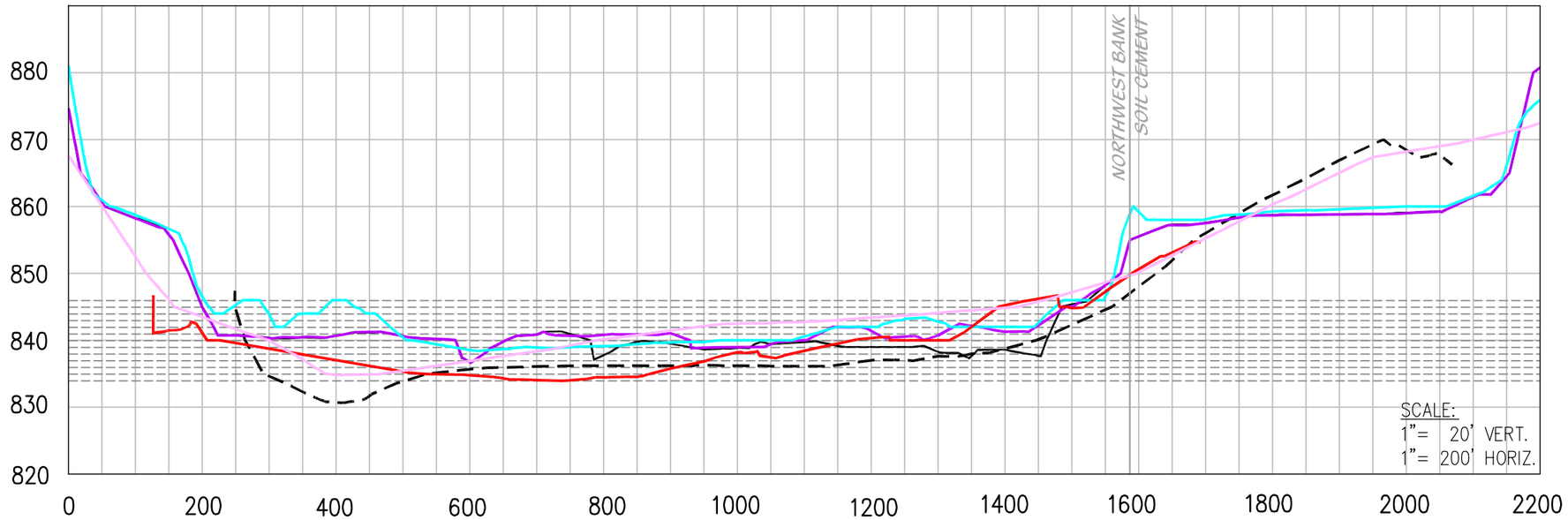
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2N

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 14315 – 5.2N By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRE2 SECTION 12195

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 12195 (sf)					
ELEV	1947	1963	1999	2004	2005
834.9	0.0	158.7	0.0	0.0	0.0
835.9	119.1	387.7	0.0	0.0	0.0
836.9	204.3	492.5	0.0	1.0	1.0
837.9	289.0	605.3	0.0	22.5	35.3
838.9	375.4	768.6	25.4	41.9	183.8
839.9	450.2	884.2	300.2	179.4	571.9
840.9	533.1	1086.7	583.8	422.2	914.9
841.9	638.1	1143.6	641.8	923.4	1217.1
842.9	779.7	1205.6	881.3	1221.6	1258.1
843.9	1003.2	1232.1	1009.7	1258.5	1268.5
844.9	1167.2	1249.6	1127.4	1279.4	1279.0
845.9	1279.6	1280.2	1201.1	1307.6	1304.0
Area	6838.7	10494.9	5770.7	6657.4	8033.7

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

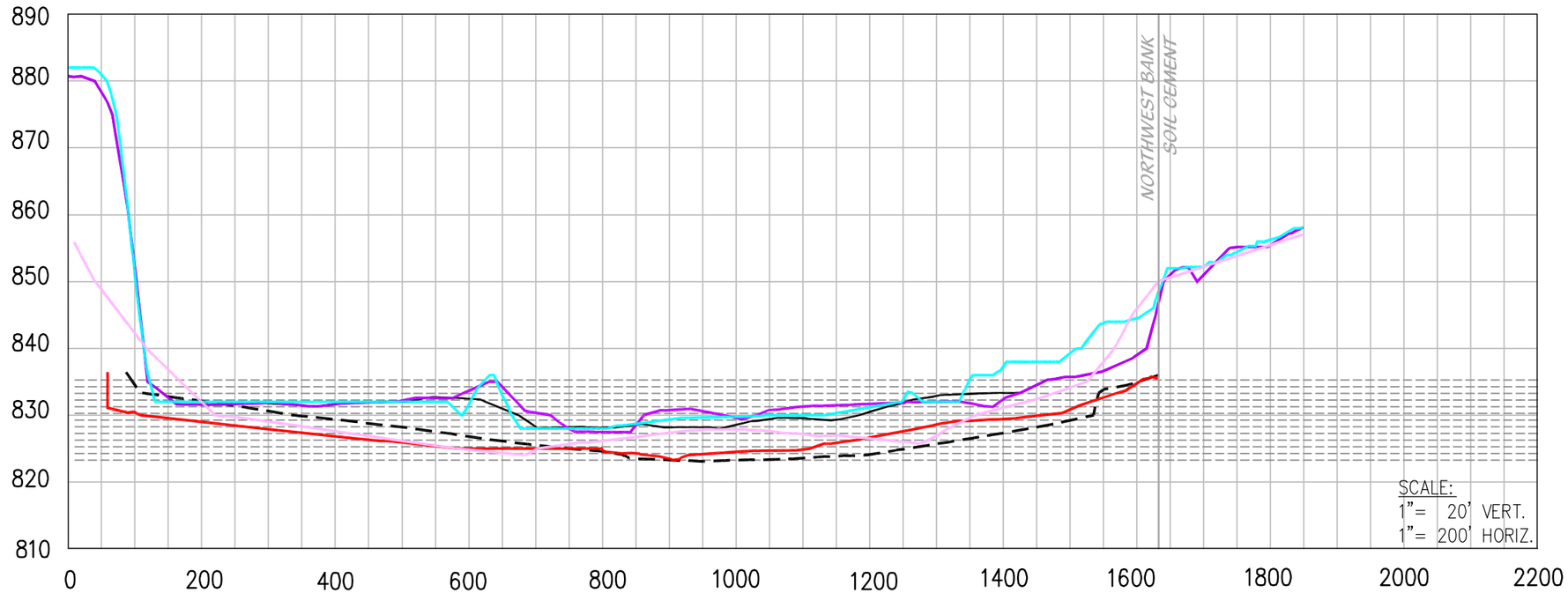
JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.20

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 12195 – 5.20 By: ddrahn on Mar. 14, 2006 at 05:07 pm



SUBREACH SRE3 SECTION 10390

LOOKING DOWNSTREAM

CROSS SECTIONAL AREAS AT STA 10390 (sf)					
ELEV	1947	1963	1999	2004	2005
824.3	3.9	43.1	0.0	0.0	0.0
825.3	94.2	315.5	0.0	0.0	0.0
826.3	252.1	633.1	0.0	0.0	0.0
827.3	533.3	801.6	0.0	0.0	0.0
828.3	853.0	945.9	36.7	73.0	24.6
829.3	1015.2	1093.0	184.0	114.7	306.3
830.3	1109.9	1302.8	345.4	169.4	475.5
831.3	1174.3	1422.9	529.3	332.7	554.3
832.3	1223.3	1464.8	739.8	793.6	816.8
833.3	1269.3	1494.6	1147.2	1159.9	1125.6
834.3	1308.6	1524.2	1180.8	1247.2	1296.9
835.3	1346.9	1541.5	1201.4	1314.9	1332.6
Area	10183.9	12582.9	5364.7	5205.4	5932.6

LEGEND:

- 2005 TERRAIN
- 2004 TERRAIN
- 1999 TERRAIN
- 1963 TERRAIN
- 1947 TERRAIN
- 1930 TERRAIN

TITLE
HISTORICAL CROSS SECTIONS BY STATION

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE AS NOTED
DESIGNED DAJ
DRAWN DEP
CHECKED MEK
DATE 12/20/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
5.2P

Dimscale = 200; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Santa Clara River HEC Cross Sections and End Area Data.dwg – Tab: HEC 10390 – 5.2P By: ddrahn on Mar. 14, 2006 at 05:07 pm

characteristics. The Interstate 5 Bridge has not been outflanked by bed migration since its construction. Moreover, despite narrowing of the bed locally, bridge placement does not appear to have led to general bed degradation on the River as a whole. Periodic fires have burned the flora of the watershed historically, and as recently as the summer of 2004. Fires are important to changes of the River bed because these fires deplete vegetation stalks and root systems that hold soil in upland areas, thereby leading to increased erosion on slopes and increased sediment delivery to creeks and rivers. Agricultural fills are also important to the historic River fluvial mechanics because the fills limit the extent to which the River may migrate, and in turn cause vertical erosion of the creek bed. LACDPW has noted that lateral erosion of agricultural fill has occurred periodically although no data is presently available to date to gage the extent or depth of this erosion. Certainly, the volume of fill laterally eroded is not sufficient to prevent vertical bed erosion. As noted in Table 4.2 above, the River can transport over 730,000 tons (approximately 327,000 cubic yards) of sediment per day in some sections. LACDPW has indicated that the constraining of the lateral erosion at the agricultural infill locations may exacerbate or exceed background erosion downstream.

Table 5.1A shows the long-term historical cross-sections area from 1947 to 2005. The table lists the area for each historical section in a given subreach. The table also lists the difference between historical sections (e.g. 1947 section 23000 area – 2005 section 23000 area). Table 5.1B shows the historical cross-section average depth and average depth change by section and year. As noted above, the average depth is the area of a given section by year divided by the section geometric top width for that year. The difference between historical areas is also shown. It is important to note that the vertical elevation for each section is the same.

Table 5.1A: Santa Clara River Long-term Historical Cross-Section Area & Area Change 1947-2005

Subreach	Station	Area by Year (sf)			Δ Area by Year (sf)			
		1947	2004	2005	47-05	Change	04-05	Change
SRA1	44585 [1,3]	9209	12312	14990	-5781	DEGRADE	-2678	DEGRADE
SRA2	42215	5609	17251	17107	-11498	DEGRADE	144	AGGRADE
SRA3	40825	4761	7403	10210	-5449	DEGRADE	-2807	DEGRADE
SRA4	36080 [2]	12270	21059	21208	-8938	DEGRADE	-149	DEGRADE
SRB1	34720	14344	16868	19520	-5176	DEGRADE	-2652	DEGRADE
SRB2	33500	9132	14857	16523	-7391	DEGRADE	-1666	DEGRADE
SRC1	30445	9172	13898	13351	-4179	DEGRADE	547	AGGRADE
SRC2	27925	7909	7691	7802	107	AGGRADE	-111	DEGRADE
SRC3	25965	7734	9757	9519	-1785	DEGRADE	238	AGGRADE
SRC4	23000	18321	14968	13563	4758	AGGRADE	1405	AGGRADE
SRD1	20845	20069	14737	16091	3978	AGGRADE	-1354	DEGRADE
SRD2	18650	9589	10838	12011	-2422	DEGRADE	-1173	DEGRADE
SRD3	16305	11158	9704	11772	-614	DEGRADE	-2068	DEGRADE
SRE1	14315	8670	12499	13590	-4920	DEGRADE	-1091	DEGRADE
SRE2	12195	6839	6657	8034	-1195	DEGRADE	-1377	DEGRADE
SRE3	10390	10184	5205	5933	4251	AGGRADE	-728	DEGRADE

1 - Long-term change analyzed using 1963 data instead of 1947 data because 1947 data is unavailable at this section

2 - STA 36080 was chosen to represent sra4 because the downstream confluence is of particular engineering interest to that subreach

3- STA 44585 1947 area uses 1963 data since 1947 data is not available.

Table 5.1B: Santa Clara River Historical Cross-Section Average Depth & Average Depth Change Aggradation/Degradation Change 1947-2005

Subreach	Station	Average Depth by Year = Area/Top Width (ft)			Δ Average Depth by Year (ft)			
		1947	2004	2005	47-05	Change	04-05	Change
SRA1	44585 [1,3]	16.0	18.4	17.8	-2.8	DEGRADE	0.6	AGGRADE
SRA2	42215	5.1	12.8	13.1	-8.0	DEGRADE	-0.3	DEGRADE
SRA3	40825	4.5	7.4	9.7	-5.2	DEGRADE	-2.3	DEGRADE
SRA4	36080 [2]	11.6	14.2	14.3	-2.7	DEGRADE	-0.1	DEGRADE
SRB1	34720	9.9	11.4	13.1	-3.2	DEGRADE	-1.7	DEGRADE
SRB2	33500	6.4	8.8	9.8	-3.4	DEGRADE	-1.0	DEGRADE
SRC1	30445	7.3	8.9	8.6	-1.3	DEGRADE	0.3	AGGRADE
SRC2	27925	9.9	14.0	14.3	-4.4	DEGRADE	-0.3	DEGRADE
SRC3	25965	5.7	7.6	7.4	-1.7	DEGRADE	0.2	AGGRADE
SRC4	23000	8.5	7.3	6.6	1.9	AGGRADE	0.7	AGGRADE
SRD1	20845	7.8	5.9	6.4	1.4	AGGRADE	-0.5	DEGRADE
SRD2	18650	5.6	5.6	6.2	-0.6	DEGRADE	-0.6	DEGRADE
SRD3	16305	5.6	5.1	6.3	-0.7	DEGRADE	-1.2	DEGRADE
SRE1	14315	6.1	6.5	7.1	-1.0	DEGRADE	-0.6	DEGRADE
SRE2	12195	5.3	5.1	6.2	-0.9	DEGRADE	-1.1	DEGRADE
SRE3	10390	7.6	4.0	4.5	3.1	AGGRADE	-0.5	DEGRADE

1 - Long-term change analyzed using 1963 data instead of 1947 data because 1947 data is unavailable at this section

2 - STA 36080 was chosen to represent sra4 because the downstream confluence is of particular engineering interest to that subreach

3- STA 44585 1947 area uses 1963 data since 1947 data is not available.

Section 44585 (SRA1) shows a gradual shifting of the thalweg toward the left (looking downstream) bank (Figure 5.2A) over the period of record. Topographic data is not available for this section for 1947, however, between 1963 and 2005, 2.8 feet of degradation has occurred (Table 5.1A-B), although the thalweg elevation increased between 1999 and 2005. Between 2004 and 2005, 0.6 feet of aggradation appears to have occurred (Table 5.1A-B) on the section as a whole. This portion of the River is narrower than most other portions and is slightly bent. Development has occurred on both banks, and this development along with the increased runoff from increased impervious area may have caused the observed degradation. A great deal of woody brush was present in the recent past, which may have rendered some portions of the bed more resistant to erosion, leading to some natural incising of the channel. It is also important to note that the dense brush in this and other woody sections may make the topography appear to be at higher elevation than is actually present. This difference results from the aerial survey technology used to create the topography, and is mostly evident in some portions of the 1999 topography.

Section 42215 (SRA2) appears to have greatly down cut and widened since 1947, degrading an average 8.1 feet along the section. Some of the observed long-term change may be related to the presence of the theme park and water treatment facility on the bank at this location. In recent years (1999-2005), the creek appears to have become relatively stable: area has increased from 17946 to 17101 over the period (Figure 5.2B). The River is relatively wide at this location although a bend is present. Development has occurred on both banks with agricultural development on the north bank and the Magic Mountain theme park on the south bank. Historical development may have led to the observed degradation, although at present the bed appears to be stable or degrading only slightly. The impacts of woody vegetation in this section may have played a role in the recent degradation. Finally, the 2004-2005 winter was very

wet and high flows were present on the River. During the heavy storms of December 2004 and January 2005, approximately 4.4 acres of the south bank was lost to the Santa Clara River. Some of the single-season degradation may possibly be attributed to this event. The features located at station 775 and 1325 in the 1999 topography are expected to be related the aerial surveying methodology, as noted above.

Similar to the other sections in Reach A, section 40825 (SRA3) is also degrading. The section has degraded 5.2 feet on average over the period of record (Table 5.1B). The 1963 data is insufficient in this section as indicated by the flat portions of the section, although the other years sufficiently indicate the trend. The 2005 thalweg is at the approximate elevation of the 1930 thalweg, although the present channel is more incised than the historic channel. The presently observed channel widening may possibly be attributed to recent high discharges, and migration of the channel may be related to these discharges. Features in the 1999 topography at stations 775 and 1325 are expected to be related to the aerial surveying methodology, as noted above.

Section 36080 (as applied to SRA4) borders the SRA4 and SRB1 subreaches. The section is adjacent to a local confluence in the River. The section shows consistent degradation over the period of record amounting to 2.7 feet, on average. The 1930 and 1963 topographies are insufficient in this section; however, widening of the channel in this location is readily apparent (Figure 5.2D). Little or no degradation is observed over the period of record, although a slight increase in the depth of the thalweg is observed during the 2004-2005 rainy season. Agriculture is present on the north overbank of the section although it is not clear how the history of farming practice may have affected the section.

The 1930 and 1963 topographic data of sections 34720 (SRB1) and 33500 (SRB2) is insufficient, as indicated by the long, straight portions of the section. Despite these difficulties, the data illustrate a clear degradational trend in the historic bed. Over the period of record, the section has degraded 3.2 and 3.4 feet, on average respectively, and 1.8 and 1.0 feet, on average respectively, during the 2004-2005 rainy season (Table 5.1). The River is broad and woody in this reach, with the northern end of the Travel Village development occupying the right overbank. It is unclear why a wide, straight portion of the River such as this would be subject to the observed degradation. Some of the long-term and single season degradation may possibly be attributed to the woody nature of the bed and the large recent discharges, respectively. It should be noted that the present thalweg appears to be at an elevation similar to the 1930 thalweg on section 34720, while the thalweg of the 2005 topography at section 33500 may or may not be lower than the 1930 topography. As with other portions of historic topography, features often present at the time of surveying are not highly resolved. When this occurs, historic topography is included for completeness. The degradation of these reaches may also be reflective of the large changes in development along the River upstream of the study area. This may apply to other sections considered as well, although currently it is not clear.

Section 30445 (SRC1) is downstream of two major tributaries, the larger being Castaic Creek, which is discussed in the companion Castaic Creek Fluvial Study, submitted separately. The section is also adjacent to a historic agricultural area and the proposed Landmark project. Historical analysis indicates 1.4 feet of degradation over the historic record, but 0.3 feet of aggradation during the 2004-2005 rainy season

(Table 5.1B). The aggradation appears to be the result of build up of sediments on the Castaic Creek side of the channel. If Castaic Creek contributed to the bed in this location, it may be the result of forest fires during the summer of 2004 and subsequent heavy rains of that winter, as discussed in the Castaic Creek report. It should be noted that some problems exist with the 1947 topography in this section below station 300.

At sections 27925 (SRC2) and 25965 (SRC3), the upstream degradational trends diminish and historic topographic data begin to indicate a bed that is fluctuating about a mean (Figures 5.2H and 5.2I, respectively). Section 27925 is quite narrow and adjacent to historic agricultural practice. The channel at this section is confined between steep bluffs on the left bank and tree-lined agricultural embankments on the right. Data in Table 5.1 indicate that the section has degraded 4.4 feet over the period of record and 0.3 feet during the most recent season. A relatively low-radius bend in the River is also present here. At section 25965, in contrast, the less narrow, although similarly confined and more gradually bending channel, takes an increasingly braided form with only 1.7 feet of degradation over the period of record. Data in Table 5.1 also indicate the most recent trend in this section is 0.2 feet of aggradation.

Sections 23000 (SRC4) and 20845 (SRD1) are the first historically aggradational sections analyzed (Figure 5.2J and 5.2K, respectively). Section 23000 is adjacent to the Chiquito Canyon Creek and Long Canyon Creek tributaries at the west end of the proposed Landmark development and between two historic agricultural production areas. Section 20845 is downstream of the proposed Landmark site and the left overbank has historically been used for agriculture. Both banks of section 20885 are tree-lined. Both sections are relatively wide and straight with braided channel beds. Both sections have aggraded over the period of historic record: 1.9 and 1.4 feet, respectively. In the most recent short term, however, section 23000 has aggraded 0.7 feet while section 20845 has degraded 0.5 feet. Section 23000 shows some incising below the 1930 historical bed although the average bed elevation is higher now than in the past. The dominant change in bed elevation between 2004 and 2005 at section 20845 occurred to the left of station 2600, while the remaining portion remained stable. It is not clear why this occurred, although agricultural practices or high discharges from the Chiquito and Long tributaries may have played a role. Agricultural practices may have stabilized the bank position and height while the creeks may influence the bed by discharging high volumes of water and sediments that have the dual ability to erode or deposit at this location. It should be noted that the topographic artifact between station 2600 and 3000 in the 1999 topography is a function of topographic sampling. As noted above, the dense brush in this and other woody sections may make the topography appear to be at a higher elevation than is actually present and results from the aerial survey technology used to create the topography.

Sections 18650 (SRD2), 16305 (SRD3), 14315 (SRE1), and 12195 (SRE2) all exhibit very mild long-term degradation (one foot or less) between 1947 and 2005 (Table 5.1). Additionally, short-term adjustment for all of these sections ranges between -0.6 and -1.2 feet between 2004 and 2005. Sections 16305 and 12195 exhibit 1.2 and 1.1 feet of degradation, respectively, and are among the five highest single season changes in bed elevation of the sections examined. Sections in SRA3 and SRB1 degrade significantly more with -2.3 and -1.7 feet, respectively. All of the sections from 18650 to 12195 are recovering from the 1928 dam break event, the sections low elevations, and all sections exhibit oscillations in bed elevation over the historic record (Figure

5.2L though 5.2O, respectively). These sections have in common a relatively wide, straight and braided bed. Grande Canyon Creek and Potrero Canyon Creek confluence with the River at near section 17000. The influence of the confluences is not immediately evident but may include some of the observed fluctuations in bed elevation as well as affecting the wide historic meandering between the north and south bank (Figure 5.1). The observed features in the 1999 and 2004 topographies in section 16305 at stations 425 and 850 appear to be the south and north low-flow banks, respectively. Several of the features in the 1999 bed at section 14315 appear to correlate to the presence of vegetation on the bank and relate to surveying methodology, as noted above.

Section 10390 (SRE3) illustrates 3.1 feet of aggradation from 1947 to 2005 and 0.5 feet of degradation between 2004 and 2005 (Table 5.1). In this subreach, the River is relatively very wide and braided. Little woody vegetation is observed on the banks and steep bluffs dominate both banks, although a small farm plot sets the bluff on the right bank back. Figure 5.2P indicates that the bed is recovering from scouring related to the 1928 dam break. The observed feature in the 1999 and 2004 topographies at station 625 appears to be the south bank of the thalweg.

Based on the above analysis and Table 5.1, sections above approximately 25965 appear to be degrading, while sections below appear to be stable or fluctuating around a mean elevation. This may be the result of historic development within the overbank areas or owing to the presence of the generally narrower, winding channel bed in the upstream portion of the study reach. The lower portion of the study reach is relatively flat, broad and straight. Data in Appendix Chapter 4.5 indicate that for reaches A through E the slope decreases as S_0=0.0061, 0.0060, 0.0055, 0.0055, and 0.0054, respectively.

5.1 Single Season Bed Adjustment

With historical topography from successive years, estimates of single-season change can be developed. This is a powerful tool because it can be used to determine the predictive accuracy of SAM modeling. The 2004-2005 rain season was wet on Santa Clara River with strong rain events occurring on already saturated soils both in December 2004 and January 2005. These events produced very high discharges on the River. Topography from before and after these events provides a tool to estimate the impacts of a single large discharge event, in general, and single season cumulative impacts. The 2004 and 2005 beds are described in Table 5.1 and Figure 5.2A-P. The table and figures illustrate that the bed elevations show alternating degradation and aggradation. Degradation ranges from 0.1 to 2.3 feet, on average, with most degrading sections changing less than one foot, on average. Aggrading sections change from 0.2 to 0.7 feet, on average. More sections degrade than aggrade. The pattern of aggradation and degradation over the single season does not appear to be a function of proximity to a river confluence. For comparison, aggradation predicted by SAM in the proposed condition (Table 4.2B) ranges from 0.0 to 2.1 feet, while degradation ranges from 0.0 to 1.6 feet. The values of bed change estimated by SAM vary similar to those observed in the topographic datasets. These differences can be attributed to the discontinuous nature of the zero-dimensional SAM model.

6 Other Scour

The calculation of scour depth for design of toe-down for structures is given in Chapter 5 of LACH&SM. The manual defines the toe-down depth as the sum of long-term adjustment, general adjustment, and five local effects that fall into the category of other scour. Other scour falls into four sub-categories: local scour, bend scour, low-flow incisement, and bed form height. Local scour occurs in the vicinity of flow obstructions including piers and abutments. Bend scour occurs because differential velocity gradients around curves in open channel flow. Three distinct bends are located in the River between Interstate 5 and the end of the study area near the Los Angeles/Ventura County line. These bends have radii of 9,000, 3,000, and 17,000 feet from east to west in the River, respectively. The bends can be seen in Figure 1.1. Low flow incisement is included to represent thalweg or low flow channel depth. On-site inspection and analysis of historic topographic data of this feature estimates the thalweg at approximately two feet. Finally, bedform height represents the dunes and anti-dunes that develop in active soft-bottomed channels during flow events. Because no observations are available, bedform height has been limited after Kennedy (1963).

Bend scour and bedform height have been calculated based on LACH&SM design curves in Chapter 5 and Appendix Q. Bend scour is based on equation Q-6A of the manual, given as (Zeller, 1981):

$$Z_{bs} = \frac{0.0685YV^{0.8}}{Y_h^{0.4}S_e^{0.3}}\left[1.59\left(\frac{w}{r}\right)^{0.2} - 1\right]$$

where Z_{bs} is the bend scour depth, V is mean velocity, Y is maximum depth of flow, Y_h is hydraulic depth of flow, S_e is energy slope, w is channel top width, and r is radius of curvature to the centerline of the channel. Bedform height is given by equation Q-8 of the manual, given as:

$$h = 0.027V^2$$

where h is bedform height.

Results of calculations of other scour components are summarized in Table 6 as well as in LACH&SM calculations tables in Appendix Chapter 6.1 for both the existing and proposed conditions. Pier scour is zero in the existing condition and ranges from 0.0 to 17.4 in the proposed condition. The tables show that in the existing and proposed conditions bend scour ranges from 0.0 to 11.3 feet and 0.0 to 8.9 feet, respectively. Observed changes result from changes to river hydraulics in the study reach. For both the existing and proposed conditions, the table also shows that bed form height ranges from 0.5 to 8.3 feet in both the existing and proposed conditions.

Table 6: Santa Clara River Summary of Other Scour (ft)							
		Existing Condition		Proposed Condition			
Subreach	Section	Outside Curved Reach	Straight-Inside Curved Reach	Outside Curved Reach	Straight-Inside Curved Reach	Δ Curved	Δ Straight
SRA1	46195	8.3	8.3	8.3	8.3	0.0	0.0
	46020	9.9	9.9	9.9	9.9	0.0	0.0
	45545	7.6	7.6	7.6	7.6	0.0	0.0
	45030	10.3	10.3	10.3	10.3	0.0	0.0
	44585	7.0	7.0	7.0	7.0	0.0	0.0
	44210	9.7	9.7	9.7	9.7	0.0	0.0
SRA2	43820	7.3	7.3	7.3	7.3	0.0	0.0
	43610	8.9	8.9	8.9	8.9	0.0	0.0
	43410	7.7	7.7	7.7	7.7	0.0	0.0
	43200	8.2	8.2	8.2	8.2	0.0	0.0
	42975	7.4	7.4	7.4	7.4	0.0	0.0
	42815	7.3	7.3	7.4	7.4	0.1	0.1
	42590	6.9	6.5	7.0	6.6	0.1	0.1
	42430	7.0	6.8	7.3	7.2	0.3	0.4
	42215	5.0	3.5	7.1	6.6	2.1	3.1
	41940	5.4	3.8	5.3	3.8	-0.1	0.0
	41730	5.2	3.9	5.1	3.9	-0.1	0.0
	41460	5.7	3.8	4.7	3.8	-1.0	0.0
SRA3	41280	5.7	5.7	5.6	5.6	-0.1	-0.1
	41080	7.3	7.3	7.4	7.4	0.1	0.1
	40825	6.9	6.4	6.9	6.4	0.0	0.0
	40585	6.3	5.9	6.3	5.9	0.0	0.0
	40335	5.9	3.7	4.9	3.5	-1.0	-0.2
	40130	6.5	3.7	5.0	3.7	-1.5	0.0
	39945	6.4	3.4	4.9	3.6	-1.5	0.2
	39755	6.7	5.2	5.7	5.7	-1.0	0.5
	39605	7.9	7.1	7.2	7.2	-0.7	0.1
	39310	6.7	5.5	5.9	5.7	-0.8	0.2
	39100	5.7	4.1	7.2	7.2	1.5	3.1
	38925	4.9	3.8	4.2	4.2	-0.6	0.4
SRA4	38710	4.2	3.5	4.0	4.0	-0.2	0.5
	38475	6.3	6.3	6.3	6.3	0.0	0.0
	38300	6.9	6.9	7.1	7.1	0.2	0.2
	38065	4.7	4.7	4.9	4.9	0.2	0.2
	37810	6.5	6.5	6.5	6.5	0.0	0.0
	37655	7.1	7.1	7.3	7.3	0.2	0.2
	37390	5.1	5.1	5.3	5.3	0.2	0.2
	37135	6.4	5.9	5.7	5.7	-0.7	-0.2
	36930	6.5	5.9	6.1	6.1	-0.4	0.2
	36735	5.9	5.0	5.5	5.5	-0.4	0.5
	36515	7.0	5.8	4.6	4.2	-2.4	-1.6
	36265	5.7	4.3	5.0	4.1	-0.7	-0.2
SRB1	36080	5.7	4.1	19.1	18.2	13.4	14.1
	35845	5.7	3.6	5.3	3.6	-0.4	0.0
	35725	7.0	4.9	6.8	5.0	-0.2	0.1
	35515	7.7	5.9	7.7	5.9	0.0	0.0
	35245	7.2	4.8	7.6	6.0	0.4	1.2
	35040	8.8	7.1	8.9	7.2	0.1	0.1
	34860	7.8	6.4	7.8	6.6	0.0	0.2
	34720	7.9	6.4	8.0	6.6	0.1	0.2
	34495	7.4	6.4	7.1	6.1	-0.3	-0.3
	34310	7.3	6.2	7.0	5.8	-0.3	-0.4
	34090	6.9	6.0	6.9	5.9	0.0	-0.1
SRB2	33880	6.5	5.3	6.9	5.7	0.4	0.4
	33710	6.9	5.7	6.5	5.2	-0.4	-0.5
	33500	6.9	5.4	7.1	5.5	0.2	0.1
	33310	7.5	5.4	7.5	5.4	0.0	0.0
	33115	6.7	5.3	5.6	3.4	-1.1	-1.9
	32795	6.3	4.0	6.6	4.3	0.3	0.3
	32605	6.1	4.7	7.1	4.8	1.0	0.1
SRC1	32265	8.2	5.8	7.9	5.4	-0.3	-0.4
	31875	6.9	3.6	7.1	4.1	0.2	0.5
	31585	8.6	5.7	6.6	3.6	-2.0	-2.1
	31360	6.3	3.3	6.3	3.4	0.0	0.1
	31060	5.6	2.8	5.5	2.9	-0.1	0.1
	30720	6.1	2.6	5.9	2.6	-0.2	0.0
	30445	6.0	2.5	5.9	2.5	-0.1	0.0
	30095	6.7	2.6	6.1	2.6	-0.6	0.0
	29815	7.1	2.8	5.7	2.8	-1.4	0.0
	29565	7.4	2.7	5.1	2.7	-2.3	0.0
	29385	7.8	3.0	5.0	2.9	-2.8	-0.1
SRC2	29140	7.8	3.4	4.4	3.1	-3.4	-0.3
	28895	8.8	7.2	7.5	6.8	-1.3	-0.4
	28695	10.0	10.0	9.0	9.0	-1.0	-1.0
	28500	8.8	8.8	8.8	8.8	0.0	0.0
	28280	7.9	7.9	7.6	7.4	-0.3	-0.5
	28080	7.7	7.7	3.9	3.7	-3.8	-4.0
	27925	6.3	6.3	4.3	4.3	-2.0	-2.0
	27725	7.7	7.7	6.9	6.9	-0.8	-0.8
	27545	8.6	8.6	9.0	9.0	0.4	0.4
	27335	8.0	8.0	8.2	8.2	0.2	0.2
	27155	8.6	8.6	6.9	6.9	-1.7	-1.7
SRC3	26990	8.1	7.6	7.9	7.7	-0.2	0.1
	26780	8.5	7.5	8.3	7.6	-0.2	0.1
	26575	12.8	7.5	12.7	7.6	-0.1	0.1
	26355	12.4	5.4	12.1	5.4	-0.3	0.0
	26170	14.1	6.4	13.3	5.9	-0.8	-0.5
	25965	13.7	6.3	13.8	6.5	0.1	0.2
	25785	14.2	7.2	13.4	6.8	-0.8	-0.4
	25600	16.0	7.6	12.6	6.6	-3.4	-1.0
	25425	16.1	7.4	11.8	6.5	-4.3	-0.9
	25215	13.9	4.8	10.7	4.7	-3.2	-0.1
	25000	16.6	6.1	10.4	4.3	-6.2	-1.8
SRC4	24795	17.7	6.9	10.3	4.7	-7.4	-2.2
	24550	17.6	7.4	10.4	5.1	-7.2	-2.3
	24335	15.0	4.8	11.0	6.5	-4.0	1.7
	24115	15.5	6.8	11.5	7.4	-5.0	0.7
	23975	14.6	6.9	11.9	7.8	-2.7	0.9
	23755	13.8	5.8	11.2	6.4	-2.6	0.6
	23565	14.1	4.8	12.5	7.5	-1.6	2.7
	23365	13.3	5.9	12.3	6.6	-1.0	0.7
	23180	13.5	4.3	13.8	8.3	0.3	4.0
	23000	11.0	3.1	11.0	7.6	0.0	4.5
	22790	11.0	3.2	24.8	21.0	13.8	17.8
	22600	13.0	3.7	12.8	7.3	-0.2	3.6
	22415	12.6	3.9	12.0	7.4	-0.6	3.5

Table 6: Santa Clara River Summary of Other Scour (ft) continued

Subreach	Section	Existing Condition		Proposed Condition		Δ Curved	Δ Straight
		Outside Curved Reach	Straight-Inside Curved Reach	Outside Curved Reach	Straight-Inside Curved Reach		
SRD1	22195	11.8	4.7	11.1	4.5	-0.7	-0.2
	22010	13.6	5.5	13.1	5.5	-0.5	0.0
	21790	13.1	7.2	13.1	7.2	0.0	0.0
	21615	10.4	6.3	10.3	6.3	-0.1	0.0
	21440	13.4	6.8	11.9	6.1	-1.5	-0.7
	21225	16.9	7.1	14.1	6.4	-2.8	-0.7
	21020	12.9	6.4	10.4	6.9	-2.5	0.5
	20845	15.5	5.9	13.0	5.1	-2.5	-0.8
	20595	15.4	5.1	11.9	4.1	-3.5	-1.0
	20435	15.6	4.3	12.2	4.0	-3.4	-0.3
	20280	15.6	4.6	13.2	5.3	-2.4	0.7
	20070	13.3	6.6	14.6	7.0	1.3	0.4
SRD2	19855	14.2	6.3	12.5	7.1	-1.7	0.8
	19630	12.9	6.3	10.3	6.4	-2.6	0.1
	19440	12.8	3.9	10.2	4.3	-2.6	0.4
	19240	13.3	4.6	11.0	5.4	-2.3	0.8
	19050	12.7	3.6	12.1	6.8	-0.6	3.2
	18830	13.6	3.5	12.5	4.4	-1.1	0.9
	18650	13.5	3.3	12.7	4.0	-0.8	0.7
	18475	12.6	2.9	11.6	3.1	-1.0	0.2
	18290	12.9	3.0	12.1	3.3	-0.8	0.3
	18025	2.8	2.8	2.8	2.8	0.0	0.0
	17785	3.0	3.0	3.0	3.0	0.0	0.0
SRD3	17510	4.6	4.6	3.6	3.6	-1.0	-1.0
	17360	5.9	5.9	5.9	5.9	0.0	0.0
	17110	8.4	8.4	8.7	8.7	0.3	0.3
	16970	8.8	8.8	8.8	8.8	0.0	0.0
	16720	6.5	6.5	6.6	6.6	0.1	0.1
	16515	6.8	6.8	7.1	7.1	0.3	0.3
	16305	7.1	6.8	3.8	3.8	-3.3	-3.0
	16130	6.0	5.5	5.3	5.3	-0.7	-0.2
	15960	6.1	5.4	6.2	6.2	0.1	0.8
	15745	4.5	3.6	4.0	4.0	-0.5	0.4
	15540	4.6	3.6	3.5	3.5	-1.1	-0.1
	15335	5.1	4.2	5.5	5.5	0.4	1.3
SRE1	15125	5.5	5.5	23.7	23.7	18.2	18.2
	14900	4.9	4.9	6.9	6.9	2.0	2.0
	14720	6.0	5.8	6.5	6.4	0.5	0.6
	14480	5.0	4.7	6.5	6.4	1.5	1.7
	14315	5.2	5.0	5.0	4.6	-0.2	-0.4
	14090	4.7	4.6	4.9	4.8	0.2	0.2
	13850	5.4	5.3	4.3	4.2	-1.1	-1.1
	13635	5.2	5.2	5.3	5.2	0.1	0.0
	13425	6.3	6.0	6.2	5.9	-0.1	-0.1
	13190	4.3	4.0	4.3	4.0	0.0	0.0
SRE2	13030	4.9	4.7	4.9	4.7	0.0	0.0
	12835	4.4	4.4	4.4	4.4	0.0	0.0
	12615	4.1	4.1	4.1	4.1	0.0	0.0
	12395	4.0	4.0	4.0	4.0	0.0	0.0
	12195	3.5	3.5	3.5	3.5	0.0	0.0
	11995	4.2	4.2	4.2	4.2	0.0	0.0
	11780	4.1	4.1	4.1	4.1	0.0	0.0
	11605	4.7	4.7	4.6	4.6	-0.1	-0.1
	11405	4.3	4.3	4.3	4.3	0.0	0.0
	11180	5.7	5.7	5.7	5.7	0.0	0.0
SRE3	11015	6.9	6.9	6.9	6.9	0.0	0.0
	10835	7.4	7.4	7.4	7.4	0.0	0.0
	10575	5.7	5.7	5.7	5.7	0.0	0.0
	10390	6.4	6.4	6.4	6.4	0.0	0.0
	10225	6.3	6.3	6.3	6.3	0.0	0.0
	10000	5.0	5.0	5.0	5.0	0.0	0.0
	9820	6.7	6.7	6.7	6.7	0.0	0.0
	9595	4.9	4.9	4.9	4.9	0.0	0.0
	9385	5.5	5.4	5.5	5.4	0.0	0.0
	9220	5.8	5.6	5.8	5.6	0.0	0.0
	9025	5.5	5.4	5.5	5.4	0.0	0.0

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

7 Total Scour

To be conservative, general adjustment, long-term adjustment, and other scour are summed to determine total potential bed adjustment following LACH&SM methodology, as presented in Chapter 5 of the LACH&SM manual. SAM values represent general adjustment, and the long-term analysis presented in Chapter 5 represent long-term trends. Previous versions of this report used long-term analysis based on historical thalweg analysis. The presently employed cross-section analysis provides greater detail at individual sections and has replaced the thalweg analysis. The historical thalweg analysis is included in Appendix Chapter 5.2 for completeness. Individual and combined scour components are shown in Figure 7.1A-D and Table 7.1A-D, for the existing and proposed conditions. For cross-sections where SAM modeling predicts aggradation, the general adjustment contribution to total bed adjustment is not included. This conservative approach ensures that major trends are captured by the study but local or minor bed adjustments do not decrease total potential degradation. Long-term degradation values are taken as the larger of long-term degradation or two feet. The figure shows that total bed degradation on the outside bank of curved reaches ranges from approximately -6.9 to -19.7 feet in the existing condition at sections 38710/13030 and section 24795, respectively. In the proposed condition, total bed degradation outside of curved reaches range from approximately -6.7 to -26.1 feet at section 38710 and section 15125, respectively. In straight and inside bank of curved reaches in the existing condition, total degradation ranges from -6.2 to -15.4 feet at section 38710 and section 43820, respectively. In straight and inside of curved reaches in the proposed condition, total degradation ranges from -6.7 feet at multiple sections to -26.2 feet at section 15125, respectively. The largest adjustment for both conditions is in the vicinity of the Grande and Portrero confluences. The existing and proposed conditions closely match ($\Delta \leq 1.0$) at all subreaches except at SRC2, SRC4, and SRD2 where the proposed condition total adjustment is shallower than that in the existing condition, and at SRB1 and SRE1 where the proposed condition total adjustment is deeper than the existing condition. In the cases of SRB1 and SRE1, the total degradation in the proposed condition is deeper due to proposed bridges at these locations. In the other cases where total degradation in the existing condition is deeper, general adjustment and other components differ significantly between the existing and proposed conditions. It is important to note that the total toe-down is primarily a function of the large other components, which greatly exceed the general adjustment and long-term degradation components.

Table 7.1A: Santa Clara River Existing Conditions Outside Curved Reach Summary of Degradation Components (ft)

Subreach	US Station	Z_{DEG}	Z_{GS} (SAM)*	Z_{OTHER}	Z_{TOTAL}
SRA1	46195	-2.8	0.6	-8.3	-11.1
SRA2	43820	-8.1	0.4	-7.3	-15.4
SRA3	41280	-5.2	-0.3	-5.7	-11.2
SRA4	38710	-2.7	0.3	-4.2	-6.9
SRB1	36080	-3.2	-0.6	-5.7	-9.5
SRB2	33880	-3.4	0.0	-6.5	-9.9
SRC1	32265	-2.0	0.8	-8.2	-10.2
SRC2	29140	-4.4	-2.9	-7.8	-15.1
SRC3	26990	-2.0	-0.4	-8.1	-10.5
SRC4	24795	-2.0	0.2	-17.7	-19.7
SRD1	22195	-2.0	-0.6	-11.8	-14.4
SRD2	19855	-2.0	1.3	-14.2	-16.2
SRD3	17510	-2.0	-1.2	-4.6	-7.8
SRE1	15125	-2.0	-0.6	-5.5	-8.1
SRE2	13030	-2.0	2.3	-4.9	-6.9
SRE3	11015	-2.0	-1.4	-6.9	-10.3

*Positive values in Z_{GS} represent aggradation

Table 7.1B: Santa Clara River Proposed Conditions Outside Curved Reach Summary of Degradation Components (ft)

Subreach	US Station	Z_{DEG}	Z_{GS} (SAM)*	Z_{OTHER}	Z_{TOTAL}
SRA1	46195	-2.8	0.6	-8.3	-11.1
SRA2	43820	-8.1	0.2	-7.3	-15.4
SRA3	41280	-5.2	-0.1	-5.6	-10.9
SRA4	38710	-2.7	0.1	-4.0	-6.7
SRB1	36080	-3.2	-0.7	-19.1	-23.0
SRB2	33880	-3.4	0.2	-6.9	-10.3
SRC1	32265	-2.0	0.8	-7.9	-9.9
SRC2	29140	-4.4	-1.6	-4.4	-10.4
SRC3	26990	-2.0	-1.3	-7.9	-11.2
SRC4	24795	-2.0	0.2	-10.3	-12.3
SRD1	22195	-2.0	-0.2	-11.1	-13.3
SRD2	19855	-2.0	1.4	-12.5	-14.5
SRD3	17510	-2.0	-1.3	-3.6	-6.9
SRE1	15125	-2.0	-0.4	-23.7	-26.1
SRE2	13030	-2.0	2.1	-4.9	-6.9
SRE3	11015	-2.0	-1.5	-6.9	-10.4

*Positive values in Z_{GS} represent aggradation

Table 7.1C: Santa Clara River Existing Conditions Straight-Inside Curved Reach Summary of Degradation Components (ft)

Subreach	US Station	Z_{DEG}	Z_{GS} (SAM)*	Z_{OTHER}	Z_{TOTAL}
SRA1	46195	-2.8	0.6	-8.3	-11.1
SRA2	43820	-8.1	0.4	-7.3	-15.4
SRA3	41280	-5.2	-0.3	-5.7	-11.2
SRA4	38710	-2.7	0.3	-3.5	-6.2
SRB1	36080	-3.2	-0.6	-4.1	-7.9
SRB2	33880	-3.4	0.0	-5.3	-8.7
SRC1	32265	-2.0	0.8	-5.8	-7.8
SRC2	29140	-4.4	-2.9	-3.4	-10.7
SRC3	26990	-2.0	-0.4	-7.6	-10.0
SRC4	24795	-2.0	0.2	-6.9	-8.9
SRD1	22195	-2.0	-0.6	-4.7	-7.3
SRD2	19855	-2.0	1.3	-6.3	-8.3
SRD3	17510	-2.0	-1.2	-4.6	-7.8
SRE1	15125	-2.0	-0.6	-5.5	-8.1
SRE2	13030	-2.0	2.3	-4.7	-6.7
SRE3	11015	-2.0	-1.4	-6.9	-10.3

*Positive values in Z_{GS} represent aggradation

Table 7.1D: Santa Clara River Proposed Conditions Straight-Inside Curved Reach Summary of Degradation Components (ft)

Subreach	US Station	Z_{DEG}	Z_{GS} (SAM)*	Z_{OTHER}	Z_{TOTAL}
SRA1	46195	-2.8	0.6	-8.3	-11.1
SRA2	43820	-8.1	0.2	-7.3	-15.4
SRA3	41280	-5.2	-0.1	-5.6	-10.9
SRA4	38710	-2.7	0.1	-4.0	-6.7
SRB1	36080	-3.2	-0.7	-18.2	-22.1
SRB2	33880	-3.4	0.2	-5.7	-9.7
SRC1	32265	-2.0	0.8	-5.4	-7.4
SRC2	29140	-4.4	-1.6	-3.1	-9.1
SRC3	26990	-2.0	-1.3	-7.7	-11.0
SRC4	24795	-2.0	0.2	-4.7	-6.7
SRD1	22195	-2.0	-0.2	-4.5	-6.7
SRD2	19855	-2.0	1.4	-7.1	-9.1
SRD3	17510	-2.0	-1.3	-3.6	-6.9
SRE1	15125	-2.0	-0.4	-23.7	-26.1
SRE2	13030	-2.0	2.1	-4.7	-6.7
SRE3	11015	-2.0	-1.5	-6.9	-10.4

*Positive values in Z_{GS} represent aggradation

Figure 7.2A-D presents a comparison of total bed adjustment for the summed methodology, presented previously, and the methodology based on the Los Angeles County Flood Control District's Design Manual (LACFCDDM), Table F-31. Calculations are shown in Table 7.2A-D. The LACFCDDM methodology is based only on velocity and does not account for any other river parameters. Generally, the

Figure 7.1A: Santa Clara River Existing Conditions Outside Curved Reach Summary of Degradation Components

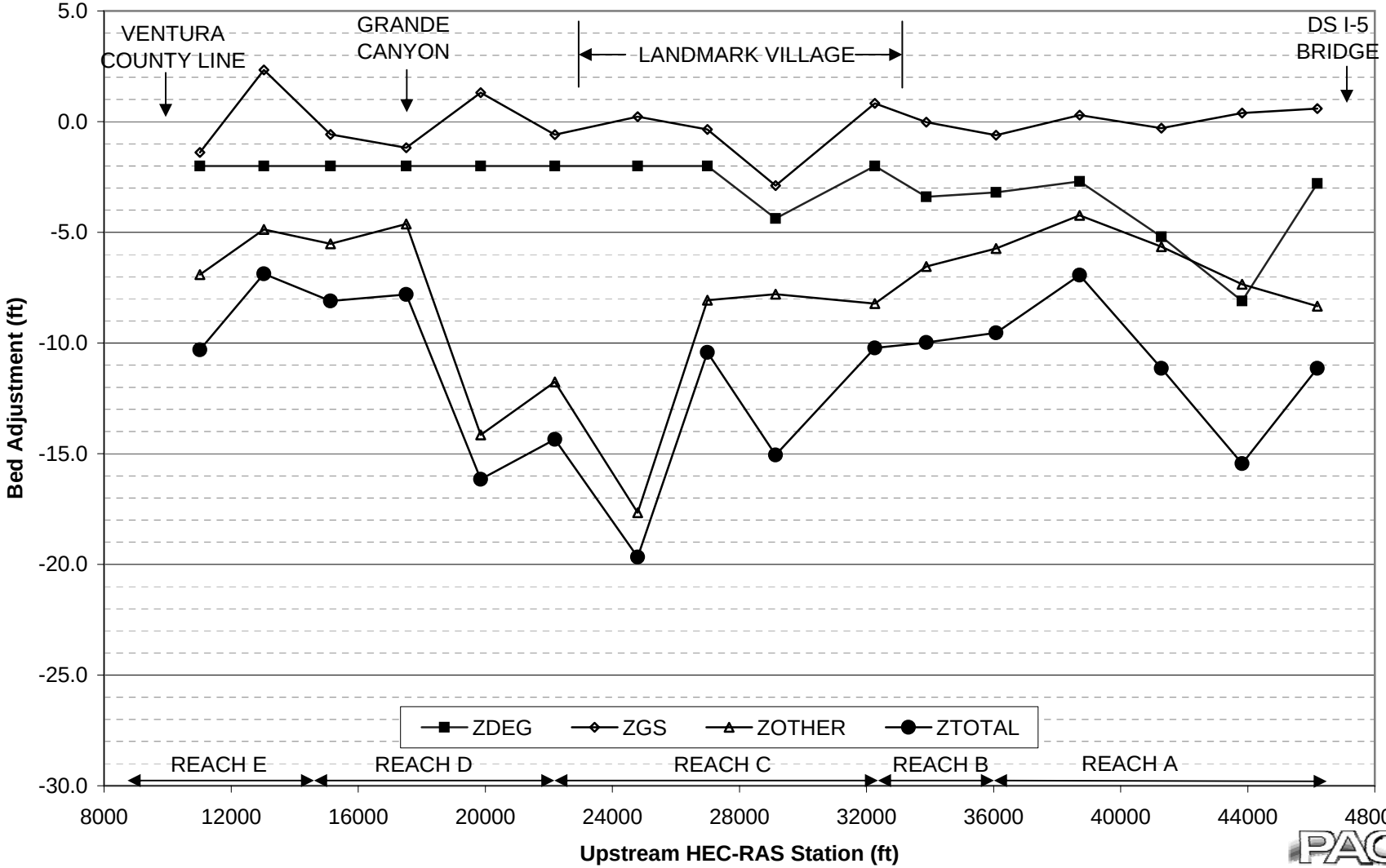
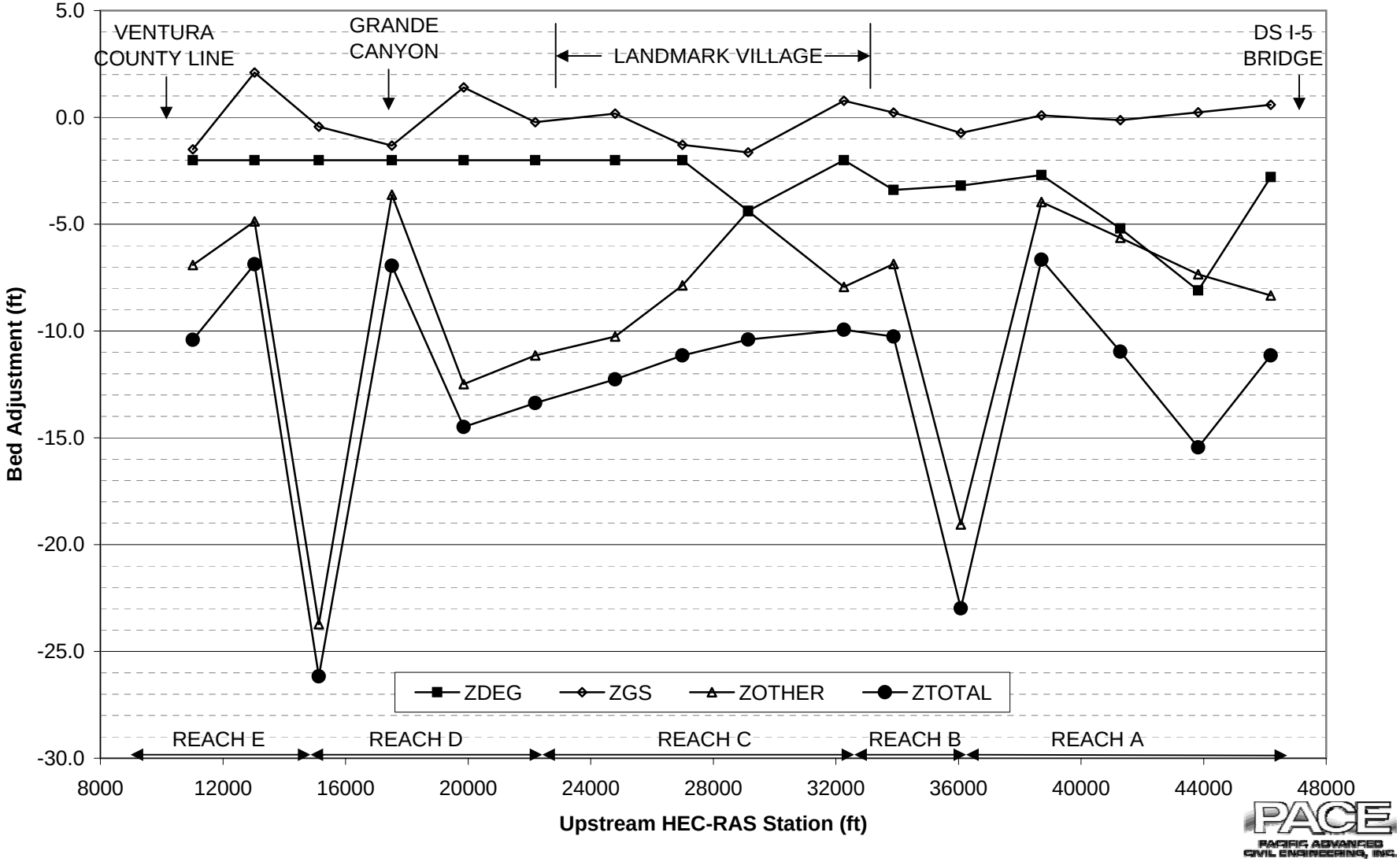


Figure 7.1B: Santa Clara River Proposed Conditions Outside Curved Reach Summary of Degradation Components



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

Figure 7.1C: Santa Clara River Existing Conditions Straight-Inside Curved Reach Summary of Degradation Components

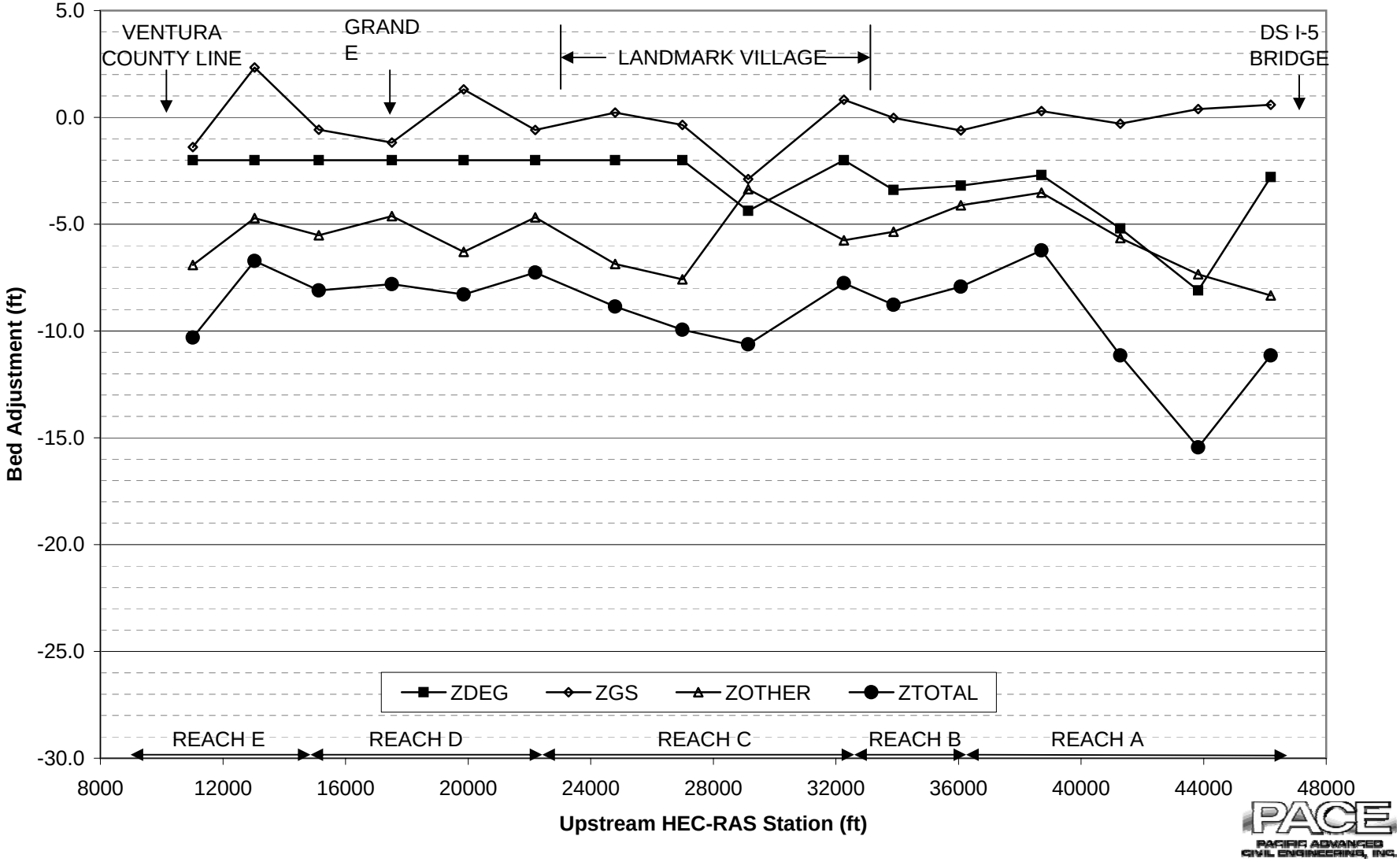
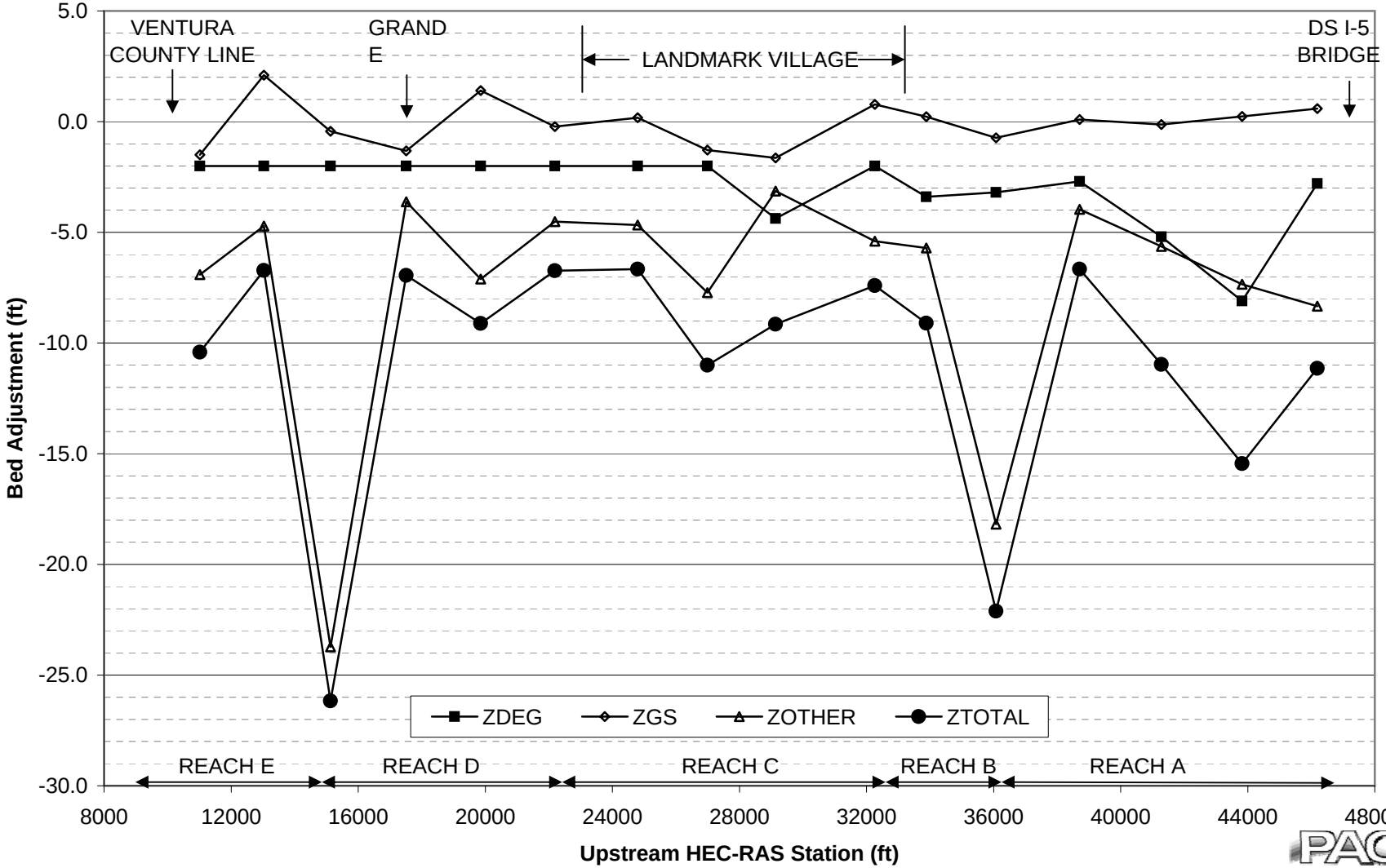


Figure 7.1D: Santa Clara River Proposed Conditions Straight-Inside Curved Reach Summary of Degradation Components



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

LACFCDDM is the most conservative among all total scour methodologies. Figure 7.2A-D shows that the more intensive LACH&SM methodology generally predicts a shallower toe-down in both the existing and proposed conditions than does the LACFCDDM methodology for most sections. At section 43820, LACH&SM predicts 1.4 feet deeper toe-down than does the LACFCDDM for both existing and proposed conditions and outside of curved and straight or inside of curved reaches because of very high long-term adjustment. At section 29140 in straight or inside of curved reaches for both existing and proposed conditions, LACH&SM predicts 0.6 and 1.2 feet, respectively, deeper toe-down than does the LACFCDDM because of higher long-term adjustment combined with moderate bedform height in this reach. At section 36080 and section 15125 in the proposed condition, LACH&SM predicts more than 10 feet deeper toe-down than does LACFCDDM due to proposed bridges at these locations. The LACFCDDM does not effectively account for the local degradation; therefore, the LACH&SM methodology utilizing SAM calculations predicts a deeper toe-down at some locations than does the LACFCDDM methodology. Figure 7.3A-D shows the 1999 (model) minimum bed elevation as previously discussed in Chapter 4, the existing bed minimum elevation (2005), and the calculated project toe-down from Figure 7.2A-D. Figure 7.3A-D shows that the calculated toe-down is below the 1999 model and existing 2005 minimum bed elevation at every section examined by approximately 6 to 26 feet, depending on the section.

Table 7.2A: Santa Clara River Existing Conditions Outside Curved Reach Toe-down Summary by Methodology (ft)

Subreach	US Station	HEC-RAS Model (1999) Elevation	LACH&SM (SAM)	LACH&SM Toe-down Elevation	LACFCDDM	LACFCDDM Toe-down Elevation	Δ (LACH&SM-LACFCDDM)
SRA1	46195	1034.6	-11.1	1023.5	-14.0	1020.6	2.9
SRA2	43820	1018.0	-15.4	1002.6	-14.0	1004.0	-1.4
SRA3	41280	1002.0	-11.2	990.8	-12.5	989.5	1.3
SRA4	38710	988.0	-6.9	981.1	-15.0	973.0	8.1
SRB1	36080	973.2	-9.5	963.7	-15.0	958.2	5.5
SRB2	33880	960.0	-9.9	950.1	-18.0	942.0	8.1
SRC1	32265	951.4	-10.2	941.2	-18.0	933.4	7.8
SRC2	29140	932.0	-15.1	916.9	-15.0	917.0	-0.1
SRC3	26990	920.0	-10.5	909.5	-21.0	899.0	10.5
SRC4	24795	908.0	-19.7	888.3	-21.0	887.0	1.3
SRD1	22195	894.0	-14.4	879.6	-15.0	879.0	0.6
SRD2	19855	880.1	-16.2	863.9	-18.0	862.1	1.8
SRD3	17510	868.0	-7.8	860.2	-10.0	858.0	2.2
SRE1	15125	854.0	-8.1	845.9	-12.5	841.5	4.4
SRE2	13030	843.3	-6.9	836.4	-15.0	828.3	8.1
SRE3	11015	832.0	-10.3	821.7	-14.0	818.0	3.7

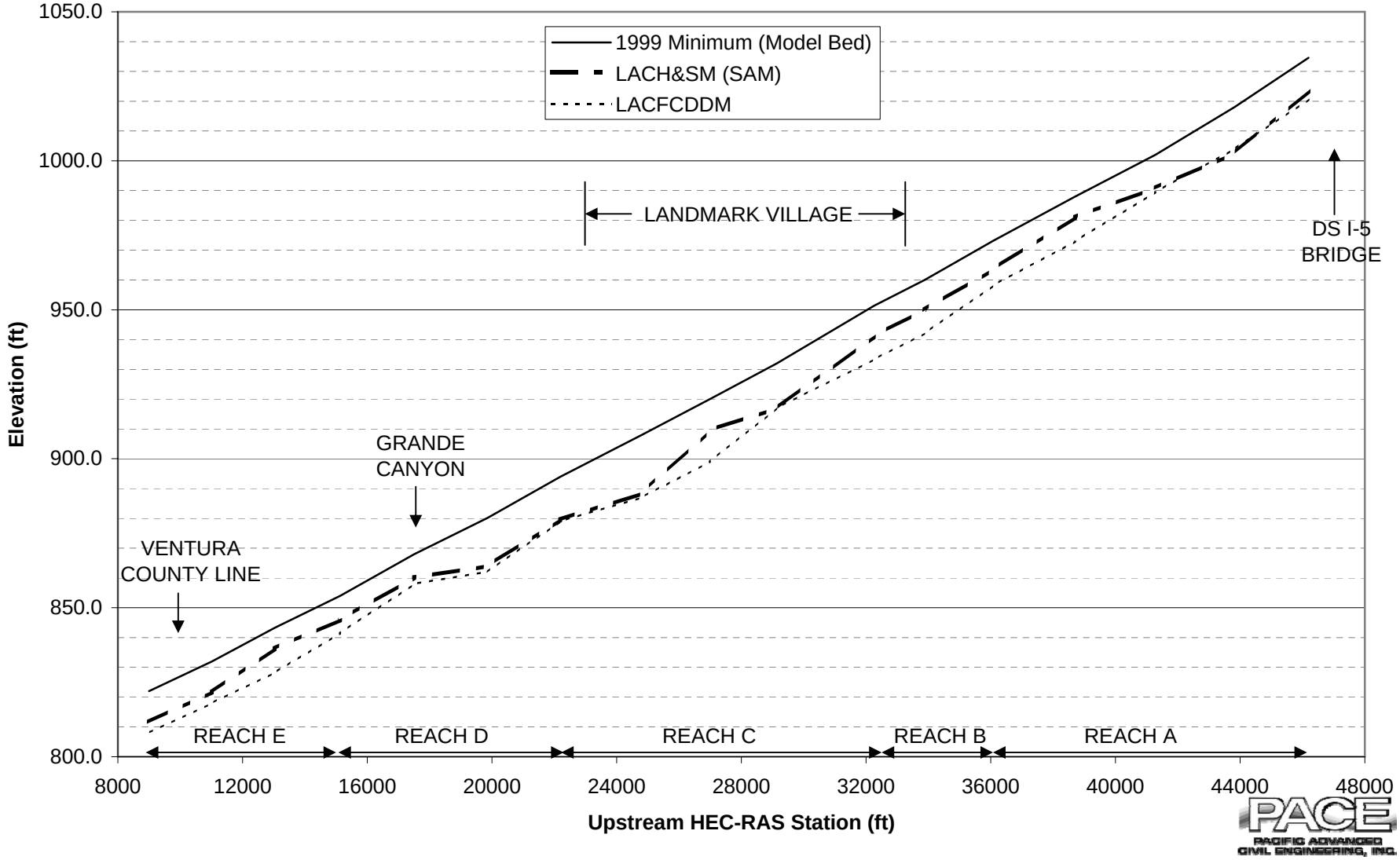
Table 7.2B: Santa Clara River Proposed Conditions Outside Curved Reach Toe-down Summary by Methodology (ft)

Subreach	US Station	HEC-RAS Model (1999) Elevation	LACH&SM (SAM)	LACH&SM Toe-down Elevation	LACFCDDM	LACFCDDM Toe-down Elevation	Δ (LACH&SM-LACFCDDM)
SRA1	46195	1034.6	-11.1	1023.5	-14.0	1020.6	2.9
SRA2	43820	1018.0	-15.4	1002.6	-14.0	1004.0	-1.4
SRA3	41280	1002.0	-10.9	991.1	-12.5	989.5	1.6
SRA4	38710	988.0	-6.7	981.3	-10.0	978.0	3.3
SRB1	36080	973.2	-23.0	950.2	-15.0	958.2	-8.0
SRB2	33880	960.0	-10.3	949.7	-18.0	942.0	7.7
SRC1	32265	951.4	-9.9	941.5	-18.0	933.4	8.1
SRC2	29140	932.0	-10.4	921.6	-12.0	920.0	1.6
SRC3	26990	920.0	-11.2	908.8	-21.0	899.0	9.8
SRC4	24795	908.0	-12.3	895.7	-15.0	893.0	2.7
SRD1	22195	894.0	-13.3	880.7	-15.0	879.0	1.7
SRD2	19855	880.1	-14.5	865.6	-21.0	859.1	6.5
SRD3	17510	868.0	-6.9	861.1	-10.0	858.0	3.1
SRE1	15125	854.0	-26.1	827.9	-12.5	841.5	-13.6
SRE2	13030	843.3	-6.9	836.4	-15.0	828.3	8.1
SRE3	11015	832.0	-10.4	821.6	-14.0	818.0	3.6

Table 7.2C: Santa Clara River Existing Conditions Straight-Inside Curved Reach Toe-down Summary by Methodology (ft)

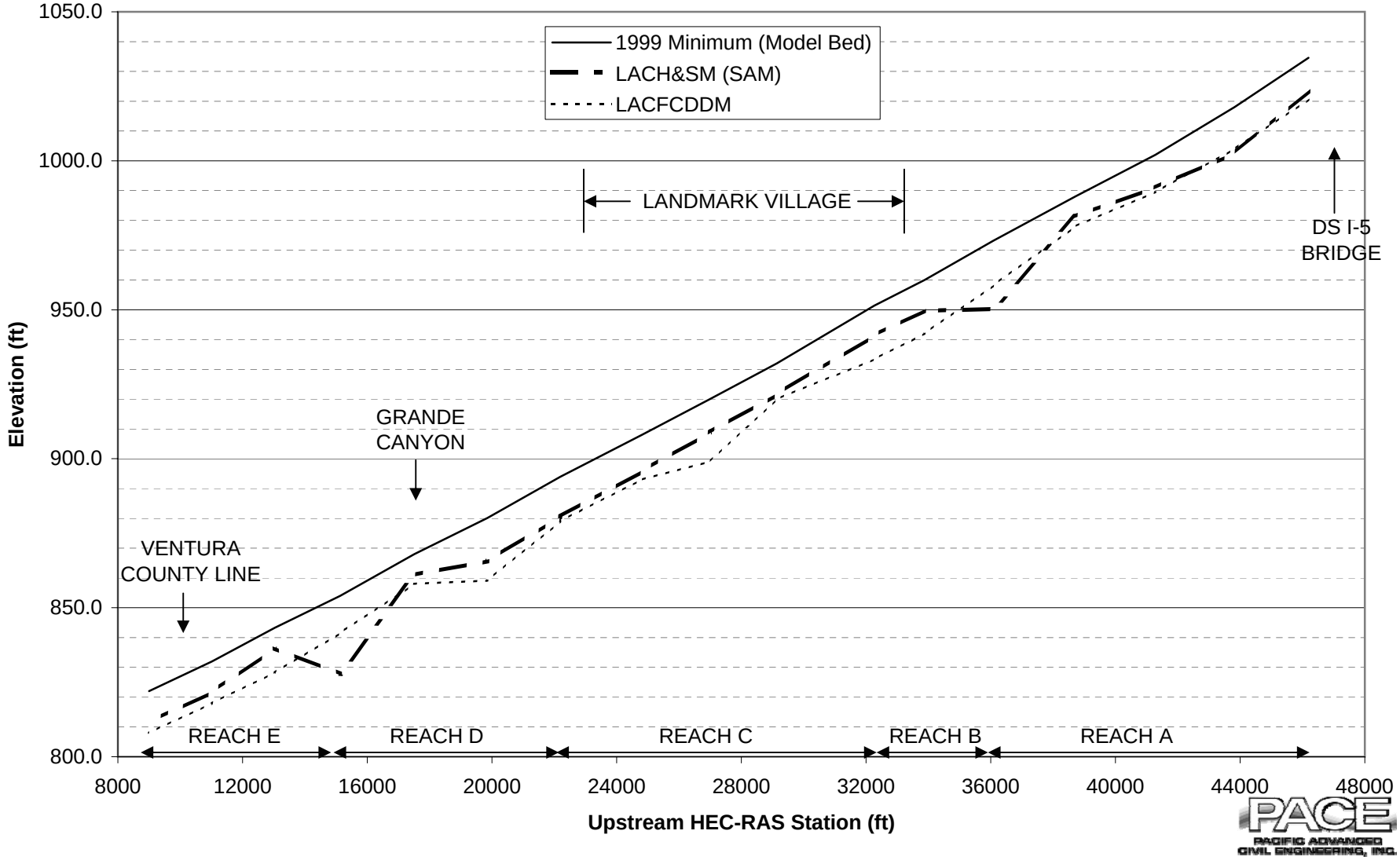
Subreach	US Station	HEC-RAS Model (1999) Elevation	LACH&SM (SAM)	LACH&SM Toe-down Elevation	LACFCDDM	LACFCDDM Toe-down Elevation	Δ (LACH&SM-LACFCDDM)
SRA1	46195	1034.6	-11.1	1023.5	-14.0	1020.6	2.9
SRA2	43820	1018.0	-15.4	1002.6	-14.0	1004.0	-1.4
SRA3	41280	1002.0	-11.2	990.8	-12.5	989.5	1.3
SRA4	38710	988.0	-6.2	981.8	-10.0	978.0	3.8
SRB1	36080	973.2	-7.9	965.3	-10.0	963.2	2.1
SRB2	33880	960.0	-8.7	951.3	-12.5	947.5	3.8
SRC1	32265	951.4	-7.8	943.6	-12.5	938.9	4.7
SRC2	29140	932.0	-10.7	921.3	-10.0	922.0	-0.7
SRC3	26990	920.0	-10.0	910.0	-14.0	906.0	4.0
SRC4	24795	908.0	-8.9	899.1	-14.0	894.0	5.1
SRD1	22195	894.0	-7.3	886.7	-10.0	884.0	2.7
SRD2	19855	880.1	-8.3	871.8	-12.5	867.6	4.2
SRD3	17510	868.0	-7.8	860.2	-10.0	858.0	2.2
SRE1	15125	854.0	-8.1	845.9	-12.5	841.5	4.4
SRE2	13030	843.3	-6.7	836.6	-10.0	833.3	3.3
SRE3	11015	832.0	-10.3	821.7	-14.0	818.0	3.7

Figure 7.2A: Santa Clara River Existing Conditions Outside Curved Reach Toe-down Depths by Methodology



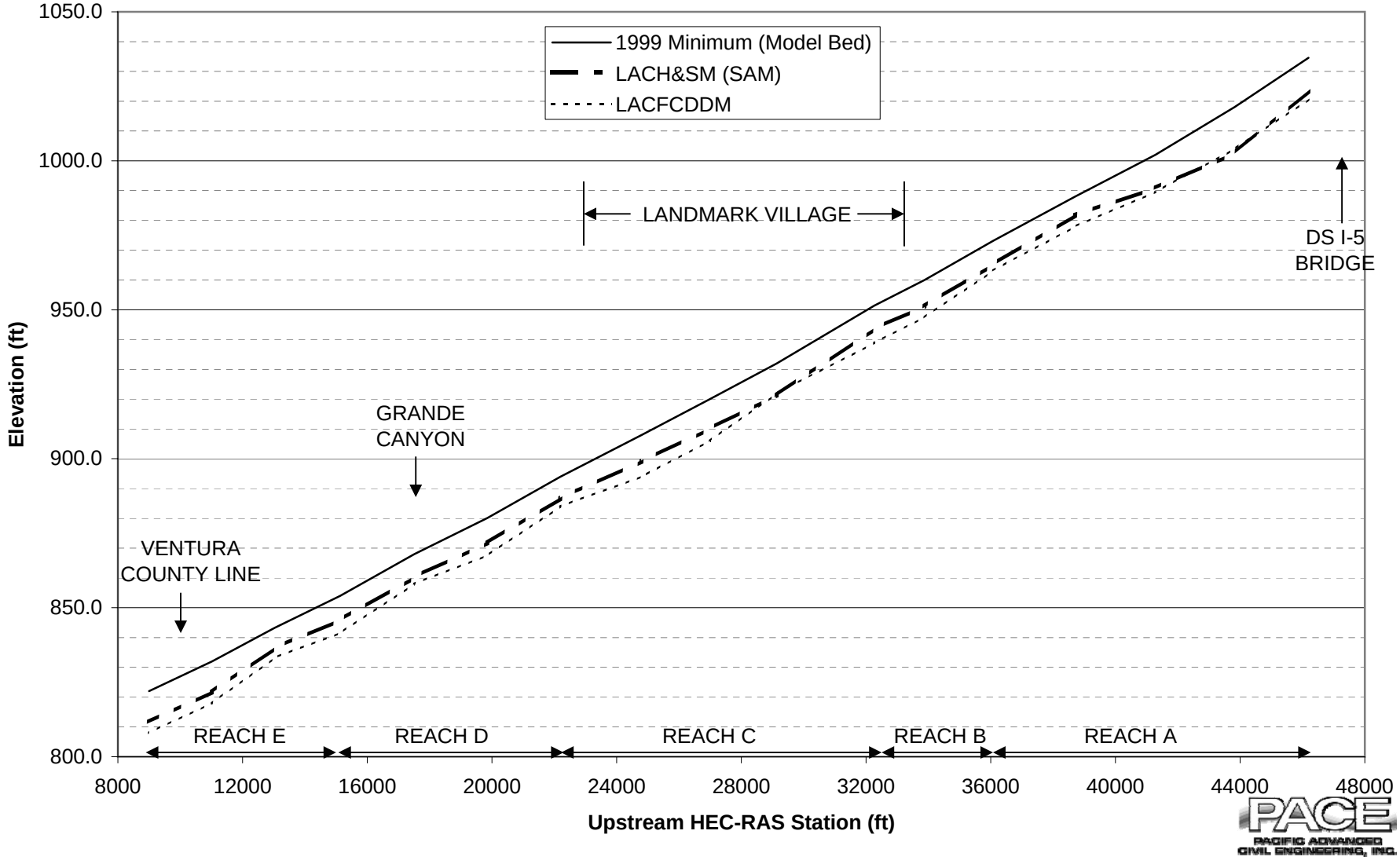
P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

Figure 7.2B: Santa Clara River Proposed Conditions Outside Curved Reach Toe-down Depths by Methodology



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

Figure 7.2C: Santa Clara River Existing Conditions Straight-Inside Curved Reach Toe-down Depths by Methodology



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

Figure 7.2D: Santa Clara River Proposed Conditions Straight-Inside Curved Reach Toe-down Depths by Methodology

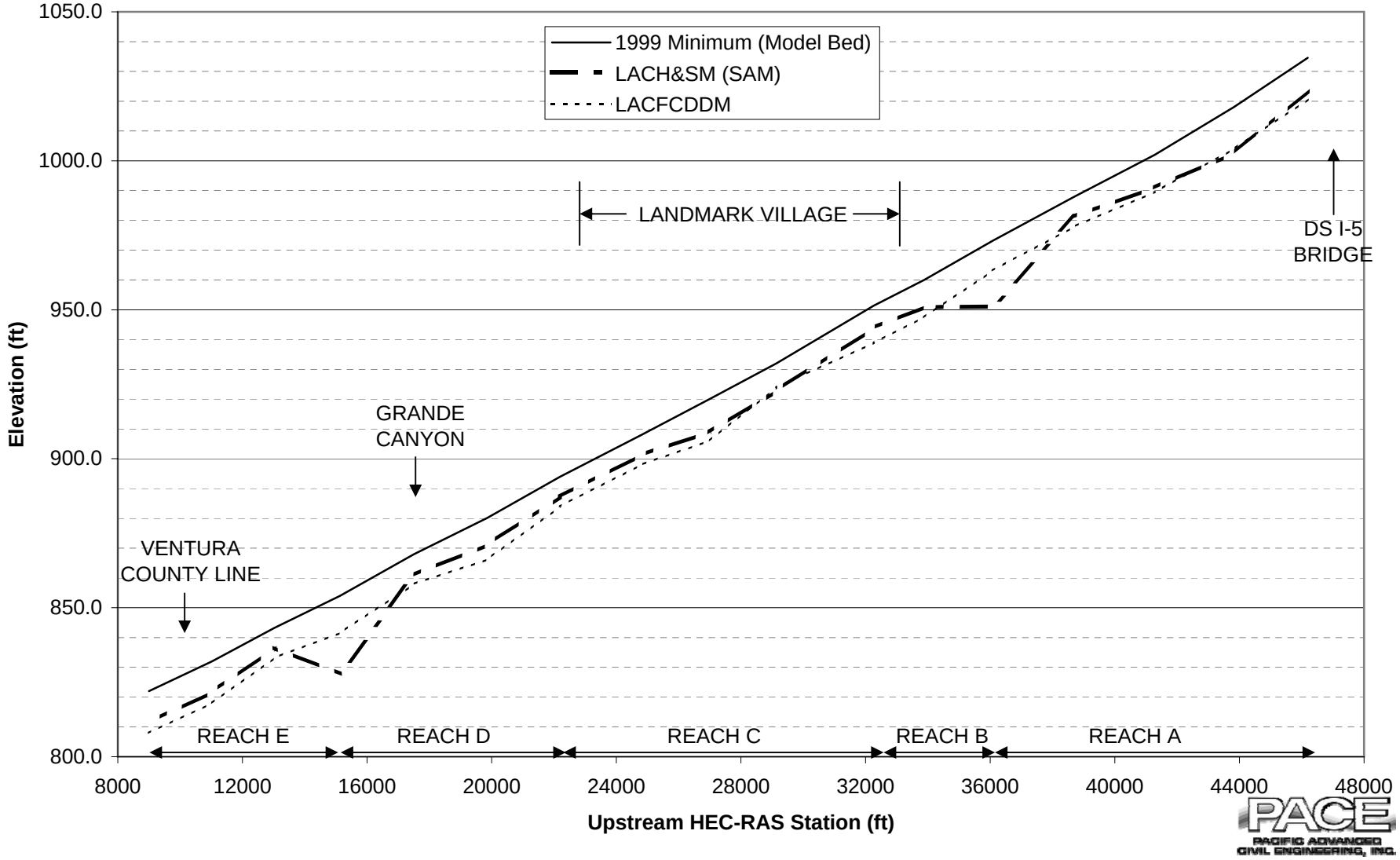
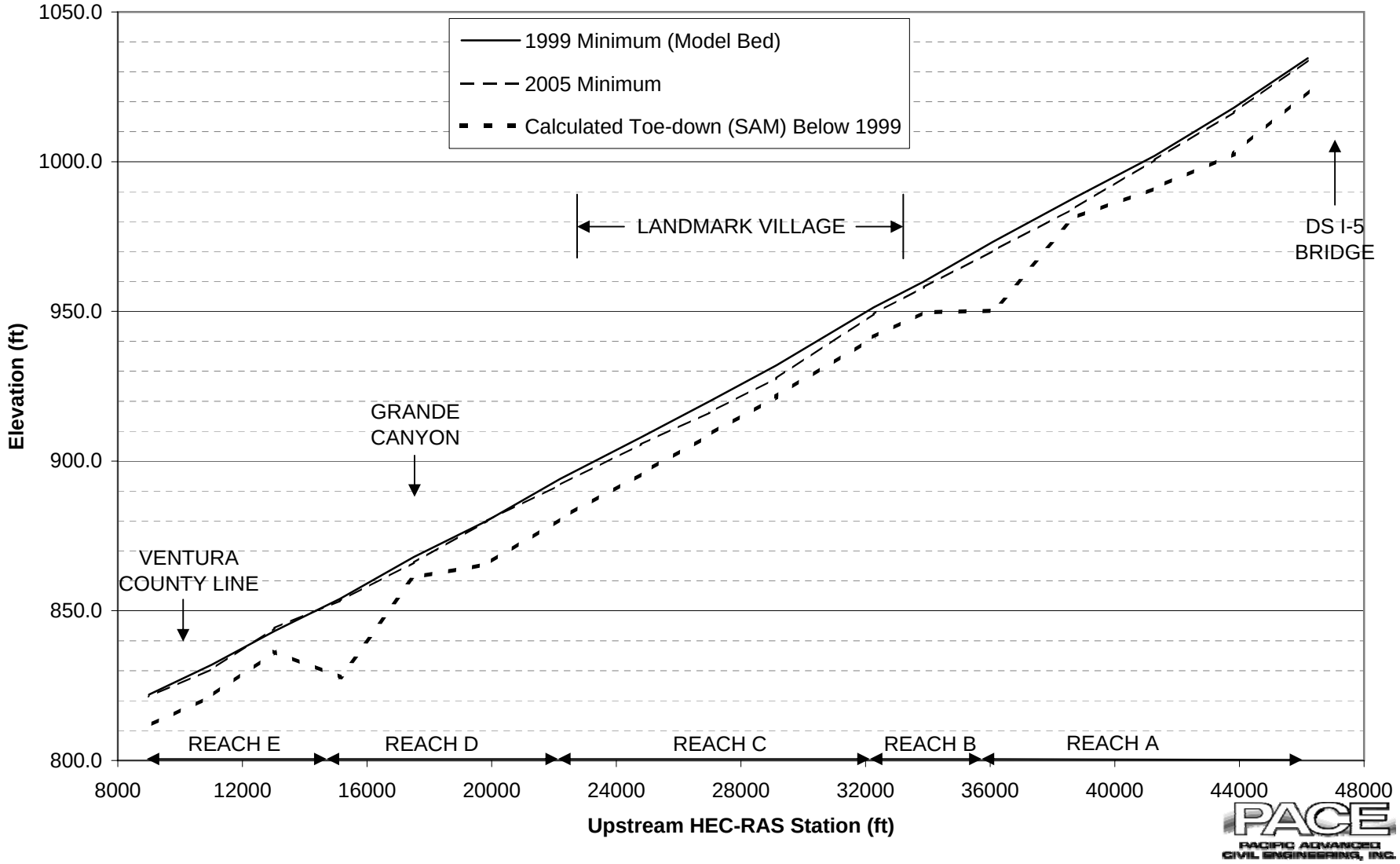


Figure 7.3B: Santa Clara River Outside Curved Reach Existing, Historic Minimum, and Proposed Conditions Toe-down Elevation



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Table 7.x toedownsummary 02-22-06

Figure 7.3C: Santa Clara River Straight-Inside Curved Reach Existing, Historic Minimum, and Existing Conditions Toe-down Elevation

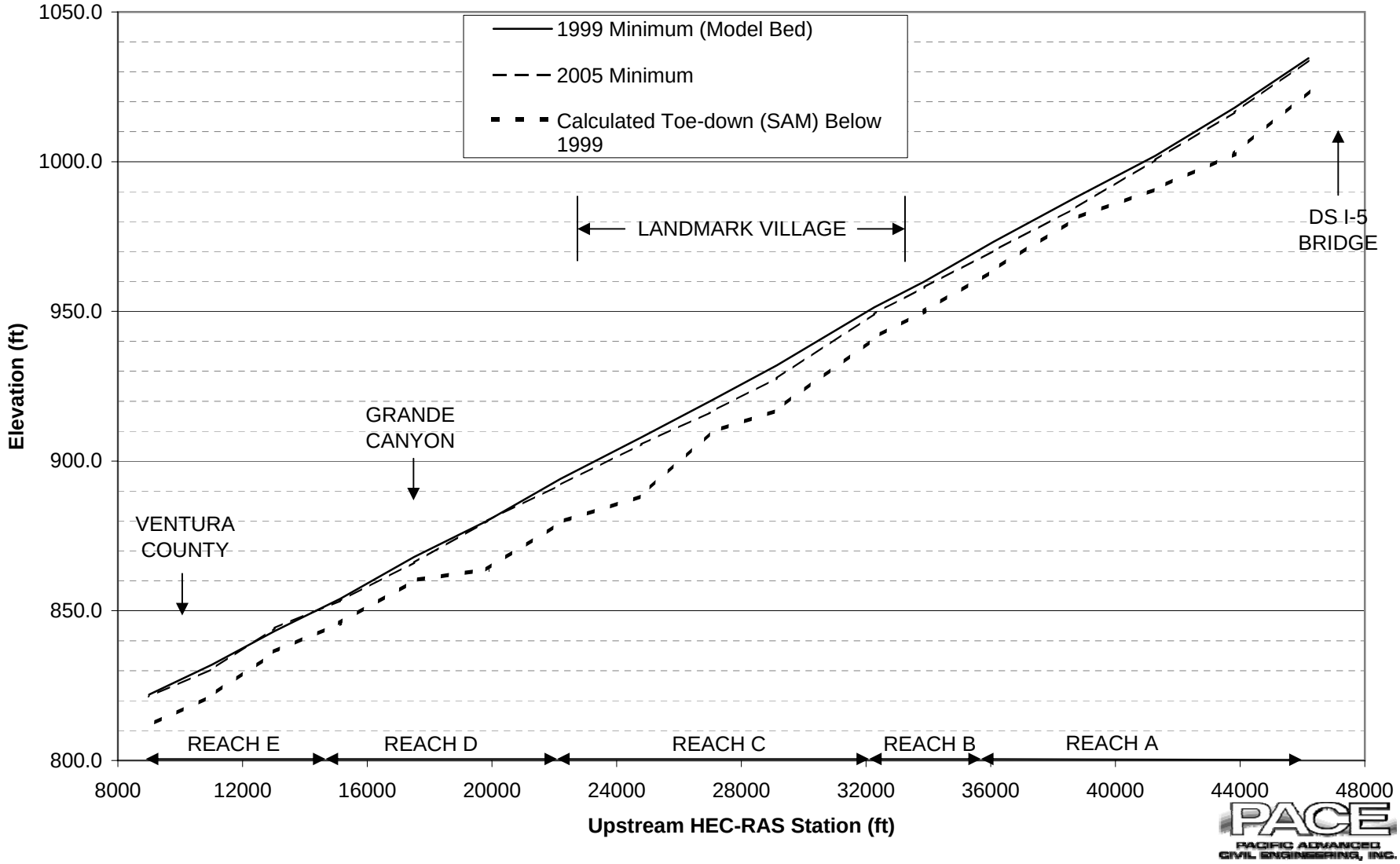


Figure 7.3D: Santa Clara River Straight-Inside Curved Reach Existing, Historic Minimum, and Proposed Conditions Toe-down Elevation

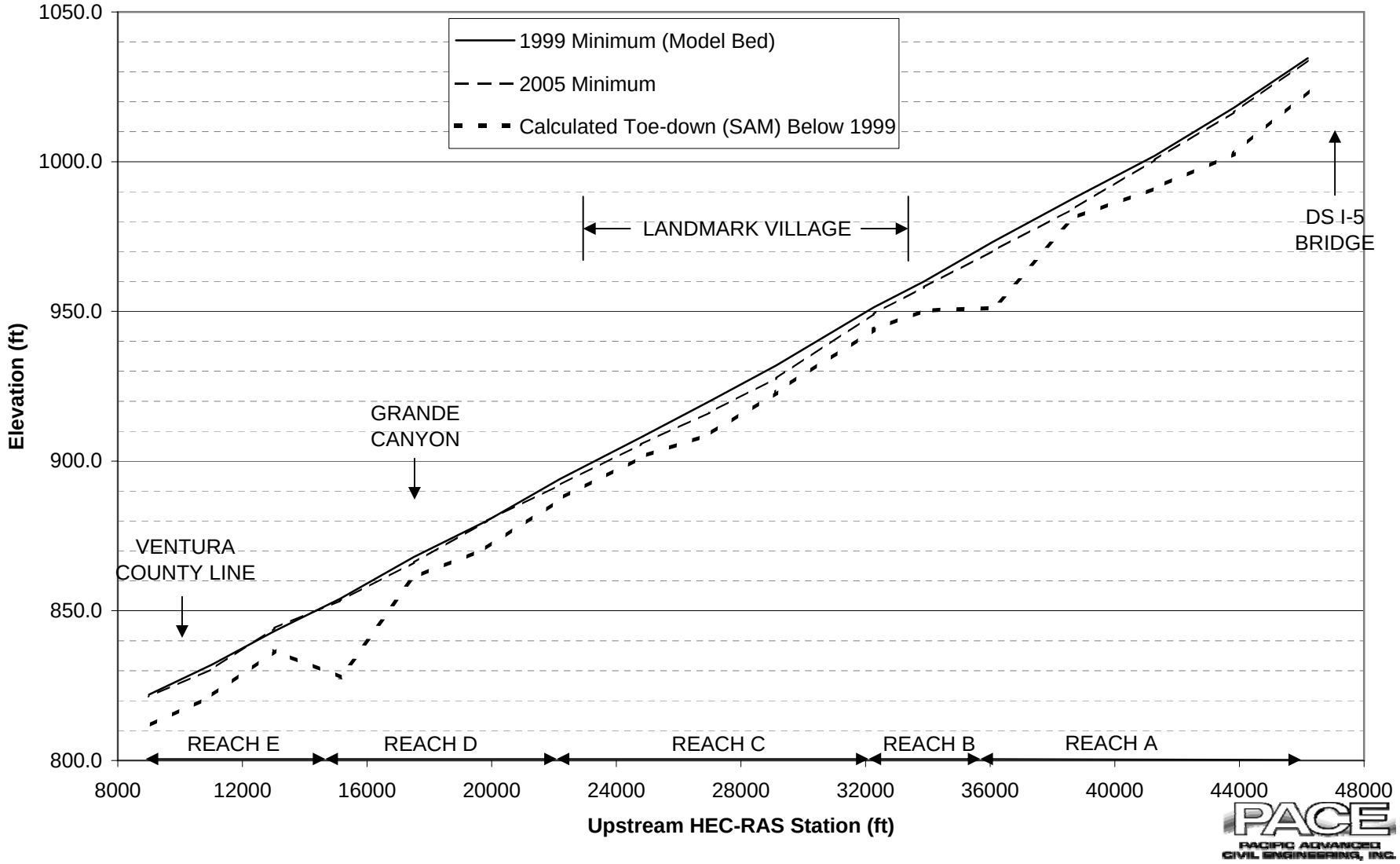


Table 7.2D: Santa Clara River Proposed Conditions Straight-Inside Curved Reach Toe-down Summary by Methodology (ft)

Subreach	US Station	HEC-RAS Model (1999) Elevation	LACH&SM (SAM)	LACH&SM Toe-down Elevation	LACFCDDM	LACFCDDM Toe-down Elevation	Δ (LACH&SM-LACFCDDM)
SRA1	46195	1034.6	-11.1	1023.5	-14.0	1020.6	2.9
SRA2	43820	1018.0	-15.4	1002.6	-14.0	1004.0	-1.4
SRA3	41280	1002.0	-10.9	991.1	-12.5	989.5	1.6
SRA4	38710	988.0	-6.7	981.3	-10.0	978.0	3.3
SRB1	36080	973.2	-22.1	951.1	-10.0	963.2	-12.1
SRB2	33880	960.0	-9.7	950.3	-12.5	947.5	2.8
SRC1	32265	951.4	-7.4	944.0	-12.5	938.9	5.1
SRC2	29140	932.0	-9.1	922.9	-8.0	924.0	-1.1
SRC3	26990	920.0	-11.0	909.0	-14.0	906.0	3.0
SRC4	24795	908.0	-6.7	901.3	-10.0	898.0	3.3
SRD1	22195	894.0	-6.7	887.3	-10.0	884.0	3.3
SRD2	19855	880.1	-9.1	871.0	-14.0	866.1	4.9
SRD3	17510	868.0	-6.9	861.1	-10.0	858.0	3.1
SRE1	15125	854.0	-26.1	827.9	-12.5	841.5	-13.6
SRE2	13030	843.3	-6.7	836.6	-10.0	833.3	3.3
SRE3	11015	832.0	-10.4	821.6	-14.0	818.0	3.6

Previous studies presented in Chapter 2 found that a toe-down of 12.5 feet would be required for adequate protection of structures within the sphere of the river bed. The results of this study, however, suggest that a variable toe-down from approximately 5 to 27 feet based on SAM modeling, or 8 to 21 feet based on LACFCDDM is appropriate. A large portion of this difference can be attributed to the difference in other adjustment, which in this study was as much as 17.4 feet.

7.1 Freeboard Elevation

Freeboard is considered for the purposes of this report to be the additional height required above the top of a levee or other bank protection to prevent overtopping. The factors considered in the calculation of freeboard are long-term adjustment as aggradation, general adjustment as aggradation, super elevation, and bedform height. Freeboard elevation is calculated in this study based on LACH&SM Chapter 5A-3, and includes LACFCDDM calculations. Freeboard calculations are presented in Appendix Chapter 6.2. Long-term adjustment was calculated based on historical records in the form of topographic data, and taken as the greater of positive long-term area change values as presented in Table 5.1B, or one foot. General adjustment is taken from SAM aggradation values. Table 7.3A-B summarizes the freeboard calculations for both outside of curved reaches and inside of curved or straight reaches. The table shows that long-term aggradation is generally set to one foot. General aggradation ranges from 0 to 2.1 feet with the maximum general aggradation occurring in subreach SRE2. In all cases, either long-term aggradation or bedform height accounts for the largest component of freeboard except in subreach SRD2 and SRE2 where general adjustment dominates. The table also compares the freeboard based on LACH&SM and LACFCDDM methodologies. At the majority of locations, the LACFCDDM values are more conservative and the maximum calculated freeboard based on the two methodologies range from 2.5 to 5.2 feet for either type of reaches.

Table 7.3A: Santa Clara River Proposed Conditions Outside Curved Reach Freeboard Summary (ft)

Subreach	HEC-RAS Station	Y_{AGG}+	Y_{GA}+	Y_{SE}+	H/2	$Y_{H\&SM}$	Y_{DM}	Y_{MAX}
SRA1	46195	1.0	0.6	0.0	1.5	3.1	2.5	3.1
SRA2	43820	1.0	0.2	0.0	2.7	3.9	2.5	3.9
SRA3	41280	1.0	0.0	0.1	1.0	2.1	2.5	2.5
SRA4	38710	1.0	0.1	0.0	0.9	2.0	2.5	2.5
SRB1	36080	1.0	0.0	0.0	0.8	1.9	2.5	2.5
SRB2	33880	1.0	0.2	0.1	0.7	2.0	2.5	2.5
SRC1	32265	1.0	0.8	0.0	0.4	2.2	2.5	2.5
SRC2	29140	1.0	0.0	0.0	0.8	1.9	2.5	2.5
SRC3	26990	1.0	0.0	0.1	1.2	2.3	2.5	2.5
SRC4	24795	1.9	0.2	0.3	1.3	3.7	2.5	3.7
SRD1	22195	1.4	0.0	0.3	0.8	2.4	2.5	2.5
SRD2	19855	1.0	1.4	0.1	0.5	3.0	2.5	3.0
SRD3	17510	1.0	0.0	0.0	0.7	1.7	2.5	2.5
SRE1	15125	1.0	0.0	0.0	0.4	1.4	2.5	2.5
SRE2	13030	1.0	2.1	0.1	1.0	4.2	2.5	4.2
SRE3	11015	3.1	0.0	0.0	0.7	3.8	2.5	3.8

Table 7.3B: Santa Clara River Proposed Conditions Straight-Inside Curved Reach Freeboard Summary (ft)

Subreach	HEC-RAS Station	Y_{AGG}+	Y_{GA}+	Y_{SE}+	H/2	$Y_{H\&SM}$	Y_{DM}	Y_{MAX}
SRA1	46195	1.0	0.6	0.0	1.5	3.1	2.5	3.1
SRA2	43820	1.0	0.2	0.0	2.7	3.9	2.5	3.9
SRA3	41280	1.0	0.0	0.0	1.0	2.0	2.5	2.5
SRA4	38710	1.0	0.1	0.0	0.9	2.0	2.5	2.5
SRB1	36080	1.0	0.0	0.0	0.8	1.8	2.5	2.5
SRB2	33880	1.0	0.2	0.0	0.7	1.9	2.5	2.5
SRC1	32265	1.0	0.8	0.0	0.4	2.2	2.5	2.5
SRC2	29140	1.0	0.0	0.0	0.8	1.8	2.5	2.5
SRC3	26990	1.0	0.0	0.0	1.2	2.2	2.5	2.5
SRC4	24795	1.9	0.2	0.0	1.3	3.4	2.5	3.4
SRD1	22195	1.4	0.0	0.0	0.8	2.2	2.5	2.5
SRD2	19855	1.0	1.4	0.0	0.5	2.9	2.5	2.9
SRD3	17510	1.0	0.0	0.0	0.7	1.7	2.5	2.5
SRE1	15125	1.0	0.0	0.0	0.4	1.4	2.5	2.5
SRE2	13030	1.0	2.1	0.0	1.0	4.1	2.5	4.1
SRE3	11015	3.1	0.0	0.0	0.7	3.8	2.5	3.8

YAGG: LONG-TERM AGGRADATION; YGA: GENERAL AGGRADATION; YSE: SUPER ELEVATION ADJUSTMENT; H: BEDFORM HEIGHT;
YH&SM: TOTAL FREEBOARD BASED ON LACDPW H&SM METHODOLOGY; YDM: TOTAL FREEBOARD BASED ON LACFCDDM METHODOLOGY;
YMAX: LARGER OF YH&SM AND YDM. YAGG IS CALCULATED AS THE GREATER OF LONG TERM AGGRADATION FROM TABLE 5.1 OR 1 FOOT.

8 Summary

The total toe-down is the sum of the individual degradational components as described in Chapter 7: general adjustment, or single-event degradation, calculated using the SAM zero-dimensional numerical modeling (Chapter 4); long-term adjustment, or long-term degradation, calculated from long-term historical topographic analysis (Chapter 5); and other adjustments calculated using LACH&SM (Chapter 6). Likewise, total freeboard is calculated as the sum of aggradational components: general aggradation from SAM calculations; long-term aggradation from long-term topographic analysis, and other aggradation from LACH&SM calculations, which includes superelevation changes to water surface elevations. This data is summarized in Table 8 for the outside of curved reaches and inside of curved or straight reaches. The table shows the maximum toe-down below the 1999 model minimum channel bed elevation and the total freeboard above the HEC-RAS water surface elevation by subreach and section. A summary of the significant components and influences of each subreach follows.

Reach A: Reach A is comprised of four subreaches that extend from below Interstate 5 to Commerce Center Drive. Relatively steep, narrow, winding channels lined with woody brush highlight the channel in this section of the river. The north overbank of the channel is primarily occupied by agriculture and on the south overbank is the Magic Mountain theme park and tentatively proposed development. In these subreaches, long-term degradation ranges from approximately -2 to -8 feet, with a maximum of 8.1 feet in SRA2, and it is likely that the physical parameters of the channel listed above lead to this change. SAM modeling in this reach predicts a general adjustment of -0.1 to +0.6 feet (Table 4.2) with the predominant trend in the reach being mild aggradation. Other adjustment dominates the toe-down, ranging from -4.0 to -8.3 feet for both curved and straight reaches (Table 7.1). Like the long-term adjustment, local effects are likely the result of river bed physical characteristics in this reach. At section 43820, LACH&SM estimates of toe-down exceed that estimated by LACFCDDM calculations; for other sections, LACFCDDM calculations are deeper. Maximum total toe-down based on the LACH&SM and LACFCDDM methodologies ranges from -14.0 to -21.0 feet at section 40825 for outside of curved reaches (Table 8). For straight or inside of curved reaches, maximum total toe-down ranges from -10.0 to -17.0 feet at section 43610 (Table 8). Freeboard in this reach ranges from +2.5 to +4.0 feet with a maximum at section 43610 for both curved and straight reaches.

Reach B: Reach B is comprised of two subreaches. The north overbank is occupied by the existing Travel Village development and steep bluffs mark the south bank. Castaic Creek confluences at the southern terminus of the reach. Reach B is relatively narrow and steep, although it is more braided and less woody than Reach A, possibly owing to the development on the north bank. General adjustment on Reach B ranges from -0.7 to +0.2 feet (Table 4.2) and long-term adjustment ranges from -3.2 to -3.4 feet (Table 5.1). Other adjustment (Table 7.1) ranges from -6.9 to -19.1 feet for outside of curved reaches and from -5.7 to -18.2 for straight or inside of curved reaches. Like Reach A, other adjustment dominates the total potential adjustment. LACFCDDM estimates of total toe-down are greater than LACH&SM estimates in this reach. One proposed bridge is located in this reach at section 36080 with a pier scour of -13.3 feet (Appendix Chapter 6.1). Maximum total toe-down ranges from -15.0 to -22.9 feet at section 36080 for outside of curved reaches and ranges from -10.0 to -

22.0 feet at section 36080 for straight or inside of curved reaches (Table 8). Freeboard in this reach is +2.5 feet for both types of reaches.

Reach C: Reach C is comprised or four subreaches. The reach contains the confluences of Castaic Creek at its upstream end, the proposed Landmark development on the north overbank, and steep bluffs on the south bank. The channel is relatively steep and narrow, although some braiding is present in the channel. The north bank of this reach is relatively woody. Historically, the north overbank has been the location of agriculture, and some agricultural fill has been placed in the River. Long Canyon Creek confluences at the downstream terminus of this reach. General adjustment on Reach C ranges from -1.6 to +0.8 feet (Table 4.2) and generally the reach is predicted to degrade. Long-term adjustment ranges from -4.4 to +1.9 feet (Table 5.1). Other adjustment (Table 7.1) is moderate in Reach C and ranges from -4.4 to -10.3 feet for outside of curved reaches and ranges from -3.1 to -7.7 feet for straight or inside of curved reaches. A proposed bridge at section 22790 is expected to have -14.7 feet of pier scour. Maximum total toe-down ranges from -10.3 to -26.8 feet at section 22790 for outside of curved reaches and ranges from -8.0 to -23.0 at section 22790 for straight or inside of curved reaches (Table 8). Freeboard in this reach is from +2.5 to +4.8 feet for outside of curved reaches and from +2.5 to +4.7 feet for straight or inside of curved reaches with maximum freeboard at section 28895.

Reach D: Reach D is relatively flatter and wider than more upstream reaches analyzed in this study. The bank is generally braided with woody vegetation on the banks. Reach D resides between the Long and Chiquito tributaries to the east and the Grande and Potrero tributaries to the west. Historical agriculture has occupied both overbanks. Reach D is comprised of three subreaches. General adjustment on Reach D ranges from -1.3 to +1.4 feet (Table 4.2) and generally the reach is predicted to be in balance. Long-term adjustment ranges from -0.7 to +1.4 feet (Table 5.1). Other adjustment (Table 7.1) is varied in Reach D and ranges from -3.6 to -12.5 feet for outside of curved reaches and ranges from -3.6 to -7.1 feet for straight or inside of curved reaches. Maximum total toe-down ranges from -8.0 to -21.0 feet for outside of curved reaches and ranges from -8.0 to -14.0 feet for straight or inside of curved reaches (Table 8). Freeboard in this reach is from +2.5 to +4.1 feet with a maximum freeboard at section 19050 for both types of reaches.

Reach E: Reach E is the most downstream in the study with a relatively mild slope and a wide braided channel. The banks have sparse to moderate woody vegetation and steep bluffs and some minor agriculture dominate the overbanks. There are three subreaches in Reach E. General adjustment on Reach E ranges from -1.5 to +2.1 feet (Table 4.2) and generally the reach is predicted to be slightly aggrading or in balance. Long-term adjustment ranges from -1.0 to +3.1 feet (Table 5.1). Other adjustment (Table 7.1) is relatively small in Reach E except at the proposed bridge and ranges from -4.9 to -23.7 feet for outside of curved reaches and from -4.7 to -23.7 feet for straight or inside of curved reaches. LACFCDDM estimates of total toe-down are greater than LACH&SM estimates in this reach. A proposed bridge at section 15125 is expected to have -17.4 feet of pier scour. Maximum total toe-down ranges from -10.0 to -26.1 feet at section 15125 (Table 8), while freeboard in this reach ranges from +2.5 feet to +5.2 feet with a maximum freeboard at section 12615 for both types of reaches.

Table 8: Santa Clara River Summary of Maximum Proposed Toe-down & Freeboard (ft)											
			Outside Curved Reach		Straight-Inside Curved Reach			Outside Curved Reach		Straight-Inside Curved Reach	
Subreach	HEC-RAS Section	Z_{99} [2]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	WSE	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRA1	46195	1035.0	14.0	1021.0	14.0	1021.0	1063.1	3.1	1066.3	3.1	1066.3
	46020	1032.0	14.0	1018.0	14.0	1018.0	1062.0	3.0	1065.0	3.0	1065.0
	45545	1030.0	14.0	1016.0	14.0	1016.0	1057.9	3.4	1061.3	3.4	1061.3
	45030	1025.0	14.0	1011.0	14.0	1011.0	1054.2	3.0	1057.3	3.0	1057.3
	44585	1022.0	14.0	1008.0	14.0	1008.0	1050.6	3.2	1053.8	3.2	1053.8
	44210	1020.0	14.0	1006.0	14.0	1006.0	1047.8	2.9	1050.8	2.9	1050.8
SRA2	43820	1018.0	15.4	1002.6	15.4	1002.6	1042.1	3.9	1046.0	3.9	1046.0
	43610	1017.0	17.0	1000.0	17.0	1000.0	1038.3	4.0	1042.2	4.0	1042.2
	43410	1016.0	15.8	1000.2	15.8	1000.2	1035.8	3.6	1039.4	3.6	1039.4
	43200	1014.0	16.3	997.7	16.3	997.7	1033.2	3.5	1036.7	3.5	1036.7
	42975	1012.0	15.5	996.5	15.5	996.5	1031.0	2.9	1033.8	2.7	1033.7
	42815	1011.0	15.5	995.5	15.5	995.5	1029.7	2.5	1032.2	2.5	1032.2
	42590	1010.0	21.0	989.0	14.7	995.3	1028.4	2.5	1030.9	2.5	1030.9
	42430	1008.0	21.0	987.0	15.3	992.7	1027.5	2.5	1030.0	2.5	1030.0
	42215	1006.0	21.0	985.0	14.7	991.3	1026.7	2.5	1029.2	2.5	1029.2
	41940	1005.0	15.0	990.0	11.9	993.1	1025.6	2.5	1028.1	2.5	1028.1
	41730	1004.0	15.0	989.0	12.0	992.0	1024.6	2.5	1027.1	2.5	1027.1
	41460	1002.0	15.0	987.0	11.9	990.1	1023.2	2.5	1025.7	2.5	1025.7
SRA3	41280	1001.0	12.5	988.5	12.5	988.5	1021.8	2.5	1024.3	2.5	1024.3
	41080	1000.0	14.0	986.0	14.0	986.0	1020.5	2.5	1023.0	2.5	1023.0
	40825	999.5	21.0	978.5	14.0	985.5	1019.3	2.5	1021.8	2.5	1021.8
	40585	998.0	18.0	980.0	12.5	985.5	1018.3	2.5	1020.8	2.5	1020.8
	40335	996.0	15.0	981.0	10.0	986.0	1017.4	2.5	1019.9	2.5	1019.9
	40130	995.0	15.0	980.0	10.0	985.0	1016.6	2.5	1019.1	2.5	1019.1
	39945	994.0	15.0	979.0	10.0	984.0	1015.9	2.5	1018.4	2.5	1018.4
	39755	994.0	12.5	981.5	12.5	981.5	1014.6	2.5	1017.1	2.5	1017.1
	39605	993.0	14.0	979.0	14.0	979.0	1013.7	2.5	1016.2	2.5	1016.2
	39310	992.0	18.0	974.0	12.5	979.5	1012.2	2.5	1014.7	2.5	1014.7
	39100	990.0	14.0	976.0	14.0	976.0	1011.1	2.5	1013.6	2.5	1013.6
	38925	989.5	10.0	979.5	10.0	979.5	1010.3	2.5	1012.8	2.5	1012.8
SRA4	38710	988.0	10.0	978.0	10.0	978.0	1009.2	2.5	1011.7	2.5	1011.7
	38475	986.0	12.5	973.5	12.5	973.5	1007.0	2.6	1009.5	2.6	1009.5
	38300	985.5	14.0	971.5	14.0	971.5	1005.8	2.5	1008.3	2.5	1008.3
	38065	984.0	10.0	974.0	10.0	974.0	1004.1	2.5	1006.6	2.5	1006.6
	37810	983.0	14.0	969.0	14.0	969.0	1001.4	2.8	1004.2	2.8	1004.2
	37655	982.0	14.0	968.0	14.0	968.0	999.9	2.6	1002.5	2.6	1002.5
	37390	981.0	14.0	967.0	14.0	967.0	998.5	2.5	1001.0	2.5	1001.0
	37135	980.0	12.5	967.5	12.5	967.5	996.8	2.5	999.3	2.5	999.3
	36930	978.0	14.0	964.0	14.0	964.0	995.7	2.5	998.2	2.5	998.2
	36735	977.0	12.5	964.5	12.5	964.5	994.6	2.5	997.1	2.5	997.1
	36515	975.0	15.0	960.0	10.0	965.0	993.6	2.5	996.1	2.5	996.1
	36265	974.0	15.0	959.0	10.0	964.0	992.3	2.5	994.8	2.5	994.8
SRB1	36080	973.0	22.9	950.1	22.0	951.0	990.6	2.5	993.1	2.5	993.1
	35845	971.0	15.0	956.0	10.0	961.0	989.1	2.5	991.6	2.5	991.6
	35725	970.0	15.0	955.0	10.0	960.0	988.3	2.5	990.8	2.5	990.8
	35515	969.0	18.0	951.0	12.5	956.5	986.9	2.5	989.4	2.5	989.4
	35245	968.0	18.0	950.0	12.5	955.5	985.0	2.5	987.5	2.5	987.5
	35040	967.0	21.0	946.0	14.0	953.0	983.6	2.5	986.1	2.5	986.1
	34860	966.0	21.0	945.0	14.0	952.0	982.3	2.5	984.8	2.5	984.8
	34720	965.5	21.0	944.5	14.0	951.5	981.3	2.5	983.8	2.5	983.8
	34495	964.0	18.0	946.0	12.5	951.5	979.7	2.5	982.2	2.5	982.2
	34310	963.0	18.0	945.0	12.5	950.5	978.4	2.5	980.9	2.5	980.9
	34090	962.0	18.0	944.0	12.5	949.5	977.0	2.5	979.5	2.5	979.5
SRB2	33880	960.0	18.0	942.0	12.5	947.5	975.7	2.5	978.2	2.5	978.2
	33710	959.0	18.0	941.0	12.5	946.5	974.6	2.5	977.1	2.5	977.1
	33500	958.0	18.0	940.0	12.5	945.5	973.3	2.5	975.8	2.5	975.8
	33310	957.0	18.0	939.0	12.5	944.5	972.3	2.5	974.8	2.5	974.8
	33115	956.0	15.0	941.0	10.0	946.0	971.4	2.5	973.9	2.5	973.9
	32795	954.0	15.0	939.0	10.0	944.0	969.7	2.5	972.2	2.5	972.2
	32605	952.0	15.0	937.0	10.0	942.0	968.7	2.5	971.2	2.5	971.2
SRC1	32265	950.0	18.0	932.0	12.5	937.5	967.2	2.5	969.7	2.5	969.7
	31875	949.0	15.0	934.0	10.0	939.0	965.6	2.5	968.1	2.5	968.1
	31585	946.0	15.0	931.0	10.0	936.0	964.7	2.5	967.2	2.5	967.2
	31360	944.0	15.0	929.0	10.0	934.0	963.9	2.5	966.4	2.5	966.4
	31060	942.0	12.0	930.0	8.0	934.0	963.2	2.5	965.7	2.5	965.7
	30720	940.0	12.0	928.0	8.0	932.0	962.5	2.5	965.0	2.5	965.0
	30445	938.0	12.0	926.0	8.0	930.0	962.1	2.5	964.6	2.5	964.6
	30095	936.0	12.0	924.0	8.0	928.0	961.5	2.5	964.0	2.5	964.0
	29815	935.0	12.0	923.0	8.0	927.0	960.8	2.5	963.3	2.5	963.3
	29565	934.0	12.0	922.0	8.0	926.0	960.3	2.5	962.8	2.5	962.8
	29385	933.0	12.0	921.0	8.0	925.0	959.6	2.5	962.1	2.5	962.1
SRC2	29140	932.0	12.0	920.0	9.1	922.9	958.4	2.5	960.9	2.5	960.9
	28895	930.0	21.0	909.0	14.0	916.0	953.8	4.8	958.6	4.7	958.5
	28695	928.0	15.0	913.0	15.0	913.0	952.9	2.5	955.4	2.5	955.4
	28500	927.5	14.7	912.8	14.7	912.8	950.5	3.1	953.5	2.9	953.4
	28280	926.0	21.0	905.0	14.0	912.0	949.8	2.5	952.3	2.5	952.3
	28080	925.0	15.0	910.0	10.0	915.0	949.1	2.5	951.6	2.5	951.6
	27925	924.0	10.3	913.7	10.3	913.7	948.1	2.5	950.6	2.5	950.6
	27725	923.0	14.0	909.0	14.0	909.0	946.1	2.9	949.0	2.9	949.0
	27545	922.0	15.0	907.0	15.0	907.0	944.3	3.1	947.4	3.1	947.4
	27335	921.0	14.1	906.9	14.1	906.9	943.0	2.7	945.7	2.6	945.6
	27155	920.5	14.0	906.5	14.0	906.5	941.5	2.9	944.4	2.8	944.2
SRC3	26990	920.0	21.0	899.0	14.0	906.0	940.4	2.5	942.9	2.5	942.9
	26780	918.0	21.0	897.0	14.0	904.0	939.3	2.5	941.8	2.5	941.8
	26575	917.0	21.0	896.0	14.0	903.0	938.5	2.5	941.0	2.5	941.0
	26355	916.0	18.0	898.0	12.5	903.5	937.6	2.5	940.1	2.5	940.1
	26170	915.0	18.0	897.0	12.5	902.5	936.9	2.5	939.4	2.5	939.4
	25965	914.0	21.0	893.0	14.0	900.0	936.2	2.6	938.8	2.5	938.7
	25785	913.5	21.0	892.5	14.0	899.5	935.5	2.7	938.2	2.5	938.0
	25600	912.5	21.0	891.5	14.0	898.5	934.8	2.5	937.3	2.5	937.3
	25425	911.0	21.0	890.0	14.0	897.0	934.1	2.5	936.7	2.5	936.6
	25215	910.0	15.0	895.0	10.0	900.0	933.3	2.5	935.8	2.5	935.8
	25000	909.0	15.0	894.0	10.0	899.0	932.5	2.5	935.0	2.5	935.0
SRC4	24795	908.0	15.0	893.0	10.0	898.0	931.5	3.7	935.2	3.4	934.9
	24550	906.0	18.0	888.0	12.5	893.5	930.1	3.6	933.6	3.3	933.4
	24335	905.0	21.0	884.0	14.0	891.0	928.5	3.9	932.4	3.6	932.1
	24115	904.0	21.0	883.0	14.0	890.0	927.0	3.8	930.8	3.5	930.5
	23975	903.5	21.0	882.5	14.0	889.5	926.1	3.5	929.7	3.3	929.4
	23755	902.0	21.0	881.0	14.0	888.0	924.7	3.2	927.9	3.1	927.8
	23565	900.0	21.0	879.0	14.0	886.0	923.6	3.7	927.3	3.4	927.0
	23365	900.0	21.0	879.0	14.0	886.0	922.4	3.5	925.9	3.2	925.6
	23180	899.0	21.0	878.0	14.0	885.0	921.5	3.2	924.6	3.0	924.4
	23000	898.0	21.0	877.0	14.0	884.0	920.0	3.3	923.3	3.0	923.0
	22790	897.5	26.8	870.7	23.0	874.5	917.5	3.1	920.6	3.0	920.5
	22600	896.0	21.0	875.0	14.0	882.0	915.8	3.2	919.0	2.9	918.7
	22415	895.5	21.0	874.5	14.0	881.5	914.4	3.2	917.6	2.9	917.4

1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

Table 8: Santa Clara River Summary of Proposed Toe-down & Freeboard (ft) continued

Subreach	HEC-RAS Section	Z_{99} [2]	Outside Curved Reach		Straight-Inside Curved Reach		WSE	Outside Curved Reach		Straight-Inside Curved Reach	
			Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]		Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRD1	22195	894.0	15.0	879.0	10.0	884.0	913.1	2.5	915.6	2.5	915.6
	22010	892.0	18.0	874.0	12.5	879.5	911.4	2.5	913.9	2.5	913.9
	21790	891.5	21.0	870.5	14.0	877.5	909.9	2.6	912.6	2.5	912.4
	21615	892.0	21.0	871.0	14.0	878.0	908.9	2.6	911.5	2.5	911.4
	21440	890.0	18.0	872.0	12.5	877.5	907.8	2.5	910.3	2.5	910.3
	21225	888.0	21.0	867.0	14.0	874.0	906.7	2.5	909.2	2.5	909.2
	21020	887.0	21.0	866.0	14.0	873.0	905.6	2.5	908.1	2.5	908.1
	20845	886.0	18.0	868.0	12.5	873.5	904.7	2.5	907.2	2.5	907.2
	20595	885.0	15.0	870.0	10.0	875.0	903.6	2.5	906.1	2.5	906.1
	20435	884.0	15.0	869.0	10.0	874.0	902.8	2.5	905.3	2.5	905.3
	20280	883.7	18.0	865.7	12.5	871.2	901.8	2.5	904.3	2.5	904.3
	20070	882.0	21.0	861.0	14.0	868.0	900.6	2.5	903.1	2.5	903.1
SRD2	19855	880.5	21.0	859.5	14.0	866.5	899.6	3.0	902.6	2.9	902.5
	19630	880.0	21.0	859.0	14.0	866.0	898.6	2.9	901.5	2.9	901.5
	19440	878.0	15.0	863.0	10.0	868.0	897.9	3.0	900.8	3.0	900.8
	19240	877.5	18.0	859.5	12.5	865.0	896.9	3.4	900.3	3.4	900.2
	19050	876.0	21.0	855.0	14.0	862.0	896.2	4.1	900.3	4.1	900.3
	18830	874.0	15.0	859.0	10.0	864.0	895.4	4.1	899.4	4.0	899.4
	18650	873.5	15.0	858.5	10.0	863.5	894.7	4.0	898.7	4.0	898.7
	18475	872.0	13.6	858.4	8.0	864.0	894.3	3.4	897.6	3.4	897.6
	18290	871.5	14.1	857.4	8.0	863.5	893.6	3.2	896.8	3.2	896.8
	18025	870.0	8.0	862.0	8.0	862.0	892.9	3.1	895.9	3.1	895.9
	17785	868.0	8.0	860.0	8.0	860.0	892.0	3.2	895.2	3.2	895.2
SRD3	17510	868.0	10.0	858.0	10.0	858.0	890.4	2.5	892.9	2.5	892.9
	17360	868.0	12.5	855.5	12.5	855.5	888.3	2.5	890.8	2.5	890.8
	17110	864.0	14.0	850.0	14.0	850.0	885.5	2.5	888.0	2.5	888.0
	16970	863.7	14.0	849.7	14.0	849.7	884.0	2.5	886.5	2.5	886.5
	16720	863.5	14.0	849.5	14.0	849.5	882.3	2.5	884.8	2.5	884.8
	16515	862.0	14.0	848.0	14.0	848.0	881.2	2.5	883.7	2.5	883.7
	16305	860.0	10.0	850.0	10.0	850.0	880.4	2.5	882.9	2.5	882.9
	16130	860.0	12.5	847.5	12.5	847.5	879.4	2.5	881.9	2.5	881.9
	15960	859.0	12.5	846.5	12.5	846.5	878.6	2.5	881.1	2.5	881.1
	15745	858.0	10.0	848.0	10.0	848.0	877.6	2.5	880.1	2.5	880.1
	15540	857.5	10.0	847.5	10.0	847.5	876.7	2.5	879.2	2.5	879.2
	15335	856.0	12.5	843.5	12.5	843.5	874.8	2.5	877.3	2.5	877.3
SRE1	15125	854.0	26.1	827.9	26.1	827.9	872.0	2.5	874.5	2.5	874.5
	14900	853.0	14.0	839.0	14.0	839.0	869.7	2.5	872.2	2.5	872.2
	14720	852.0	21.0	831.0	14.0	838.0	868.4	2.5	870.9	2.5	870.9
	14480	850.5	21.0	829.5	14.0	836.5	866.9	2.5	869.4	2.5	869.4
	14315	850.0	15.0	835.0	10.0	840.0	866.0	2.5	868.5	2.5	868.5
	14090	850.0	15.0	835.0	10.0	840.0	864.8	2.5	867.3	2.5	867.3
	13850	848.0	15.0	833.0	10.0	838.0	863.6	2.5	866.1	2.5	866.1
	13635	846.0	18.0	828.0	12.5	833.5	862.5	2.5	865.0	2.5	865.0
	13425	845.0	21.0	824.0	14.0	831.0	861.8	2.5	864.3	2.5	864.3
	13190	844.0	15.0	829.0	10.0	834.0	861.1	2.5	863.6	2.5	863.6
SRE2	13030	843.0	15.0	828.0	10.0	833.0	860.6	4.2	864.8	4.1	864.8
	12835	842.0	10.0	832.0	10.0	832.0	860.0	4.7	864.7	4.6	864.7
	12615	841.0	10.0	831.0	10.0	831.0	859.3	5.2	864.6	5.2	864.6
	12395	840.0	10.0	830.0	10.0	830.0	858.7	5.1	863.8	5.1	863.8
	12195	839.0	10.0	829.0	10.0	829.0	858.1	4.2	862.3	4.2	862.3
	11995	837.0	10.0	827.0	10.0	827.0	857.3	4.1	861.4	4.1	861.4
	11780	836.0	10.0	826.0	10.0	826.0	856.6	4.0	860.5	4.0	860.5
	11605	835.5	10.0	825.5	10.0	825.5	855.8	4.0	859.8	4.0	859.8
	11405	834.0	10.0	824.0	10.0	824.0	854.6	3.9	858.6	3.9	858.6
	11180	833.0	12.5	820.5	12.5	820.5	852.7	3.9	856.6	3.9	856.6
SRE3	11015	831.5	14.0	817.5	14.0	817.5	850.2	3.8	854.0	3.8	854.0
	10835	831.0	14.0	817.0	14.0	817.0	848.1	3.7	851.8	3.7	851.8
	10575	830.0	14.0	816.0	14.0	816.0	846.1	3.8	849.9	3.8	849.9
	10390	828.0	14.0	814.0	14.0	814.0	845.1	3.1	848.2	3.1	848.2
	10225	827.5	12.5	815.0	12.5	815.0	844.1	3.1	847.2	3.1	847.2
	10000	826.0	10.0	816.0	10.0	816.0	842.6	3.1	845.7	3.1	845.7
	9820	824.0	14.0	810.0	14.0	810.0	841.4	3.1	844.5	3.1	844.5
	9595	823.8	10.0	813.8	10.0	813.8	839.9	3.1	843.0	3.1	843.0
	9385	823.0	18.0	805.0	12.5	810.5	838.6	3.1	841.7	3.1	841.7
	9220	822.0	18.0	804.0	12.5	809.5	837.6	3.1	840.7	3.1	840.7
	9025	821.0	18.0	803.0	12.5	808.5	836.6	3.1	839.7	3.1	839.7

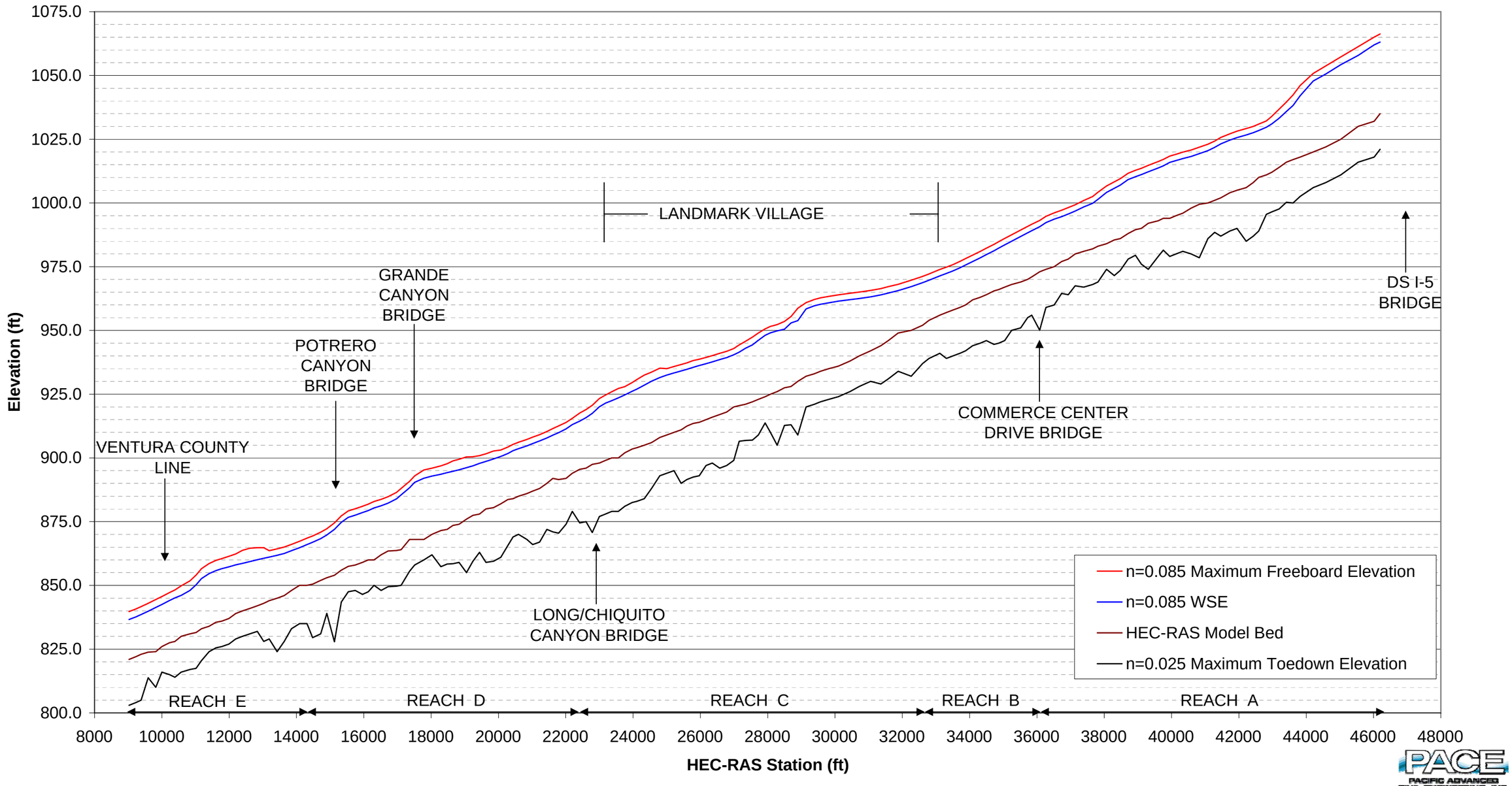
1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

Figure 8: Santa Clara River Proposed Conditions Outside Curved Reach Maximum Toedown & Freeboard Summary



9 References

Kennedy, J.F. (1963). The Mechanics of Dunes and Antidunes in Erodible Bed Channels: Journal of Fluid Mechanics, 16, 521-544.

Los Angeles County Department of Public Works Hydrology and Sedimentation Manual (LACH&SM) (December 1991)

Los Angeles County Flood Control District Design Manual (LACFCDDM) (October 1979)

Sikand Engineering in the *Newhall Ranch Santa Clara River HEC-RAS Study* (June 2000)

Simons, Li & Associates (November 1990) Fluvial Study of Santa Clara River and the Tributaries.

US Army Corps of Engineers (ACOE) (September 2002) SAM Hydraulic Design Package For Channels.

US Geological Survey (USGS) (August 1979) Sediment Discharge in the Santa Clara River Basin, Ventura and Los Angeles Counties, California. Water Resource Investigations 79-78.

Santa Clara River Fluvial Study

APPENDIX CHAPTER 3.1

Site Visit Photos

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Photo 1. Santa Clara River looking upstream from I-5.

Photo 2. Santa Clara River immediately upstream of I-5.

Photo 3. Upstream of I-5 Bridge at Santa Clara River Crossing

Photo 4. Santa Clara River downstream of the Old Rd. Bridge

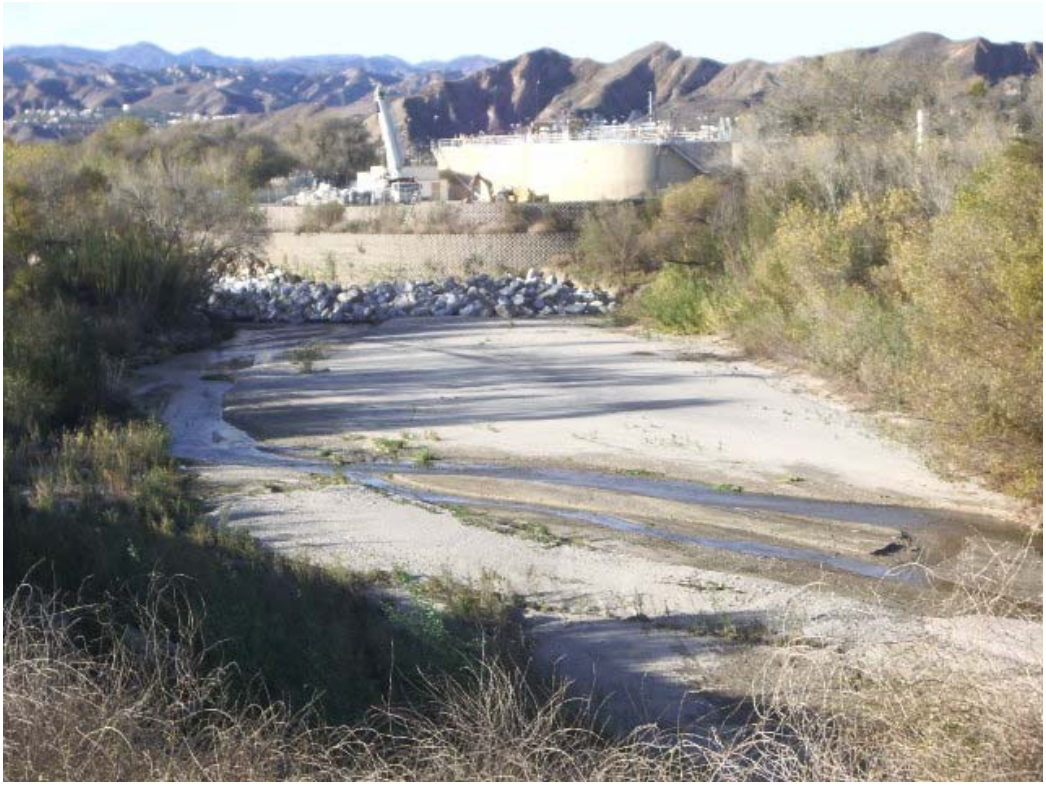


Photo 5. Approximately 1000 ft. downstream of Old Rd. Crossing.

Photo 6. Looking downstream from Magic Mountain Overflow Parking Facility.

Photo 7. Looking downstream from Magic Mountain Overflow Parking Facility (Storm damage to left bank).

Photo 8. Looking upstream at Castaic Junction.

Photo 9. Looking upstream from Feed Mill Rd. approximately 1000 ft. downstream of Magic Mountain Overflow Parking Facility.

Photo 10. Santa Clara River and Castaic Creek confluence looking upstream.

Photo 11 . Santa Clara River and Castaic Creek confluence looking downstream.

Photo 12. Santa Clara River downstream of Potrero Canyon.

Photo13. Santa Clara River downstream of Potrero Canyon looking downstream.

Photo 14. Santa Clara River looking upstream at Ventura County Line. Photo 24.

Santa Clara River Fluvial Study

APPENDIX CHAPTER 3.2

Allan Seward Sampling Study

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

ALLAN E. SEWARD
ENGINEERING GEOLOGY, INC.
Geological And Geotechnical Consultants

February 14, 2005 Job No: 05-1155BE-9 (2)

Pacific Advanced Civil Engineering, Inc. (PACE)
17520 Newhope Street
Suite 200
Fountain Valley, CA 92708

Attn: Mr. Bruce Phillips

Subject: **NEW SEDIMENT GRADATION TEST DATA**
Fluvial Analysis of Santa Clara River and Tributaries

Project: Newhall Ranch
Los Angeles County, California

Dear Mr. Phillips:

Per your request, we completed gradation tests on sediment samples to assist PACE in completing a fluvial study of the Santa Clara River and its major tributaries on Newhall Ranch. A total of 17 samples were collected adjacent to six different crossings located on various reaches of the Santa Clara River on Newhall Ranch and to the west. Six additional samples were collected from selected tributary canyons as requested. All of the samples were collected by hand from the upper foot of the active or recently active portion of the subject channels. The location and designation of each sample collected are illustrated on the attached Sample Location Map. Particle size distribution test reports and backup data sheets for each sample are attached for your use.

27825 Smyth Drive, Valencia, California 91355 661-294-0065 FAX 661-294-0833

This opportunity to be of service is appreciated. If you have any questions concerning this report, please give us a call.

Respectfully,

Brian J. Swanson, CEG 2055
Senior Project Geologist

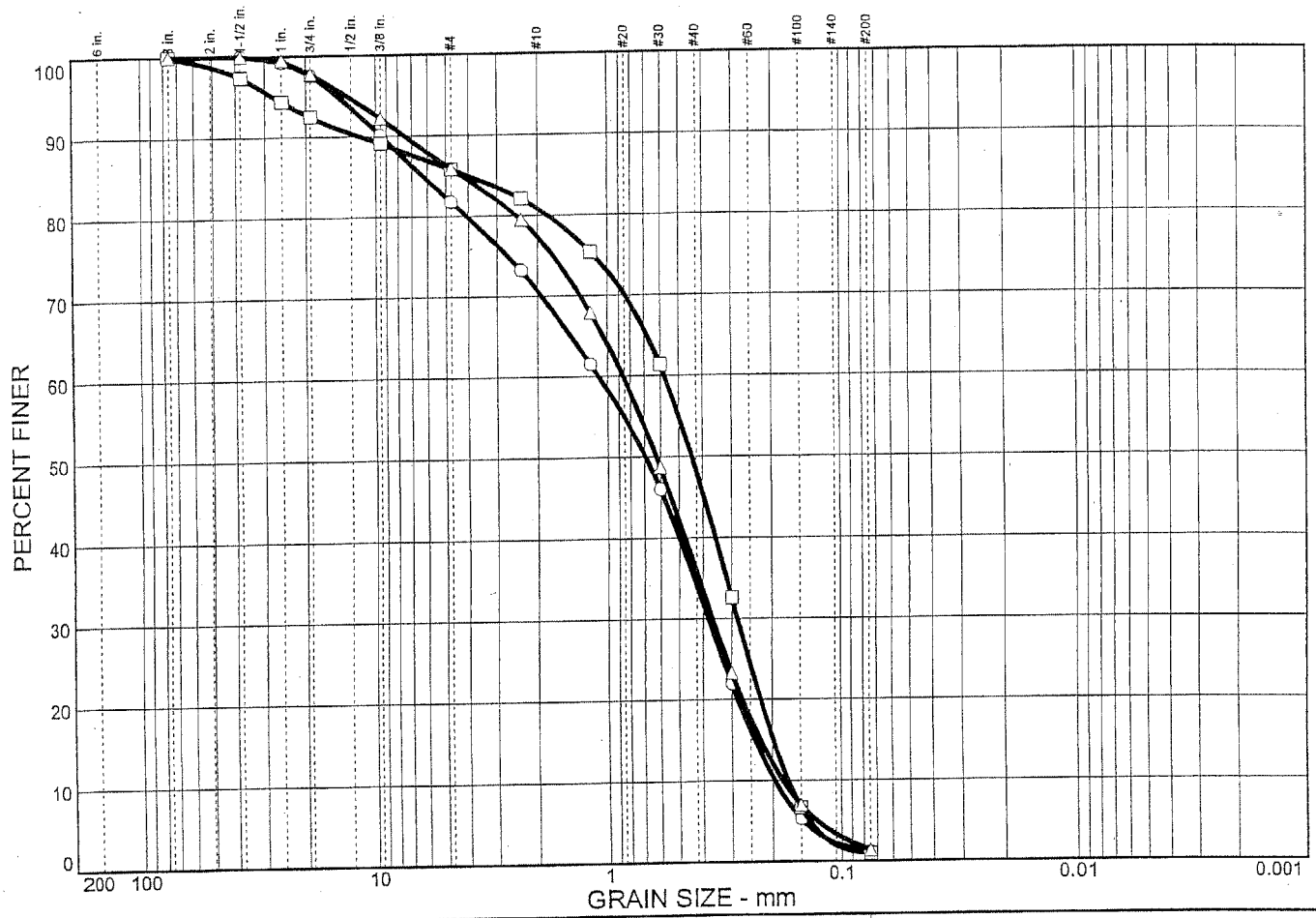
Eric J. Seward, CEG 2110
Principal Engineering Geologist
Vice President

The following attachments complete this report.

Particle Size Distribution Test Reports	Figures 1-8
Laboratory Back up Data Sheets for each Test (23 Total)	
Sample Location Map and Summary Table (Revised)	Plate I

Distribution: (1) PACE
Attn: Addressee
(1) The Newhall Land & Farming Company
Attn: Mr. Glen Adamick

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	2.4	15.8	11.1	36.4	33.1	1.2	
□	0.0	7.5	6.7	4.9	32.6	47.3	1.0	
△	0.0	2.2	11.9	8.5	41.5	34.5	1.4	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	SC-1		0-1'	Poorly graded SAND with gravel	SP
□	SC-2		0-1'	Poorly graded SAND	SP
△	SC-3		0-1'	Poorly graded SAND	SP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD

ENGINEERING GEOLOGY, INC.

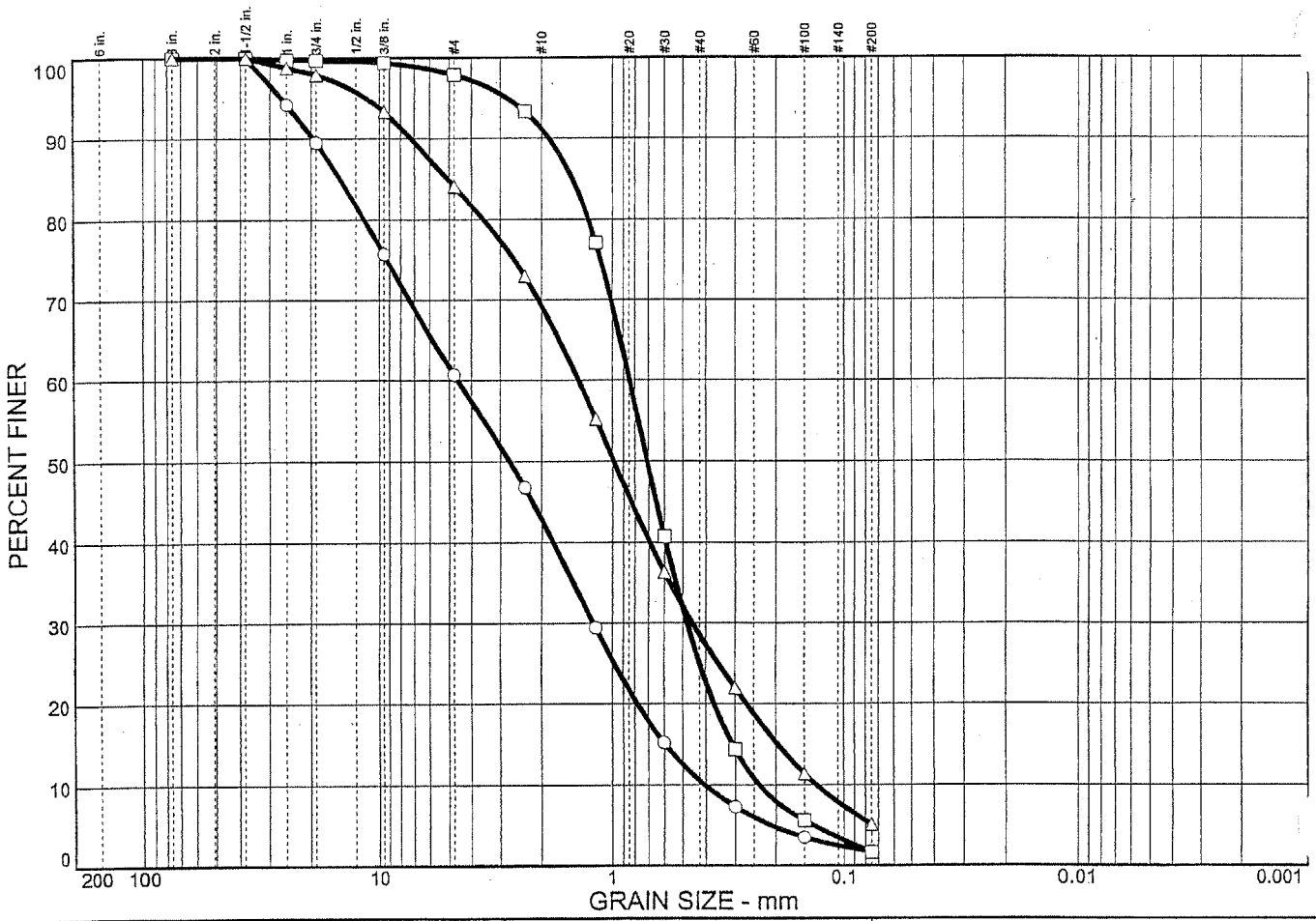
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 1

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	10.5	28.8	17.8	32.4	8.8	1.7	
□	0.0	0.3	1.8	6.7	66.1	23.5	1.6	
△	0.0	2.1	13.8	14.7	40.8	23.5	5.1	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	MC-1		0-1'	Poorly graded SAND with gravel	SP
□	MC-2		0-1'	Poorly graded SAND	SP
△	MC-3		0-1'	Well graded SAND with silt and gravel	SW-SM

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD ENGINEERING GEOLOGY, INC.

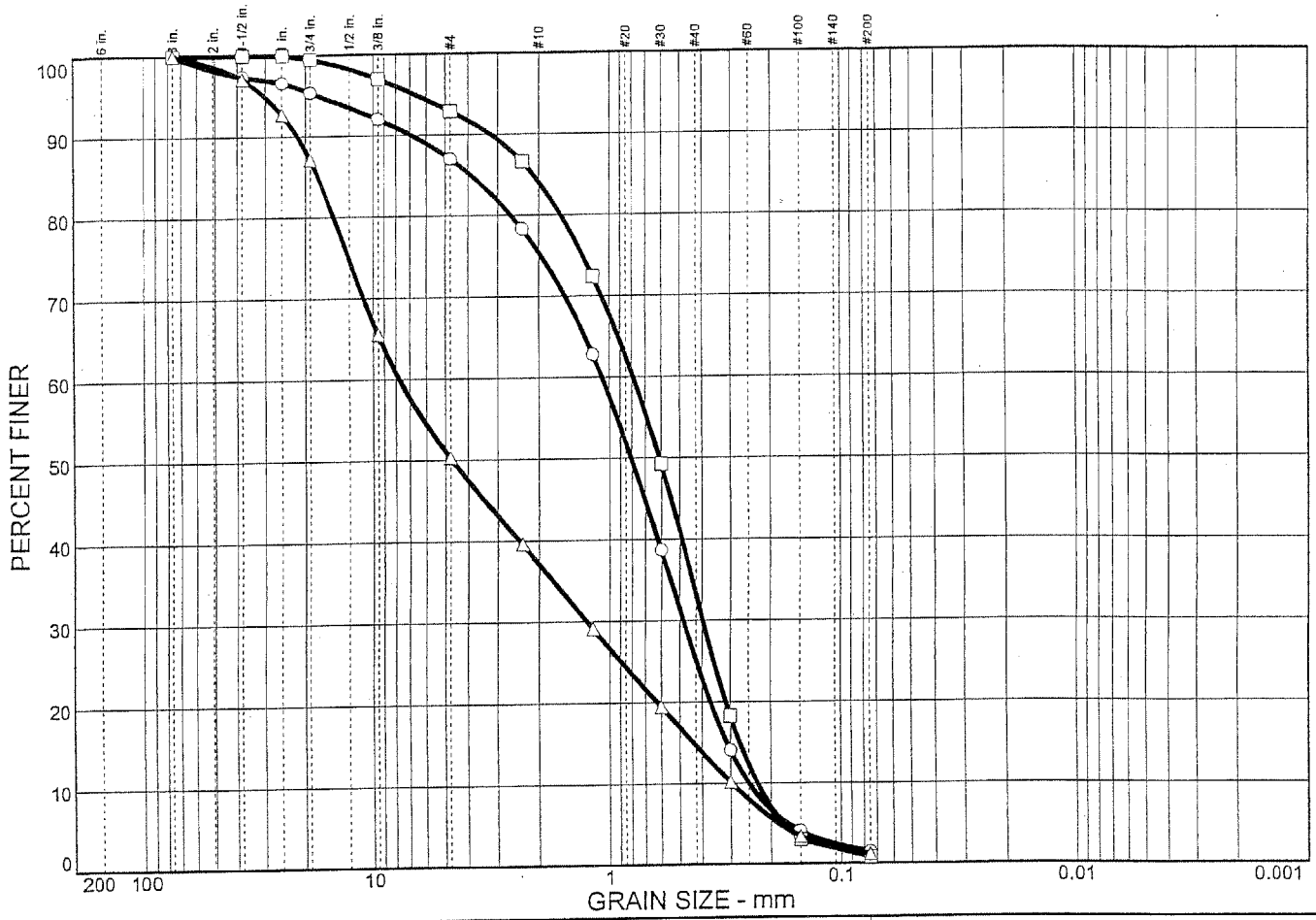
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 2

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	4.6	8.4	11.6	50.1	23.8	1.5	
□	0.0	0.5	6.6	8.9	50.7	32.5	0.8	
△	0.0	12.9	36.8	13.2	22.4	13.5	1.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	AC-1		0-1'	Poorly graded SAND	SP
□	AC-2		0-1'	Poorly graded SAND	SP
△	AC-3		0-1'	Poorly graded GRAVEL with sand	GP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD

ENGINEERING GEOLOGY, INC.

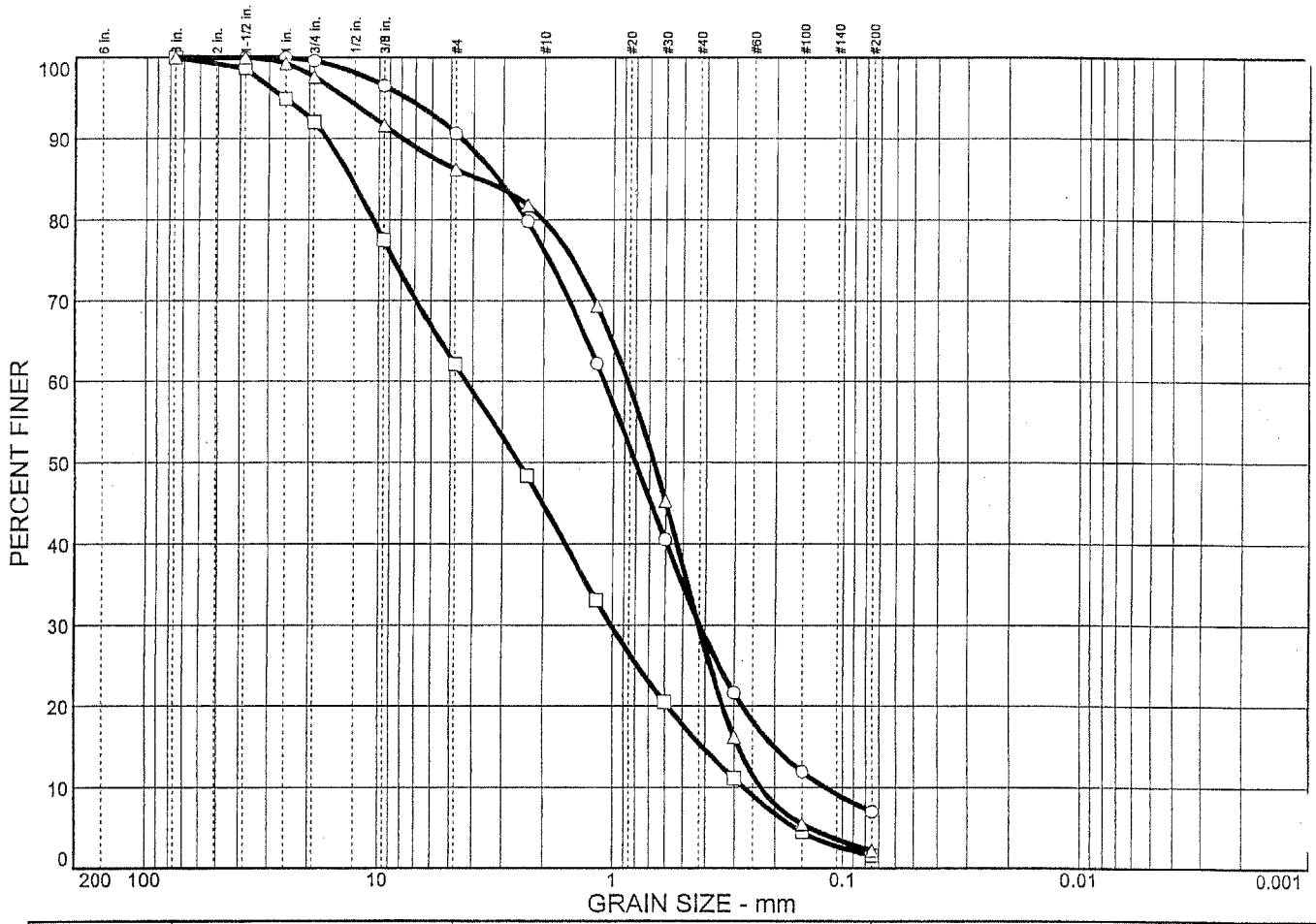
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 3

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.4	9.0	14.4	46.1	23.1	7.0	
□	0.0	8.0	29.9	17.3	29.4	13.8	1.6	
△	0.0	2.4	11.4	6.3	50.2	27.5	2.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	LC-1		0-1'	Well graded SAND with silt	SW-SM
□	LC-2		0-1'	Poorly graded SAND with gravel	SP
△	LC-3		0-1'	Poorly graded SAND	SP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD

ENGINEERING GEOLOGY, INC.

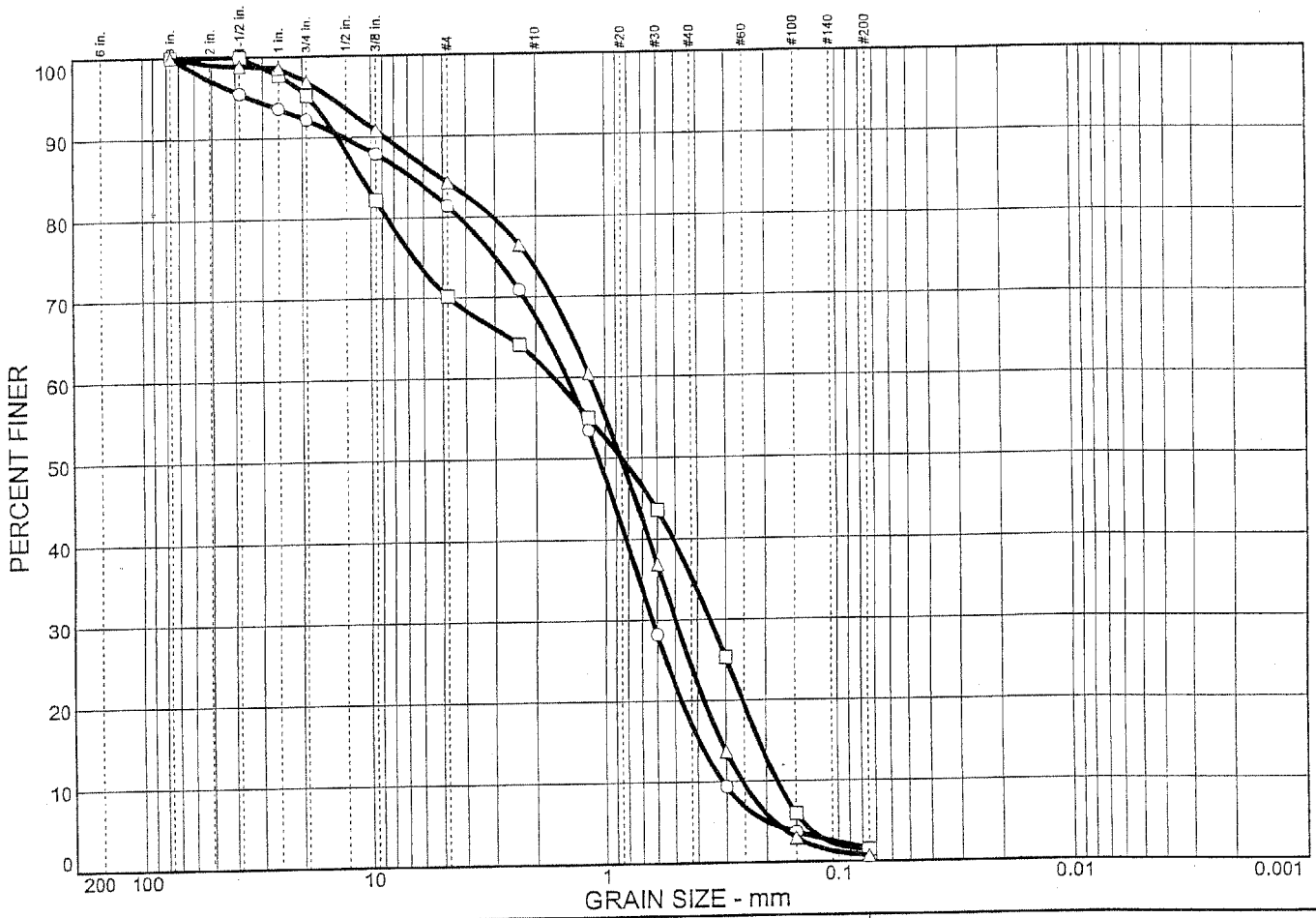
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 4

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	7.8	10.8	13.8	50.4	15.6	1.6	
□	0.0	4.8	25.0	7.9	26.9	33.9	1.5	
△	0.0	3.1	12.6	10.7	49.2	23.7	0.7	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	HR-1		0-1'	Poorly graded SAND with gravel	SP
□	HR-2		0-1'	Poorly graded SAND with gravel	SP
△	HR-3		0-1'	Poorly graded SAND with gravel	SP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD

ENGINEERING GEOLOGY, INC.

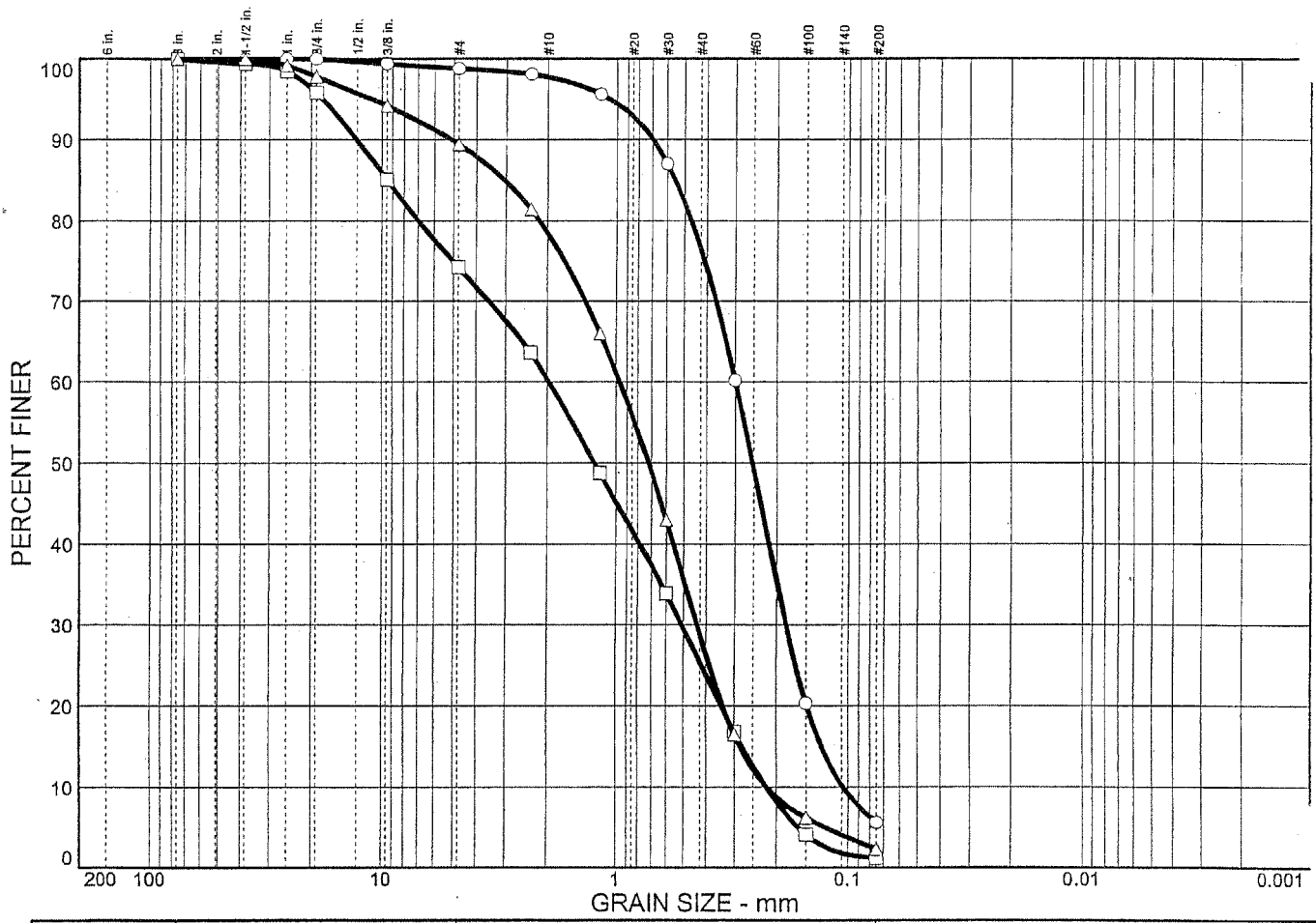
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 5

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	1.2	1.0	21.2	71.0	5.6	
□	0.0	4.2	21.6	13.8	35.0	24.2	1.2	
△	0.0	2.2	8.4	10.9	49.7	26.5	2.3	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	CB-1		0-1'	Poorly graded SAND with silt	SP-SM
□	CB-2		0-1'	Poorly graded SAND with gravel	SP
△	CB-3		0-1'	Poorly graded SAND	SP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD ENGINEERING GEOLOGY, INC.

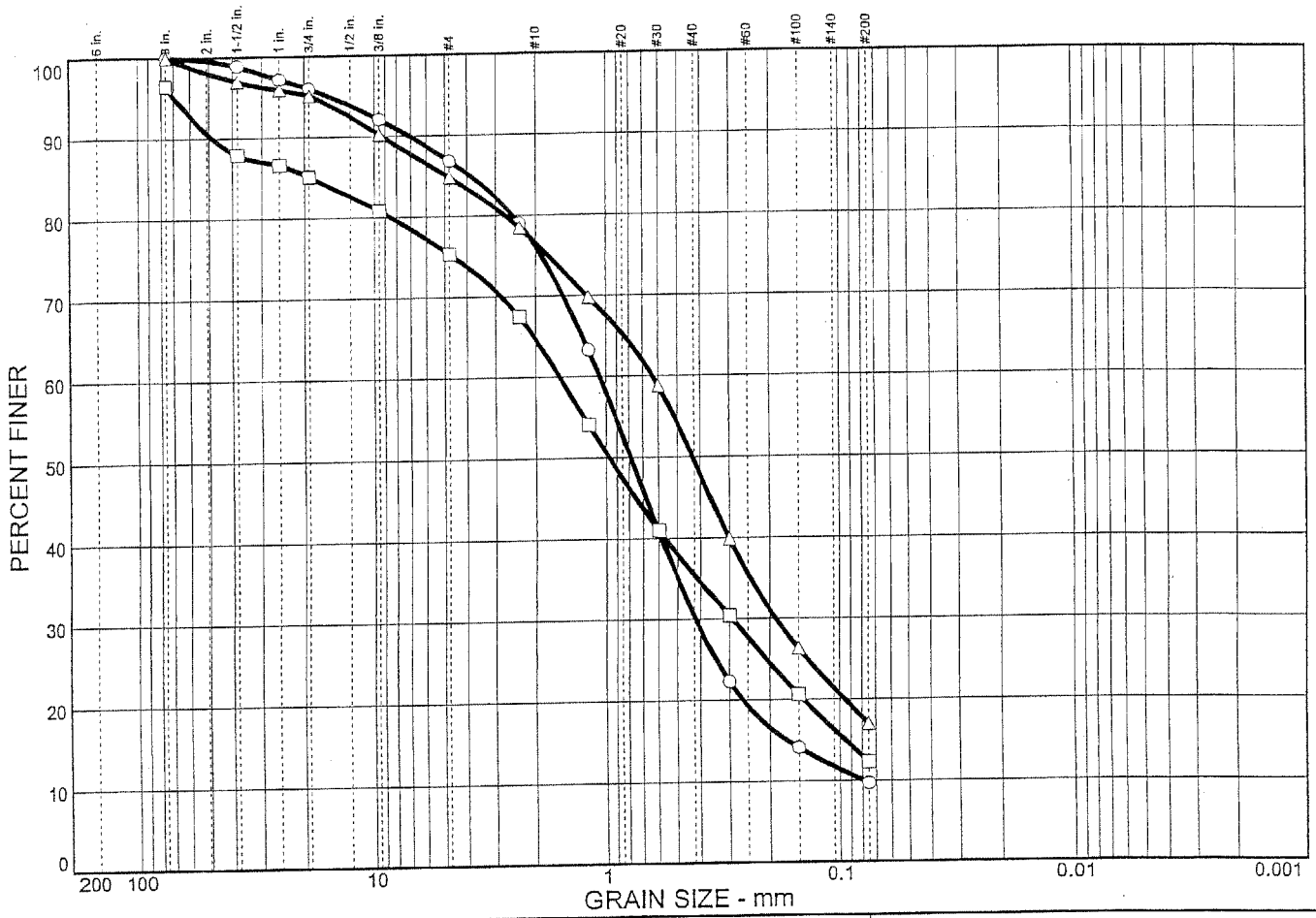
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 6

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	4.0	9.2	10.7	45.7	20.7	9.7	
□	3.5	11.4	9.8	10.6	29.2	23.2	12.3	
△	0.0	4.9	10.3	8.2	27.0	32.6	17.0	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	SM-1		0-1'	Well graded SAND with silt	SW-SM
□	SM-2		0-1'	Silty SAND with gravel	SM
△	SM-3		0-1'	Silty SAND with gravel	SM

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD

ENGINEERING GEOLOGY, INC.

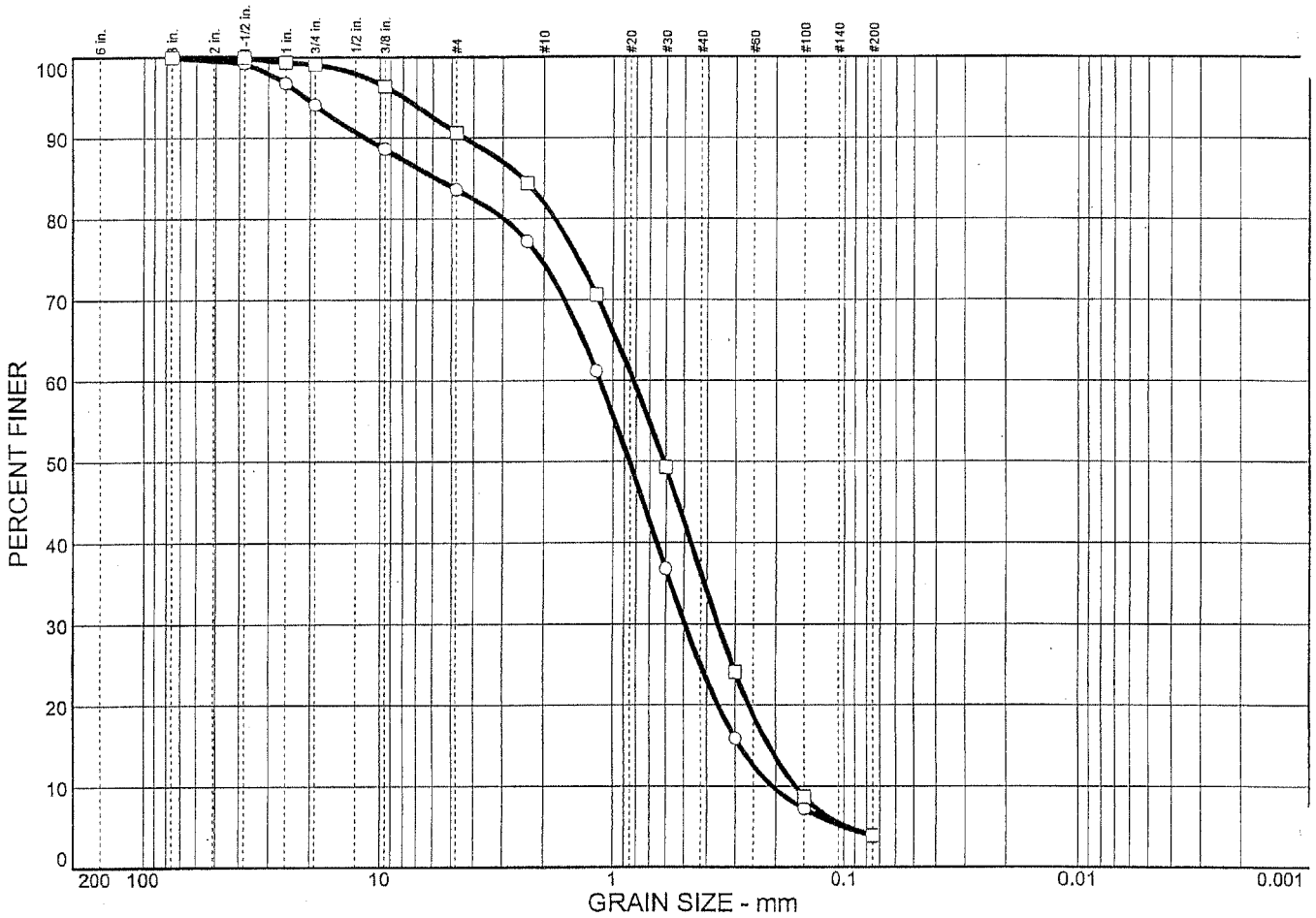
Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 7

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	5.9	10.5	9.1	49.4	21.3	3.8	
□	0.0	0.9	8.5	8.6	45.6	32.5	3.9	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	DESCRIPTION	USCS
○	CC-1		0-1'	Poorly graded SAND with gravel	SP
□	Lion-1		0-1'	Poorly graded SAND	SP

PARTICLE SIZE DISTRIBUTION TEST REPORT

ALLAN E. SEWARD ENGINEERING GEOLOGY, INC.

Client: The Newhall Land & Farming Company

Project: PACE Fluvial Study of Santa Clara River and Tributaries

Project No.: 05-1155BE-9(2)

Figure 8

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: SC-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17433.60
Tare =	0.00
Dry sample weight =	17433.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 823.18 Tare = .00 Sample weight = 823.18
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	141.95	99.2
3/4 inch	410.74	97.6
3/8 inch	1731.78	90.1
# 4	3171.78	81.8
# 8	86.53	73.2
# 16	204.60	61.5
# 30	360.50	46.0
# 50	602.30	21.9
# 100	769.92	5.3
# 200	811.58	1.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 18.2 (% coarse = 2.4 % fine = 15.8)
% SAND = 80.6 (% coarse = 11.1 % medium = 36.4 % fine = 33.1)
% FINES = 1.2

D_{85}= 6.25 D_{60}= 1.09 D_{50}= 0.69
D_{30}= 0.38 D_{15}= 0.24 D_{10}= 0.20
C_c= 0.6717 C_u= 5.5821

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: SC-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17660.60
Tare =	0.00
Dry sample weight =	17660.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 839.37 Tare = .00 Sample weight = 839.37
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	459.98	97.4
1 inch	989.08	94.4
3/4 inch	1326.98	92.5
3/8 inch	1926.73	89.1
# 4	2512.85	85.8
# 8	36.20	82.1
# 16	101.65	75.4
# 30	238.79	61.4
# 50	520.23	32.6
# 100	773.42	6.7
# 200	829.99	1.0

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 14.2 (% coarse = 7.5 % fine = 6.7)
% SAND = 84.8 (% coarse = 4.9 % medium = 32.6 % fine = 47.3)
% FINES = 1.0

D_{85}= 4.00 D_{60}= 0.57 D_{50}= 0.44
D_{30}= 0.28 D_{15}= 0.20 D_{10}= 0.17
C_c= 0.8205 C_u= 3.3796

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: SC-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17388.20
Tare =	0.00
Dry sample weight =	17388.20

Sample split on number 4 sieve
Split sample data:
Sample and tare = 760.52 Tare = .00 Sample weight = 760.52
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	78.55	99.5
3/4 inch	381.54	97.8
3/8 inch	1356.34	92.2
# 4	2446.02	85.9
# 8	57.04	79.5
# 16	159.19	67.9
# 30	328.93	48.7
# 50	553.86	23.3
# 100	698.78	7.0
# 200	748.36	1.4

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 14.1 (% coarse = 2.2 % fine = 11.9)
% SAND = 84.5 (% coarse = 8.5 % medium = 41.5 % fine = 34.5)
% FINES = 1.4

D_{85}= 4.26 D_{60}= 0.86 D_{50}= 0.62
D_{30}= 0.36 D_{15}= 0.23 D_{10}= 0.18
C_c= 0.8545 C_u= 4.789

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: MC-1
Sample No.:
Elev. or Depth: 0-1' **Sample Length(in./cm.):**
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	22700.00
Tare =	0.00
Dry sample weight =	22700.00

Sample split on number 4 sieve
Split sample data:
Sample and tare = 805.67 Tare = .00 Sample weight = 805.67
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	1308.63	94.2
3/4 inch	2378.82	89.5
3/8 inch	5513.99	75.7
# 4	8911.63	60.7
# 8	184.41	46.8
# 16	415.41	29.4
# 30	603.77	15.2
# 50	708.14	7.3
# 100	759.62	3.5
# 200	782.57	1.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 39.3 (% coarse = 10.5 % fine = 28.8)
% SAND = 59.0 (% coarse = 17.8 % medium = 32.4 % fine = 8.8)
% FINES = 1.7

D_{85}= 14.93 D_{60}= 4.59 D_{50}= 2.74
D_{30}= 1.21 D_{15}= 0.59 D_{10}= 0.40
C_c= 0.7875 C_u= 11.3357

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: MC-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17569.80
Tare =	0.00
Dry sample weight =	17569.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 651.07 Tare = .00 Sample weight = 651.07
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	41.15	99.8
3/4 inch	57.09	99.7
3/8 inch	113.76	99.4
# 4	361.27	97.9
# 8	30.69	93.3
# 16	138.31	77.1
# 30	380.43	40.7
# 50	555.53	14.4
# 100	614.15	5.6
# 200	640.41	1.6

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 2.1 (% coarse = 0.3 % fine = 1.8)
% SAND = 96.3 (% coarse = 6.7 % medium = 66.1 % fine = 23.5)
% FINES = 1.6

D_{85}= 1.48 D_{60}= 0.84 D_{50}= 0.71
D_{30}= 0.48 D_{15}= 0.31 D_{10}= 0.24
C_c= 1.152 C_u= 3.5686

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: MC-3
Sample No.:
Elev. or Depth: 0-1' **Sample Length(in./cm.):**
Location:
Description: Well graded SAND with silt and gravel
USCS: SW-SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	21565.00
Tare =	0.00
Dry sample weight =	21565.00

Sample split on number 4 sieve
Split sample data:
Sample and tare = 839.76 Tare = .00 Sample weight = 839.76
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	250.80	98.8
3/4 inch	448.46	97.9
3/8 inch	1443.29	93.3
# 4	3437.57	84.1
# 8	110.41	73.0
# 16	288.71	55.2
# 30	477.58	36.3
# 50	619.89	22.0
# 100	725.46	11.4
# 200	788.40	5.1

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 15.9 (% coarse = 2.1 % fine = 13.8)
% SAND = 79.0 (% coarse = 14.7 % medium = 40.8 % fine = 23.5)
% FINES = 5.1

D_{85}= 5.06 D_{60}= 1.40 D_{50}= 0.99
D_{30}= 0.46 D_{15}= 0.20 D_{10}= 0.13
C_c= 1.1213 C_u= 10.5481

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: Mesas Area
Alluvial Sediment Gradation Area
Project Number: 05-1155BE-9

Sample Data

Source: AC-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17978.40
Tare =	0.00
Dry sample weight =	17978.40

Sample split on number 4 sieve
Split sample data:
Sample and tare = 728.55 Tare = .00 Sample weight = 728.55
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	458.72	97.4
1 inch	612.11	96.6
3/4 inch	825.84	95.4
3/8 inch	1435.77	92.0
# 4	2338.67	87.0
# 8	73.03	78.3
# 16	202.51	62.8
# 30	404.22	38.7
# 50	610.16	14.1
# 100	694.19	4.1
# 200	716.13	1.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 13.0 (% coarse = 4.6 % fine = 8.4)
% SAND = 85.5 (% coarse = 11.6 % medium = 50.1 % fine = 23.8)
% FINES = 1.5

D_{85}= 3.89 D_{60}= 1.08 D_{50}= 0.81
D_{30}= 0.48 D_{15}= 0.31 D_{10}= 0.25
C_c= 0.8622 C_u= 4.3201

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: AC-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	19703.60
Tare =	0.00
Dry sample weight =	19703.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 721.09 Tare = .00 Sample weight = 721.09
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	0.00	100.0
3/4 inch	89.11	99.5
3/8 inch	596.94	97.0
# 4	1405.78	92.9
# 8	49.21	86.6
# 16	159.34	72.4
# 30	338.55	49.3
# 50	579.17	18.3
# 100	697.99	3.0
# 200	714.85	0.8

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 7.1 (% coarse = 0.5 % fine = 6.6)
% SAND = 92.1 (% coarse = 8.9 % medium = 50.7 % fine = 32.5)
% FINES = 0.8

D_{85}= 2.12 D_{60}= 0.79 D_{50}= 0.61
D_{30}= 0.40 D_{15}= 0.27 D_{10}= 0.23
C_c= 0.8691 C_u= 3.4521

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: AC-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded GRAVEL with sand
USCS: GP

Mechanical Analysis Data

	Initial
Dry sample and tare=	23244.80
Tare =	0.00
Dry sample weight =	23244.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 878.11 Tare = .00 Sample weight = 878.11
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	680.15	97.1
1 inch	1686.19	92.7
3/4 inch	2999.30	87.1
3/8 inch	8019.45	65.5
# 4	11551.23	50.3
# 8	187.43	39.6
# 16	369.78	29.1
# 30	537.89	19.5
# 50	700.54	10.2
# 100	817.98	3.4
# 200	856.95	1.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 49.7 (% coarse = 12.9 % fine = 36.8)
% SAND = 49.1 (% coarse = 13.2 % medium = 22.4 % fine = 13.5)
% FINES = 1.2

D_{85}= 17.59 D_{60}= 7.75 D_{50}= 4.67
D_{30}= 1.25 D_{15}= 0.43 D_{10}= 0.30
C_c= 0.6872 C_u= 26.2488

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: Mesas Area
Alluvial Sediment Gradation Area
Project Number: 05-1155BE-9

Sample Data

Source: LC-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Well graded SAND with silt
USCS: SW-SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	15209.00
Tare =	0.00
Dry sample weight =	15209.00

Sample split on number 4 sieve
Split sample data:
Sample and tare = 763.95 Tare = .00 Sample weight = 763.95
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	0.00	100.0
3/4 inch	54.29	99.6
3/8 inch	530.62	96.5
# 4	1422.64	90.6
# 8	90.96	79.8
# 16	239.41	62.2
# 30	422.48	40.5
# 50	581.66	21.6
# 100	663.72	11.9
# 200	705.30	7.0

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 9.4 (% coarse = 0.4 % fine = 9.0)
% SAND = 83.6 (% coarse = 14.4 % medium = 46.1 % fine = 23.1)
% FINES = 7.0

D_{85}= 3.14 D_{60}= 1.10 D_{50}= 0.80
D_{30}= 0.42 D_{15}= 0.20 D_{10}= 0.12
C_c= 1.3693 C_u= 9.2286

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: LC-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	18387.00
Tare =	0.00
Dry sample weight =	18387.00

Sample split on number 4 sieve
Split sample data:
Sample and tare = 832.53 Tare = .00 Sample weight = 832.53
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	242.95	98.7
1 inch	937.81	94.9
3/4 inch	1474.70	92.0
3/8 inch	4129.38	77.5
# 4	6963.31	62.1
# 8	183.83	48.4
# 16	388.23	33.1
# 30	557.04	20.5
# 50	684.35	11.1
# 100	771.61	4.5
# 200	810.78	1.6

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 37.9 (% coarse = 8.0 % fine = 29.9)
% SAND = 60.5 (% coarse = 17.3 % medium = 29.4 % fine = 13.8)
% FINES = 1.6

D_{85}= 13.07 D_{60}= 4.27 D_{50}= 2.55
D_{30}= 1.02 D_{15}= 0.41 D_{10}= 0.27
C_c= 0.8867 C_u= 15.6708

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: LC-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17115.80
Tare =	0.00
Dry sample weight =	17115.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 784.67 Tare = .00 Sample weight = 784.67
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	123.98	99.3
3/4 inch	416.69	97.6
3/8 inch	1442.97	91.6
# 4	2356.78	86.2
# 8	40.11	81.8
# 16	152.53	69.4
# 30	372.23	45.3
# 50	636.75	16.2
# 100	734.31	5.5
# 200	764.19	2.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 13.8 (% coarse = 2.4 % fine = 11.4)
% SAND = 84.0 (% coarse = 6.3 % medium = 50.2 % fine = 27.5)
% FINES = 2.2

D_{85}= 3.78 D_{60}= 0.87 D_{50}= 0.67
D_{30}= 0.43 D_{15}= 0.29 D_{10}= 0.23
C_c= 0.9172 C_u= 3.7901

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: HR-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	18704.80
Tare =	0.00
Dry sample weight =	18704.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 807.10 Tare = .00 Sample weight = 807.10
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	841.69	95.5
1 inch	1202.99	93.6
3/4 inch	1450.16	92.2
3/8 inch	2271.86	87.9
# 4	3483.16	81.4
# 8	104.06	70.9
# 16	276.70	53.5
# 30	527.54	28.2
# 50	713.86	9.4
# 100	770.09	3.7
# 200	791.09	1.6

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 18.6 (% coarse = 7.8 % fine = 10.8)
% SAND = 79.8 (% coarse = 13.8 % medium = 50.4 % fine = 15.6)
% FINES = 1.6

D_{85}= 6.71 D_{60}= 1.46 D_{50}= 1.07
D_{30}= 0.63 D_{15}= 0.39 D_{10}= 0.31
C_c= 0.8748 C_u= 4.7071

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: HR-2
Sample No.:
Elev. or Depth: 0-1' **Sample Length(in./cm.):**
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	18704.80
Tare =	0.00
Dry sample weight =	18704.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 733.34 Tare = .00 Sample weight = 733.34
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	433.01	97.7
3/4 inch	899.34	95.2
3/8 inch	3322.51	82.2
# 4	5573.90	70.2
# 8	63.23	64.1
# 16	158.38	55.0
# 30	277.62	43.6
# 50	468.94	25.3
# 100	670.63	6.0
# 200	717.39	1.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 29.8 (% coarse = 4.8 % fine = 25.0)
% SAND = 68.7 (% coarse = 7.9 % medium = 26.9 % fine = 33.9)
% FINES = 1.5

D_{85}= 10.86 D_{60}= 1.67 D_{50}= 0.85
D_{30}= 0.35 D_{15}= 0.22 D_{10}= 0.18
C_c= 0.4086 C_u= 9.2675

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: HR-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17660.60
Tare =	0.00
Dry sample weight =	17660.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 740.55 Tare = .00 Sample weight = 740.55
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	195.94	98.9
1 inch	253.36	98.6
3/4 inch	552.46	96.9
3/8 inch	1620.08	90.8
# 4	2777.78	84.3
# 8	68.28	76.5
# 16	209.20	60.5
# 30	416.09	36.9
# 50	620.47	13.7
# 100	713.88	3.0
# 200	734.13	0.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 15.7 (% coarse = 3.1 % fine = 12.6)
% SAND = 83.6 (% coarse = 10.7 % medium = 49.2 % fine = 23.7)
% FINES = 0.7

D_{85}= 5.13 D_{60}= 1.16 D_{50}= 0.86
D_{30}= 0.50 D_{15}= 0.32 D_{10}= 0.26
C_c= 0.8384 C_u= 4.5513

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: CB-1
Sample No.:
Elev. or Depth: 0-1' **Sample Length(in./cm.):**
Location:
Description: Poorly graded SAND with silt
USCS: SP-SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	17933.00
Tare =	0.00
Dry sample weight =	17933.00

Sample split on number 4 sieve
Split sample data:
Sample and tare = 742.07 Tare = .00 Sample weight = 742.07
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	0.00	100.0
3/4 inch	0.00	100.0
3/8 inch	103.36	99.4
# 4	223.16	98.8
# 8	5.50	98.1
# 16	23.81	95.6
# 30	88.78	87.0
# 50	289.75	60.2
# 100	589.56	20.3
# 200	700.18	5.6

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 1.2 (% coarse = 0.0 % fine = 1.2)
% SAND = 93.2 (% coarse = 1.0 % medium = 21.2 % fine = 71.0)
% FINES = 5.6

D_{85}= 0.55 D_{60}= 0.30 D_{50}= 0.25
D_{30}= 0.18 D_{15}= 0.13 D_{10}= 0.11
C_c= 1.0559 C_u= 2.8469

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: CB-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	18114.60
Tare =	0.00
Dry sample weight =	18114.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 745.01 Tare = .00 Sample weight = 745.01
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	101.07	99.4
1 inch	275.52	98.5
3/4 inch	759.46	95.8
3/8 inch	2699.95	85.1
# 4	4680.48	74.2
# 8	106.40	63.6
# 16	255.04	48.8
# 30	405.03	33.9
# 50	576.15	16.8
# 100	703.88	4.1
# 200	732.85	1.2

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 25.8 (% coarse = 4.2 % fine = 21.6)
% SAND = 73.0 (% coarse = 13.8 % medium = 35.0 % fine = 24.2)
% FINES = 1.2

D_{85}= 9.47 D_{60}= 1.96 D_{50}= 1.25
D_{30}= 0.51 D_{15}= 0.28 D_{10}= 0.22
C_c= 0.6048 C_u= 8.9372

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: CB-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	19022.60
Tare =	0.00
Dry sample weight =	19022.60

Sample split on number 4 sieve
Split sample data:
Sample and tare = 824.36 Tare = .00 Sample weight = 824.36
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	155.86	99.2
3/4 inch	413.72	97.8
3/8 inch	1112.62	94.2
# 4	2022.57	89.4
# 8	74.07	81.4
# 16	215.58	66.0
# 30	428.05	43.0
# 50	672.06	16.5
# 100	767.22	6.2
# 200	802.70	2.3

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 10.6 (% coarse = 2.2 % fine = 8.4)
% SAND = 87.1 (% coarse = 10.9 % medium = 49.7 % fine = 26.5)
% FINES = 2.3

D_{85}= 3.05 D_{60}= 0.97 D_{50}= 0.72
D_{30}= 0.44 D_{15}= 0.28 D_{10}= 0.22
C_c= 0.9072 C_u= 4.4031

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: Mesas Area
Alluvial Sediment Gradation Area
Project Number: 05-1155BE-9

Sample Data

Source: SM-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Well graded SAND with silt
USCS: SW-SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	23017.80
Tare =	0.00
Dry sample weight =	23017.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 731.81 Tare = .00 Sample weight = 731.81
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	264.51	98.9
1 inch	644.65	97.2
3/4 inch	909.55	96.0
3/8 inch	1825.48	92.1
# 4	3038.96	86.8
# 8	65.91	79.0
# 16	198.29	63.3
# 30	387.07	40.9
# 50	543.90	22.3
# 100	613.20	14.1
# 200	649.63	9.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 13.2 (% coarse = 4.0 % fine = 9.2)
% SAND = 77.1 (% coarse = 10.7 % medium = 45.7 % fine = 20.7)
% FINES = 9.7

D_{85}= 3.87 D_{60}= 1.06 D_{50}= 0.79
D_{30}= 0.42 D_{15}= 0.17 D_{10}= 0.08
C_c= 2.0885 C_u= 13.4193

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: SM-2
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Silty SAND with gravel
USCS: SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	60245.80
Tare =	0.00
Dry sample weight =	60245.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 957.88 Tare = .00 Sample weight = 957.88
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	2121.72	96.5
1-1/2 inch	7269.59	87.9
1 inch	8084.04	86.6
3/4 inch	8958.31	85.1
3/8 inch	11591.67	80.8
# 4	14891.85	75.3
# 8	99.38	67.5
# 16	269.61	54.1
# 30	436.80	41.0
# 50	571.38	30.4
# 100	695.68	20.6
# 200	801.50	12.3

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 3.5 % GRAVEL = 21.2 (% coarse = 11.4 % fine = 9.8)
% SAND = 63.0 (% coarse = 10.6 % medium = 29.2 % fine = 23.2)
% FINES = 12.3

D_{85}= 18.73 D_{60}= 1.57 D_{50}= 0.97
D_{30}= 0.29 D_{15}= 0.09

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: PACE Fluvial Study of Santa Clara River and Tributaries
Project Number: 05-1155BE-9(2)

Sample Data

Source: SM-3
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Silty SAND with gravel
USCS: SM

Mechanical Analysis Data

	Initial
Dry sample and tare=	16207.80
Tare =	0.00
Dry sample weight =	16207.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 751.27 Tare = .00 Sample weight = 751.27
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	483.46	97.0
1 inch	671.79	95.9
3/4 inch	799.18	95.1
3/8 inch	1583.39	90.2
# 4	2469.85	84.8
# 8	55.59	78.5
# 16	132.52	69.8
# 30	230.47	58.8
# 50	397.47	39.9
# 100	518.21	26.3
# 200	600.30	17.0

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 15.2 (% coarse = 4.9 % fine = 10.3)
% SAND = 67.8 (% coarse = 8.2 % medium = 27.0 % fine = 32.6)
% FINES = 17.0

D_{85}= 4.87 D_{60}= 0.63 D_{50}= 0.43
D_{30}= 0.19

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: Mesas Area
Alluvial Sediment Gradation Area
Project Number: 05-1155BE-9

Sample Data

Source: CC-1
Sample No.:
Elev. or Depth: 0-1' **Sample Length(in./cm.):**
Location:
Description: Poorly graded SAND with gravel
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	18477.80
Tare =	0.00
Dry sample weight =	18477.80

Sample split on number 4 sieve
Split sample data:
Sample and tare = 779.92 Tare = .00 Sample weight = 779.92
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	135.00	99.3
1 inch	584.04	96.8
3/4 inch	1088.55	94.1
3/8 inch	2113.98	88.6
# 4	3032.35	83.6
# 8	60.03	77.2
# 16	209.43	61.2
# 30	436.82	36.8
# 50	631.92	15.9
# 100	713.17	7.2
# 200	744.09	3.8

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 16.4 (% coarse = 5.9 % fine = 10.5)
% SAND = 79.8 (% coarse = 9.1 % medium = 49.4 % fine = 21.3)
% FINES = 3.8

D_{85}= 5.81 D_{60}= 1.14 D_{50}= 0.86
D_{30}= 0.49 D_{15}= 0.29 D_{10}= 0.21
C_c= 1.0418 C_u= 5.5003

GRAIN SIZE DISTRIBUTION TEST DATA

Client: The Newhall Land & Farming Company
Project: Mesas Area
Alluvial Sediment Gradation Area
Project Number: 05-1155BE-9

Sample Data

Source: Lion-1
Sample No.:
Elev. or Depth: 0-1'
Sample Length(in./cm.):
Location:
Description: Poorly graded SAND
USCS: SP

Mechanical Analysis Data

	Initial
Dry sample and tare=	17660.60
Tare =	0.00
Dry sample weight =	17660.60

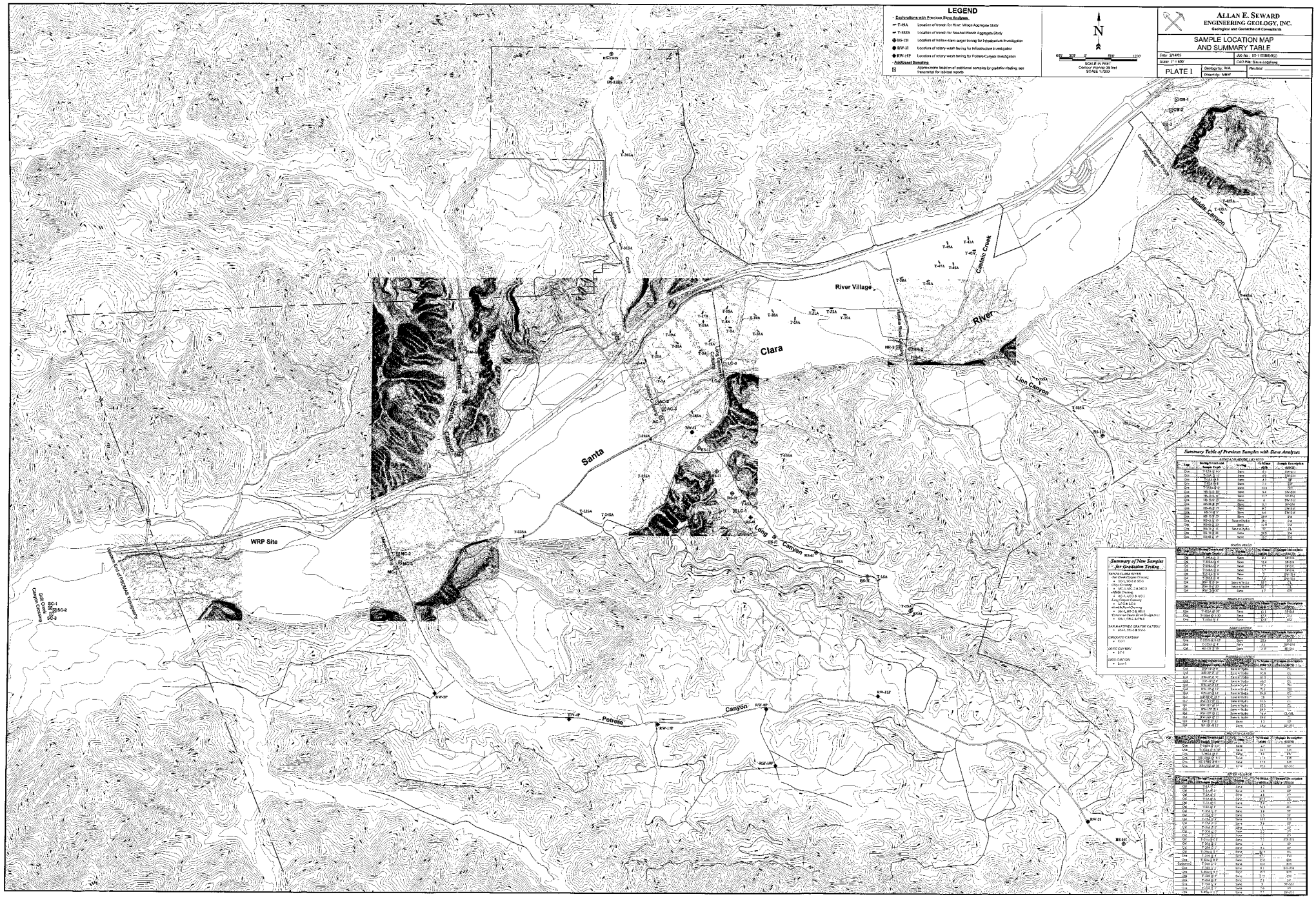
Sample split on number 4 sieve
Split sample data:
Sample and tare = 683.31 Tare = .00 Sample weight = 683.31
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
3 inch	0.00	100.0
1-1/2 inch	0.00	100.0
1 inch	106.88	99.4
3/4 inch	150.98	99.1
3/8 inch	627.92	96.4
# 4	1659.02	90.6
# 8	46.53	84.4
# 16	150.65	70.6
# 30	311.37	49.3
# 50	501.22	24.1
# 100	617.55	8.7
# 200	653.55	3.9

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 0.0 % GRAVEL = 9.4 (% coarse = 0.9 % fine = 8.5)
% SAND = 86.7 (% coarse = 8.6 % medium = 45.6 % fine = 32.5)
% FINES = 3.9

D_{85}= 2.48 D_{60}= 0.82 D_{50}= 0.61
D_{30}= 0.36 D_{15}= 0.21 D_{10}= 0.16
C_c= 0.9476 C_u= 4.9895


LEGEND
Explorations with Previous Sieve Analyses
T-18A Location of trench for River Village Aggregate Study
T-55SA Location of trench for Newhall Ranch Aggregate Study
BS-12I Location of hollow-stem-auger boring for Infrastructure Investigation
RW-2I Location of rotary-wash boring for Infrastructure Investigation
RW-19P Location of rotary-wash boring for Potrero Canyon Investigation
Additional Sampling
Approximate location of additional samples for gradation testing; see transmittal for lab-test reports
SCALE IN FEET
Contour Interval: 20 feet
SCALE: 1:7200
N
ALLAN E. SEWARD
ENGINEERING GEOLOGY, INC.
Geological and Geotechnical Consultants
SAMPLE LOCATION MAP
AND SUMMARY TABLE
PLATE I
Summary Table of Previous Samples with Sieve Analyses
Summary of New Samples for Gradation Testing
River Village
Clara
Santa
WRP Site
Potrero
Canyon
Lion Canyon
Middle Canyon
Castaic Creek
River
Long Canyon
Chiquito Canyon
Salt Creek Canyon Crossing
Newhall Ranch Road Crossing
Commerce Center Drive Bridge
Commerce Center Drive Crossing
Aqueduct Crossing
Aqueduct Bridge
Aqueduct Tunnel
Newhall Ranch Road
Long Canyon Road
Chiquito Canyon
Lion Canyon
Middle Canyon
Castaic Creek
River
Santa
Clara
Potrero
Canyon
WRP Site
BS-12I
BS-11I
RW-2I
RW-19P
RW-17P
RW-4P
RW-3P
RW-31P
RW-18P
BS-11I
SC-1
SC-2
SC-3
NC-1
NC-2
NC-3
LC-1
LC-2
LC-3
CB-1
CB-2
CB-3
T-18A
T-55SA
T-23SA
T-24SA
T-25SA
T-35SA
T-36SA
T-37SA
T-38SA
T-39SA
T-40SA
T-41SA
T-42SA
T-43SA
T-44SA
T-45SA
T-46SA
T-47SA
T-48SA
T-49SA
T-50SA
T-51SA
T-52SA
T-53SA
T-54SA
T-55SA
T-56SA
T-57SA
T-58SA
T-59SA
T-60SA
T-61SA
T-62SA
T-63SA
T-64SA
T-65SA
T-66SA
T-67SA
T-68SA
T-69SA
T-70SA
T-71SA
T-72SA
T-73SA
T-74SA
T-75SA
T-76SA
T-77SA
T-78SA
T-79SA
T-80SA
T-81SA
T-82SA
T-83SA
T-84SA
T-85SA
T-86SA
T-87SA
T-88SA
T-89SA
T-90SA
T-91SA
T-92SA
T-93SA
T-94SA
T-95SA
T-96SA
T-97SA
T-98SA
T-99SA
T-100SA
T-101SA
T-102SA
T-103SA
T-104SA
T-105SA
T-106SA
T-107SA
T-108SA
T-109SA
T-110SA
T-111SA
T-112SA
T-113SA
T-114SA
T-115SA
T-116SA
T-117SA
T-118SA
T-119SA
T-120SA
T-121SA
T-122SA
T-123SA
T-124SA
T-125SA
T-126SA
T-127SA
T-128SA
T-129SA
T-130SA
T-131SA
T-132SA
T-133SA
T-134SA
T-135SA
T-136SA
T-137SA
T-138SA
T-139SA
T-140SA
T-141SA
T-142SA
T-143SA
T-144SA
T-145SA
T-146SA
T-147SA
T-148SA
T-149SA
T-150SA
T-151SA
T-152SA
T-153SA
T-154SA
T-155SA
T-156SA
T-157SA
T-158SA
T-159SA
T-160SA
T-161SA
T-162SA
T-163SA
T-164SA
T-165SA
T-166SA
T-167SA
T-168SA
T-169SA
T-170SA
T-171SA
T-172SA
T-173SA
T-174SA
T-175SA
T-176SA
T-177SA
T-178SA
T-179SA
T-180SA
T-181SA
T-182SA
T-183SA
T-184SA
T-185SA
T-186SA
T-187SA
T-188SA
T-189SA
T-190SA
T-191SA
T-192SA
T-193SA
T-194SA
T-195SA
T-196SA
T-197SA
T-198SA
T-199SA
T-200SA
T-201SA
T-202SA
T-203SA
T-204SA
T-205SA
T-206SA
T-207SA
T-208SA
T-209SA
T-210SA
T-211SA
T-212SA
T-213SA
T-214SA
T-215SA
T-216SA
T-217SA
T-218SA
T-219SA
T-220SA
T-221SA
T-222SA
T-223SA
T-224SA
T-225SA
T-226SA
T-227SA
T-228SA
T-229SA
T-230SA
T-231SA
T-232SA
T-233SA
T-234SA
T-235SA
T-236SA
T-237SA
T-238SA
T-239SA
T-240SA
T-241SA
T-242SA
T-243SA
T-244SA
T-245SA
T-246SA
T-247SA
T-248SA
T-249SA
T-250SA
T-251SA
T-252SA
T-253SA
T-254SA
T-255SA
T-256SA
T-257SA
T-258SA
T-259SA
T-260SA
T-261SA
T-262SA
T-263SA
T-264SA
T-265SA
T-266SA
T-267SA
T-268SA
T-269SA
T-270SA
T-271SA
T-272SA
T-273SA
T-274SA
T-275SA
T-276SA
T-277SA
T-278SA
T-279SA
T-280SA
T-281SA
T-282SA
T-283SA
T-284SA
T-285SA
T-286SA
T-287SA
T-288SA
T-289SA
T-290SA
T-291SA
T-292SA
T-293SA
T-294SA
T-295SA
T-296SA
T-297SA
T-298SA
T-299SA
T-300SA
T-301SA
T-302SA
T-303SA
T-304SA
T-305SA
T-306SA
T-307SA
T-308SA
T-309SA
T-310SA
T-311SA
T-312SA
T-313SA
T-314SA
T-315SA
T-316SA
T-317SA
T-318SA
T-319SA
T-320SA
T-321SA
T-322SA
T-323SA
T-324SA
T-325SA
T-326SA
T-327SA
T-328SA
T-329SA
T-330SA
T-331SA
T-332SA
T-333SA
T-334SA
T-335SA
T-336SA
T-337SA
T-338SA
T-339SA
T-340SA
T-341SA
T-342SA
T-343SA
T-344SA
T-345SA
T-346SA
T-347SA
T-348SA
T-349SA
T-350SA
T-351SA
T-352SA
T-353SA
T-354SA
T-355SA
T-356SA
T-357SA
T-358SA
T-359SA
T-360SA
T-361SA
T-362SA
T-363SA
T-364SA
T-365SA
T-366SA
T-367SA
T-368SA
T-369SA
T-370SA
T-371SA
T-372SA
T-373SA
T-374SA
T-375SA
T-376SA
T-377SA
T-378SA
T-379SA
T-380SA
T-381SA
T-382SA
T-383SA
T-384SA
T-385SA
T-386SA
T-387SA
T-388SA
T-389SA
T-390SA
T-391SA
T-392SA
T-393SA
T-394SA
T-395SA
T-396SA
T-397SA
T-398SA
T-399SA
T-400SA
T-401SA
T-402SA
T-403SA
T-404SA
T-405SA
T-406SA
T-407SA
T-408SA
T-409SA
T-410SA
T-411SA
T-412SA
T-413SA
T-414SA
T-415SA
T-416SA
T-417SA
T-418SA
T-419SA
T-420SA
T-421SA
T-422SA
T-423SA
T-424SA
T-425SA
T-426SA
T-427SA
T-428SA
T-429SA
T-430SA
T-431SA
T-432SA
T-433SA
T-434SA
T-435SA
T-436SA
T-437SA
T-438SA
T-439SA
T-440SA
T-441SA
T-442SA
T-443SA
T-444SA
T-445SA
T-446SA
T-447SA
T-448SA
T-449SA
T-450SA
T-451SA
T-452SA
T-453SA
T-454SA
T-455SA
T-456SA
T-457SA
T-458SA
T-459SA
T-460SA
T-461SA
T-462SA
T-463SA
T-464SA
T-465SA
T-466SA
T-467SA
T-468SA
T-469SA
T-470SA
T-471SA
T-472SA
T-473SA
T-474SA
T-475SA
T-476SA
T-477SA
T-478SA
T-479SA
T-480SA
T-481SA
T-482SA
T-483SA
T-484SA
T-485SA
T-486SA
T-487SA
T-488SA
T-489SA
T-490SA
T-491SA
T-492SA
T-493SA
T-494SA
T-495SA
T-496SA
T-497SA
T-498SA
T-499SA
T-500SA
T-501SA
T-502SA
T-503SA
T-504SA
T-505SA
T-506SA
T-507SA
T-508SA
T-509SA
T-510SA
T-511SA
T-512SA
T-513SA
T-514SA
T-515SA
T-516SA
T-517SA
T-518SA
T-519SA
T-520SA
T-521SA
T-522SA
T-523SA
T-524SA
T-525SA
T-526SA
T-527SA
T-528SA
T-529SA
T-530SA
T-531SA
T-532SA
T-533SA
T-534SA
T-535SA
T-536SA
T-537SA
T-538SA
T-539SA
T-540SA
T-541SA
T-542SA
T-543SA
T-544SA
T-545SA
T-546SA
T-547SA
T-548SA
T-549SA
T-550SA
T-551SA
T-552SA
T-553SA
T-554SA
T-555SA
T-556SA
T-557SA
T-558SA
T-559SA
T-560SA
T-561SA
T-562SA
T-563SA
T-564SA
T-565SA
T-566SA
T-567SA
T-568SA
T-569SA
T-570SA
T-571SA
T-572SA
T-573SA
T-574SA
T-575SA
T-576SA
T-577SA
T-578SA
T-579SA
T-580SA
T-581SA
T-582SA
T-583SA
T-584SA
T-585SA
T-586SA
T-587SA
T-588SA
T-589SA
T-590SA
T-591SA
T-592SA
T-593SA
T-594SA
T-595SA
T-596SA
T-597SA
T-598SA
T-599SA
T-600SA
T-601SA
T-602SA
T-603SA
T-604SA
T-605SA
T-606SA
T-607SA
T-608SA
T-609SA
T-610SA
T-611SA
T-612SA
T-613SA
T-614SA
T-615SA
T-616SA
T-617SA
T-618SA
T-619SA
T-620SA
T-621SA
T-622SA
T-623SA
T-624SA
T-625SA
T-626SA
T-627SA
T-628SA
T-629SA
T-630SA
T-631SA
T-632SA
T-633SA
T-634SA
T-635SA
T-636SA
T-637SA
T-638SA
T-639SA
T-640SA
T-641SA
T-642SA
T-643SA
T-644SA
T-645SA
T-646SA
T-647SA
T-648SA
T-649SA
T-650SA
T-651SA
T-652SA
T-653SA
T-654SA
T-655SA
T-656SA
T-657SA
T-658SA
T-659SA
T-660SA
T-661SA
T-662SA
T-663SA
T-664SA
T-665SA
T-666SA
T-667SA
T-668SA
T-669SA
T-670SA
T-671SA
T-672SA
T-673SA
T-674SA
T-675SA
T-676SA
T-677SA
T-678SA
T-679SA
T-680SA
T-681SA
T-682SA
T-683SA
T-684SA
T-685SA
T-686SA
T-687SA
T-688SA
T-689SA
T-690SA
T-691SA
T-692SA
T-693SA
T-694SA
T-695SA
T-696SA
T-697SA
T-698SA
T-699SA
T-700SA
T-701SA
T-702SA
T-703SA
T-704SA
T-705SA
T-706SA
T-707SA
T-708SA
T-709SA
T-710SA
T-711SA
T-712SA
T-713SA
T-714SA
T-715SA
T-716SA
T-717SA
T-718SA
T-719SA
T-720SA
T-721SA
T-722SA
T-723SA
T-724SA
T-725SA
T-726SA
T-727SA
T-728SA
T-729SA
T-730SA
T-731SA
T-732SA
T-733SA
T-734SA
T-735SA
T-736SA
T-737SA
T-738SA
T-739SA
T-740SA
T-741SA
T-742SA
T-743SA
T-744SA
T-745SA
T-746SA
T-747SA
T-748SA
T-749SA
T-750SA
T-751SA
T-752SA
T-753SA
T-754SA
T-755SA
T-756SA
T-757SA
T-758SA
T-759SA
T-760SA
T-761SA
T-762SA
T-763SA
T-764SA
T-765SA
T-766SA
T-767SA
T-768SA
T-769SA
T-770SA
T-771SA
T-772SA
T-773SA
T-774SA
T-775SA
T-776SA
T-777SA
T-778SA
T-779SA
T-780SA
T-781SA
T-782SA
T-783SA
T-784SA
T-785SA
T-786SA
T-787SA
T-788SA
T-789SA
T-790SA
T-791SA
T-792SA
T-793SA
T-794SA
T-795SA
T-796SA
T-797SA
T-798SA
T-799SA
T-800SA
T-801SA
T-802SA
T-803SA
T-804SA
T-805SA
T-806SA
T-807SA
T-808SA
T-809SA
T-810SA
T-811SA
T-812SA
T-813SA
T-814SA
T-815SA
T-816SA
T-817SA
T-818SA
T-819SA
T-820SA
T-821SA
T-822SA
T-823SA
T-824SA
T-825SA
T-826SA
T-827SA
T-828SA
T-829SA
T-830SA
T-831SA
T-832SA
T-833SA
T-834SA
T-835SA
T-836SA
T-837SA
T-838SA
T-839SA
T-840SA
T-841SA
T-842SA
T-843SA
T-844SA
T-845SA
T-846SA
T-847SA
T-848SA
T-849SA
T-850SA
T-851SA
T-852SA
T-853SA
T-854SA
T-855SA
T-856SA
T-857SA
T-858SA
T-859SA
T-860SA
T-861SA
T-862SA
T-863SA
T-864SA
T-865SA
T-866SA
T-867SA
T-868SA
T-869SA
T-870SA
T-871SA
T-872SA
T-873SA
T-874SA
T-875SA
T-876SA
T-877SA
T-878SA
T-879SA
T-880SA
T-881SA
T-882SA
T-883SA
T-884SA
T-885SA
T-886SA
T-887SA
T-888SA
T-889SA
T-890SA
T-891SA
T-892SA
T-893SA
T-894SA
T-895SA
T-896SA
T-897SA
T-898SA
T-899SA
T-900SA
T-901SA
T-902SA
T-903SA
T-904SA
T-905SA
T-906SA
T-907SA
T-908SA
T-909SA
T-910SA
T-911SA
T-912SA
T-913SA
T-914SA
T-915SA
T-916SA
T-917SA
T-918SA
T-919SA
T-920SA
T-921SA
T-922SA
T-923SA
T-924SA
T-925SA
T-926SA
T-927SA
T-928SA
T-929SA
T-930SA
T-931SA
T-932SA
T-933SA
T-934SA
T-935SA
T-936SA
T-937SA
T-938SA
T-939SA
T-940SA
T-941SA
T-942SA
T-943SA
T-944SA
T-945SA
T-946SA
T-947SA
T-948SA
T-949SA
T-950SA
T-951SA
T-952SA
T-953SA
T-954SA
T-955SA
T-956SA
T-957SA
T-958SA
T-959SA
T-960SA
T-961SA
T-962SA
T-963SA
T-964SA
T-965SA
T-966SA
T-967SA
T-968SA
T-969SA
T-970SA
T-971SA
T-972SA
T-973SA
T-974SA
T-975SA
T-976SA
T-977SA
T-978SA
T-979SA
T-980SA
T-981SA
T-982SA
T-983SA
T-984SA
T-985SA
T-986SA
T-987SA
T-988SA
T-989SA
T-990SA
T-991SA
T-992SA
T-993SA
T-994SA
T-995SA
T-996SA
T-997SA
T-998SA
T-999SA
T-1000SA

Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.1

Existing Condition HEC-RAS Output

Plan	***Description***
FinalEx025	***Fluvial Model, Existing Conditions, n=0.025, subcritical flow***
Exist025	***Approved Model, Existing Conditions, n=0.025, mixed flow***
Exist085	***Approved Model, Existing Conditions, n=0.085, mixed flow***

HEC-RAS model modified for fluvial use. See section 4.1.1B for model assembly. For unmodified, mixed flow regimes used in report, refer also to HEC-RAS Modeling Report prepared by PACE, concurrently submitted to LACDPW.

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

HEC-RAS Plan: FinalEx025 River: Reach #1 Reach: SCR Profile: Rev BB FP

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	46195	Rev BB FP	115111.00	1035.00	1054.30	1054.30	1060.32	0.004006	19.69	5847.54	483.37	1.00
SCR	46020	Rev BB FP	115111.00	1032.00	1052.44	1052.44	1058.13	0.004154	19.14	6013.48	531.51	1.00
SCR	45545	Rev BB FP	115111.00	1030.00	1049.24	1049.24	1055.65	0.004022	20.32	5664.11	446.75	1.01
SCR	45030	Rev BB FP	115111.00	1025.00	1045.55	1044.56	1050.46	0.003176	17.78	6472.94	521.47	0.89
SCR	44585	Rev BB FP	115111.00	1022.00	1043.05	1043.05	1048.75	0.004191	19.17	6003.55	531.86	1.01
SCR	44210	Rev BB FP	115111.00	1020.00	1041.58	1038.72	1044.97	0.001990	14.77	7793.11	585.85	0.71
SCR	43820	Rev BB FP	115111.00	1018.00	1037.47	1037.47	1043.62	0.004071	19.90	5785.45	476.53	1.01
SCR	43610	Rev BB FP	115111.00	1017.00	1034.08	1034.08	1040.13	0.004047	19.74	5832.16	483.68	1.00
SCR	43410	Rev BB FP	115111.00	1016.00	1030.73	1030.73	1035.85	0.004290	18.16	6338.30	623.33	1.00
SCR	43200	Rev BB FP	115111.00	1014.00	1029.28	1029.28	1033.94	0.004388	17.31	6660.68	737.19	1.00
SCR	42975	Rev BB FP	115111.00	1012.00	1026.11	1026.11	1030.25	0.004610	16.33	7050.19	860.39	1.01
SCR	42815	Rev BB FP	115111.00	1011.00	1024.28	1024.28	1027.89	0.004790	15.25	7548.64	1051.01	1.00
SCR	42590	Rev BB FP	115111.00	1010.00	1021.27	1021.27	1024.75	0.004840	14.96	7695.66	1112.88	1.00
SCR	42430	Rev BB FP	115111.00	1008.00	1019.61	1019.61	1023.32	0.004688	15.45	7449.45	1001.02	1.00
SCR	42215	Rev BB FP	115111.00	1006.00	1020.41	1017.69	1022.03	0.001689	10.21	11269.54	1312.59	0.61
SCR	41940	Rev BB FP	115111.00	1005.00	1019.50	1017.71	1021.46	0.002356	11.22	10258.18	1332.54	0.71
SCR	41730	Rev BB FP	115111.00	1004.00	1018.92	1016.50	1020.95	0.002293	11.42	10078.82	1249.08	0.71
SCR	41460	Rev BB FP	115111.00	1002.00	1018.33	1015.19	1020.31	0.002413	11.29	10198.64	1335.15	0.72
SCR	41280	Rev BB FP	115111.00	1001.00	1015.32	1015.32	1019.50	0.004619	16.41	7014.27	851.93	1.01
SCR	41080	Rev BB FP	115111.00	1000.00	1013.55	1013.55	1017.58	0.004646	16.10	7149.54	899.03	1.01
SCR	40825	Rev BB FP	115111.00	999.50	1012.18	1012.18	1015.60	0.004898	14.84	7757.40	1146.76	1.01
SCR	40585	Rev BB FP	115111.00	998.00	1010.63	1010.63	1014.02	0.004921	14.79	7785.23	1161.38	1.01
SCR	40335	Rev BB FP	115111.00	996.00	1010.35	1008.85	1012.23	0.002580	11.01	10452.09	1494.47	0.73
SCR	40130	Rev BB FP	115111.00	995.00	1009.98	1008.43	1011.66	0.002378	10.38	11087.02	1631.34	0.70
SCR	39945	Rev BB FP	115111.00	994.00	1009.80	1007.56	1011.20	0.001767	9.48	12146.73	1639.30	0.61
SCR	39755	Rev BB FP	115111.00	994.00	1007.25	1007.25	1010.49	0.004940	14.43	7974.76	1237.97	1.00
SCR	39605	Rev BB FP	115111.00	993.00	1005.69	1005.69	1009.04	0.004873	14.70	7830.63	1171.12	1.00
SCR	39310	Rev BB FP	115111.00	992.00	1004.14	1004.14	1007.48	0.004928	14.68	7841.97	1184.07	1.01
SCR	39100	Rev BB FP	115111.00	990.00	1004.20	1001.97	1006.14	0.002266	11.20	10276.12	1302.03	0.70
SCR	38925	Rev BB FP	115111.00	989.50	1003.90	1001.28	1005.76	0.001836	10.94	10519.67	1177.05	0.65
SCR	38710	Rev BB FP	115111.00	988.00	1003.69	999.99	1005.37	0.001311	10.39	11078.47	1039.00	0.56
SCR	38475	Rev BB FP	115111.00	986.00	1000.24	1000.24	1004.59	0.004502	16.74	6875.81	795.53	1.00
SCR	38300	Rev BB FP	115111.00	985.50	998.05	997.52	1002.29	0.003650	16.53	6965.85	701.78	0.92
SCR	38065	Rev BB FP	115111.00	984.00	998.22	995.71	1001.31	0.002051	14.09	8168.84	678.40	0.72
SCR	37810	Rev BB FP	115111.00	983.00	995.21	995.21	1000.37	0.004314	18.21	6319.82	622.08	1.01
SCR	37655	Rev BB FP	115111.00	982.00	994.15	994.15	998.54	0.004123	16.80	6851.08	789.42	1.01
SCR	37390	Rev BB FP	115111.00	981.00	989.86	989.86	993.67	0.004341	15.72	7414.85	986.73	0.98
SCR	37135	Rev BB FP	115111.00	980.00	988.56	988.56	992.08	0.004805	15.06	7645.53	1091.59	1.00
SCR	36930	Rev BB FP	115111.00	978.00	987.71	986.88	990.46	0.003082	13.31	8648.06	1125.51	0.85
SCR	36735	Rev BB FP	115111.00	977.00	986.38	986.38	989.70	0.004220	14.61	7881.46	1194.24	1.00
SCR	36515	Rev BB FP	115111.00	975.00	986.32	985.26	988.59	0.002509	12.09	9521.48	1325.55	0.79
SCR	36265	Rev BB FP	115111.00	974.00	985.17	984.78	987.82	0.003492	13.07	8806.95	1373.08	0.91
SCR	36080	Rev BB FP	116236.00	973.00	984.11	984.11	987.01	0.005036	13.69	8492.54	1450.39	1.00
SCR	35845	Rev BB FP	116236.00	971.00	983.85	982.83	985.95	0.002440	11.61	10013.52	1478.08	0.79
SCR	35725	Rev BB FP	116236.00	970.00	982.55	982.55	985.50	0.003815	13.77	8438.90	1427.85	1.00
SCR	35515	Rev BB FP	116236.00	969.00	981.34	981.34	984.38	0.003984	13.99	8309.50	1362.77	1.00
SCR	35245	Rev BB FP	116236.00	968.00	980.14	980.14	983.10	0.004877	13.82	8434.21	1553.42	0.99
SCR	35040	Rev BB FP	116236.00	967.00	978.39	978.32	981.35	0.004794	13.81	8428.24	1401.79	0.98
SCR	34860	Rev BB FP	116236.00	966.00	977.44	977.44	980.48	0.004989	13.99	8307.51	1362.96	1.00
SCR	34720	Rev BB FP	116236.00	965.50	976.17	976.17	979.16	0.005117	13.87	8382.47	1419.56	1.01
SCR	34495	Rev BB FP	116236.00	964.00	974.28	974.28	977.32	0.004209	13.98	8313.86	1380.43	1.00
SCR	34310	Rev BB FP	116236.00	963.00	972.65	972.65	975.83	0.004062	14.32	8114.63	1297.65	1.01
SCR	34090	Rev BB FP	116236.00	962.00	971.64	971.64	974.82	0.004044	14.31	8123.85	1281.00	1.00
SCR	33880	Rev BB FP	116236.00	960.00	970.45	970.45	973.58	0.004005	14.20	8187.96	1320.08	1.00
SCR	33710	Rev BB FP	116236.00	959.00	969.26	969.26	972.35	0.004225	14.11	8238.14	1363.23	1.01
SCR	33500	Rev BB FP	116236.00	958.00	968.15	968.15	970.81	0.003739	13.10	8872.21	1690.39	1.01
SCR	33310	Rev BB FP	116236.00	957.00	967.01	967.01	969.61	0.003786	12.93	8986.36	1751.52	1.01
SCR	33115	Rev BB FP	116236.00	956.00	966.35	965.60	968.34	0.003605	11.33	10261.76	1811.54	0.84
SCR	32795	Rev BB FP	116236.00	954.00	964.95	964.63	967.26	0.003022	12.20	9528.82	1732.86	0.92
SCR	32605	Rev BB FP	116236.00	952.00	963.45	963.45	966.51	0.004030	14.05	8272.67	1344.60	1.00
SCR	32265	Rev BB FP	140776.00	950.00	961.37	961.37	964.12	0.004005	13.31	10579.17	1944.94	1.01
SCR	31875	Rev BB FP	140776.00	949.00	960.00	960.00	961.85	0.003750	10.91	12908.13	2482.20	0.84
SCR	31585	Rev BB FP	140776.00	946.00	957.67	956.99	959.64	0.003504	11.25	12511.05	2181.08	0.83
SCR	31360	Rev BB FP	140776.00	944.00	957.21	955.40	958.92	0.002285	10.51	13391.47	1875.23	0.69
SCR	31060	Rev BB FP	140776.00	942.00	957.24	953.29	958.34	0.000890	8.41	16729.49	1706.23	0.47
SCR	30720	Rev BB FP	140776.00	940.00	957.27	951.33	957.99	0.000542	6.81	20683.35	1886.90	0.36
SCR	30445	Rev BB FP	140776.00	938.00	957.20	949.57	957.83	0.000402	6.38	22074.12	1777.56	0.32
SCR	30095	Rev BB FP	140776.00	936.00	956.95	947.93	957.67	0.000462	6.82	20641.04	1666.43	0.34
SCR	29815	Rev BB FP	140776.00	935.00	956.59	948.10	957.51	0.000632	7.66	18372.99	1572.98	0.40
SCR	29565	Rev BB FP	140776.00	934.00	956.46	947.27	957.34	0.000612	7.51	18750.19	1613.45	0.39
SCR	29385	Rev BB FP	140776.00	933.00	956.05	948.99	957.18	0.000905	8.52	16517.20	1577.58	0.46
SCR	29140	Rev BB FP	140776.00	932.00	954.74	950.98	956.78	0.001928	11.47	12276.15	1324.48	0.66
SCR	28895	Rev BB FP	140776.00	930.00	951.63	951.63	955.99	0.002780	16.75	8402.32	965.72	1.00
SCR	28695	Rev BB FP	140776.00	928.00	947.85	947.85	953.31	0.004258	18.75	7507.53	701.05	1.01
SCR	28500	Rev BB FP	140776.00	927.50	945.09	945.09	951.16	0.003848	19.77	7160.17	654.24	0.99
SCR	28280	Rev BB FP	140776.00	926.00	941.65	941.65	947.91	0.004004	20.08	7009.50	562.69	1.00
SCR	28080	Rev BB FP	140776.00	925.00	942.26	940.11	946.59	0.002276	16.70	8441.98	682.92	0.80
SCR	27925	Rev BB FP	140776.00	924.00	940.35	939.49	946.04	0.003135	19.14	7355.35	549.81	0.92

HEC-RAS Plan: FinalEx025 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	27725	Rev BB FP	140776.00	923.00	939.27	939.27	945.37	0.003256	19.81	7106.64	586.68	1.00
SCR	27545	Rev BB FP	140776.00	922.00	937.65	937.65	943.27	0.003489	19.04	7395.60	656.47	1.00
SCR	27335	Rev BB FP	140776.00	921.00	936.22	936.22	940.84	0.003040	17.25	8160.86	887.01	1.00
SCR	27155	Rev BB FP	140776.00	920.50	935.43	935.43	939.62	0.003289	16.42	8571.55	1033.54	1.01
SCR	26990	Rev BB FP	140776.00	920.00	933.74	933.74	937.63	0.003639	15.83	8895.76	1147.56	1.00
SCR	26780	Rev BB FP	140776.00	918.00	931.35	931.35	935.09	0.003642	15.50	9080.65	1213.45	1.00
SCR	26575	Rev BB FP	140776.00	917.00	930.61	929.96	933.73	0.003645	14.19	9923.76	1259.87	0.89
SCR	26355	Rev BB FP	140776.00	916.00	929.17	929.17	932.77	0.004708	15.22	9247.19	1278.41	1.00
SCR	26170	Rev BB FP	140776.00	915.00	928.86	928.12	931.70	0.003430	13.53	10408.48	1352.53	0.86
SCR	25965	Rev BB FP	140776.00	914.00	927.22	927.22	930.82	0.004764	15.21	9254.71	1290.20	1.00
SCR	25785	Rev BB FP	140776.00	913.50	926.05	926.05	929.53	0.004772	14.97	9402.31	1344.86	1.00
SCR	25600	Rev BB FP	140776.00	912.50	924.93	924.89	927.92	0.004891	13.87	10151.10	1661.55	0.99
SCR	25425	Rev BB FP	140776.00	911.00	925.37	923.83	927.03	0.001843	10.34	13664.53	2021.56	0.69
SCR	25215	Rev BB FP	140776.00	910.00	923.33	923.33	926.30	0.005117	13.83	10181.28	1732.15	1.01
SCR	25000	Rev BB FP	140776.00	909.00	922.13	922.13	924.61	0.003543	12.64	11135.49	2284.18	1.01
SCR	24795	Rev BB FP	140776.00	908.00	920.36	920.36	922.81	0.003986	12.56	11204.68	2315.50	1.01
SCR	24550	Rev BB FP	140776.00	906.00	919.48	917.96	920.95	0.001944	9.74	14446.28	2238.32	0.68
SCR	24335	Rev BB FP	140776.00	905.00	917.62	917.62	920.25	0.004333	12.99	10833.43	2087.54	1.01
SCR	24115	Rev BB FP	140776.00	904.00	915.93	915.93	918.60	0.005232	13.09	10751.27	2018.76	1.00
SCR	23975	Rev BB FP	140776.00	903.50	914.60	914.60	917.35	0.004636	13.31	10577.23	1919.34	1.00
SCR	23755	Rev BB FP	140776.00	902.00	913.25	913.24	916.01	0.004627	13.32	10567.82	1938.03	1.01
SCR	23565	Rev BB FP	140776.00	900.00	912.40	912.40	915.10	0.004610	13.17	10691.96	2036.28	1.01
SCR	23365	Rev BB FP	140776.00	900.00	911.13	911.13	914.01	0.004622	13.63	10329.86	1783.88	1.00
SCR	23180	Rev BB FP	140776.00	899.00	910.96	909.39	912.53	0.001984	10.05	14012.48	2086.48	0.68
SCR	23000	Rev BB FP	140776.00	898.00	910.89	908.39	912.14	0.001366	8.95	15727.65	2065.37	0.57
SCR	22790	Rev BB FP	140776.00	897.50	910.43	908.15	911.83	0.001448	9.49	14833.41	1946.22	0.61
SCR	22600	Rev BB FP	140776.00	896.00	910.14	907.56	911.55	0.001434	9.52	14788.10	1866.40	0.60
SCR	22415	Rev BB FP	140776.00	895.50	909.67	906.93	911.25	0.001552	10.10	13933.69	1712.91	0.62
SCR	22195	Rev BB FP	141426.00	894.00	906.88	906.88	910.54	0.003786	15.36	9204.46	1262.71	1.00
SCR	22010	Rev BB FP	141426.00	892.00	906.16	906.16	909.69	0.003347	15.08	9380.50	1322.09	1.00
SCR	21790	Rev BB FP	141426.00	891.50	904.86	904.86	908.08	0.002972	14.39	9826.50	1586.66	1.00
SCR	21615	Rev BB FP	141426.00	892.00	903.09	903.09	906.00	0.003182	13.67	10342.23	1845.66	1.00
SCR	21440	Rev BB FP	141426.00	890.00	901.21	901.21	904.53	0.003865	14.61	9680.27	1773.54	1.00
SCR	21225	Rev BB FP	141426.00	888.00	899.81	899.81	902.28	0.003807	12.60	11221.48	2263.50	1.00
SCR	21020	Rev BB FP	141426.00	887.00	897.42	897.42	900.35	0.003921	13.75	10350.76	1908.44	0.99
SCR	20845	Rev BB FP	141426.00	886.00	897.00	897.00	899.41	0.003869	12.46	11348.13	2407.34	1.01
SCR	20595	Rev BB FP	141426.00	885.00	896.43	895.88	898.31	0.002651	10.99	12863.10	2527.28	0.86
SCR	20435	Rev BB FP	141426.00	884.00	896.19	895.33	897.84	0.002261	10.32	13709.67	2581.09	0.79
SCR	20280	Rev BB FP	141426.00	883.70	895.03	895.03	897.31	0.003977	12.14	11653.22	2572.83	1.00
SCR	20070	Rev BB FP	141426.00	882.00	892.74	892.74	895.13	0.003743	12.41	11394.63	2436.05	1.01
SCR	19855	Rev BB FP	141426.00	880.50	891.12	891.12	893.79	0.004114	13.12	10778.78	2072.85	1.01
SCR	19630	Rev BB FP	141426.00	880.00	889.83	889.73	892.52	0.003926	13.17	10735.19	1914.99	0.98
SCR	19440	Rev BB FP	141426.00	878.00	889.91	888.74	891.71	0.002179	10.75	13151.45	2083.68	0.75
SCR	19240	Rev BB FP	141426.00	877.50	888.85	888.46	891.14	0.003158	12.14	11650.49	2090.11	0.91
SCR	19050	Rev BB FP	141426.00	876.00	889.03	887.20	890.46	0.001682	9.60	14759.68	2167.39	0.64
SCR	18830	Rev BB FP	141426.00	874.00	888.73	886.52	890.09	0.001481	9.34	15134.89	2098.85	0.61
SCR	18650	Rev BB FP	141426.00	873.50	888.68	885.42	889.80	0.001016	8.50	16644.25	2025.07	0.52
SCR	18475	Rev BB FP	141426.00	872.00	888.66	884.58	889.58	0.000752	7.70	18373.58	1945.01	0.44
SCR	18290	Rev BB FP	141426.00	871.50	888.41	884.39	889.43	0.000811	8.11	17448.54	1844.66	0.46
SCR	18025	Rev BB FP	141426.00	870.00	888.32	882.81	889.21	0.000556	7.57	18674.68	1611.77	0.39
SCR	17785	Rev BB FP	141426.00	868.00	887.90	882.80	889.03	0.000782	8.54	16558.68	1418.63	0.44
SCR	17510	Rev BB FP	141426.00	867.50	886.20	883.72	888.57	0.002372	12.34	11457.08	1289.70	0.73
SCR	17360	Rev BB FP	141426.00	866.50	883.43	883.43	887.88	0.004458	16.92	8357.42	937.14	1.00
SCR	17110	Rev BB FP	141426.00	864.00	881.13	881.13	884.63	0.004863	15.00	9425.53	1362.48	1.01
SCR	16970	Rev BB FP	141426.00	863.70	879.71	879.71	882.95	0.004916	14.43	9799.49	1514.81	1.00
SCR	16720	Rev BB FP	141426.00	863.50	875.31	875.31	878.43	0.005042	14.17	9981.85	1620.98	1.01
SCR	16515	Rev BB FP	141426.00	862.00	873.47	873.47	876.26	0.005133	13.41	10549.67	1886.90	1.00
SCR	16305	Rev BB FP	141426.00	860.00	871.57	871.17	874.03	0.004195	12.59	11236.89	1898.55	0.91
SCR	16130	Rev BB FP	141426.00	860.00	870.50	870.50	873.24	0.004481	13.29	10641.43	1964.99	1.01
SCR	15960	Rev BB FP	141426.00	859.00	869.21	869.21	871.76	0.004764	12.82	11034.61	2192.96	1.01
SCR	15745	Rev BB FP	141426.00	858.00	868.55	867.80	870.41	0.003042	10.94	12927.79	2278.92	0.81
SCR	15540	Rev BB FP	141426.00	857.50	868.10	867.08	869.78	0.002644	10.40	13602.23	2324.38	0.76
SCR	15335	Rev BB FP	141426.00	856.00	866.54	866.54	868.99	0.004652	12.57	11254.13	2302.38	1.00
SCR	15125	Rev BB FP	142475.00	854.00	864.54	864.54	867.47	0.004356	13.74	10371.47	1768.96	1.00
SCR	14900	Rev BB FP	142475.00	853.00	863.28	863.28	866.30	0.005056	13.96	10205.62	1697.82	1.00
SCR	14720	Rev BB FP	142475.00	852.00	862.06	862.06	864.98	0.004688	13.72	10381.85	1810.00	1.01
SCR	14480	Rev BB FP	142475.00	850.50	860.54	860.53	863.45	0.004424	13.69	10409.04	1796.48	1.00
SCR	14315	Rev BB FP	142475.00	850.00	859.85	859.82	862.67	0.004566	13.47	10576.74	1874.03	1.00
SCR	14090	Rev BB FP	142475.00	849.71	858.68	858.68	861.60	0.004613	13.72	10387.90	1766.91	1.00
SCR	13850	Rev BB FP	142475.00	848.00	857.12	857.12	860.09	0.004634	13.84	10293.87	1731.37	1.00
SCR	13635	Rev BB FP	142475.00	846.00	855.96	855.96	859.00	0.004582	13.99	10182.29	1687.45	1.00
SCR	13425	Rev BB FP	142475.00	845.00	854.59	854.59	857.38	0.004390	13.41	10627.77	1893.46	1.00
SCR	13190	Rev BB FP	142475.00	844.00	853.13	852.76	855.64	0.003872	12.71	11213.28	1844.92	0.91
SCR	13030	Rev BB FP	142475.00	843.00	852.67	851.98	855.02	0.003287	12.32	11565.85	1764.20	0.85
SCR	12835	Rev BB FP	142475.00	842.00	852.13	851.03	854.41	0.002756	12.10	11770.00	1607.56	0.79
SCR	12615	Rev BB FP	142475.00	841.00	851.84	849.84	853.81	0.001933	11.27	12646.02	1470.54	0.68
SCR	12395	Rev BB FP	142475.00	840.00	851.49	849.20	853.39	0.001707	11.07	12874.21	1438.10	0.65
SCR	12195	Rev BB FP	142475.00	838.98	851.43	848.08	853.01	0.001240	10.08	14130.68	1388.77	0.56

HEC-RAS Plan: FinalEx025 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	11995	Rev BB FP	142475.00	837.00	850.69	848.07	852.68	0.001558	11.32	12590.58	1281.38	0.64
SCR	11780	Rev BB FP	142475.00	836.00	850.53	847.67	852.30	0.001399	10.65	13373.20	1402.92	0.61
SCR	11605	Rev BB FP	142475.00	835.50	849.74	847.20	851.99	0.001650	12.04	11832.96	1304.15	0.70
SCR	11405	Rev BB FP	142475.00	834.00	849.43	846.23	851.67	0.001422	12.02	11855.13	1132.15	0.65
SCR	11180	Rev BB FP	142475.00	833.00	847.64	845.64	851.13	0.002642	14.99	9504.91	868.52	0.80
SCR	11015	Rev BB FP	142475.00	831.50	844.84	844.84	850.40	0.003841	18.92	7530.61	680.33	1.00
SCR	10835	Rev BB FP	142475.00	831.00	843.79	843.79	848.64	0.003827	17.68	8059.61	834.48	1.00
SCR	10575	Rev BB FP	142475.00	830.00	840.17	840.17	844.13	0.004307	15.98	8918.16	1127.52	1.00
SCR	10390	Rev BB FP	142475.00	828.00	839.47	838.56	842.17	0.002692	13.18	10811.18	1390.10	0.83
SCR	10225	Rev BB FP	142475.00	827.50	838.21	838.21	841.57	0.004024	14.72	9676.62	1447.21	1.00
SCR	10000	Rev BB FP	142475.00	826.00	837.11	837.11	840.43	0.004013	14.62	9744.75	1487.06	1.01
SCR	9820	Rev BB FP	142475.00	824.00	835.35	835.35	838.82	0.004324	14.95	9530.31	1373.15	1.00
SCR	9595	Rev BB FP	142475.00	823.80	834.12	834.12	837.42	0.004911	14.58	9769.14	1619.44	1.00
SCR	9385	Rev BB FP	142475.00	823.00	833.11	833.11	836.03	0.005066	13.73	10378.48	1773.73	1.00
SCR	9220	Rev BB FP	142475.00	822.00	831.81	831.81	834.72	0.004539	13.68	10412.72	1813.72	1.01
SCR	9025	Rev BB FP	142475.00	821.00	830.41	830.41	833.36	0.004214	13.77	10347.97	1751.71	1.00

HEC-RAS Plan: Exist025 River: Reach #1 Reach: SCR Profile: Rev BB FP

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	46195	Rev BB FP	115111.00	1035.00	1053.14	1054.04	1060.43	0.005006	21.67	5313.11	452.97	1.11
SCR	46020	Rev BB FP	115111.00	1032.00	1050.08	1052.47	1059.13	0.008742	24.14	4768.34	520.89	1.41
SCR	45545	Rev BB FP	115111.00	1030.00	1049.23	1049.27	1055.65	0.004028	20.33	5661.33	446.68	1.01
SCR	45030	Rev BB FP	115111.00	1025.00	1041.51	1044.56	1052.09	0.010535	26.10	4410.21	492.54	1.54
SCR	44585	Rev BB FP	115111.00	1022.00	1043.05	1043.07	1048.75	0.004190	19.17	6004.20	531.91	1.01
SCR	44210	Rev BB FP	115111.00	1020.00	1035.36	1038.72	1045.99	0.009463	26.16	4399.47	452.62	1.48
SCR	43820	Rev BB FP	115111.00	1018.00	1037.47	1037.48	1043.62	0.004072	19.90	5785.33	476.53	1.01
SCR	43610	Rev BB FP	115111.00	1017.00	1030.80	1034.06	1041.87	0.010066	26.70	4311.38	450.58	1.52
SCR	43410	Rev BB FP	115111.00	1016.00	1027.33	1031.12	1039.61	0.011140	28.77	4308.74	583.44	1.61
SCR	43200	Rev BB FP	115111.00	1014.00	1026.42	1029.64	1036.81	0.010596	26.11	4615.54	689.15	1.54
SCR	42975	Rev BB FP	115111.00	1012.00	1022.84	1026.28	1033.82	0.016328	26.63	4368.50	735.12	1.82
SCR	42815	Rev BB FP	115111.00	1011.00	1021.61	1024.35	1030.50	0.016385	24.07	4833.92	878.46	1.78
SCR	42590	Rev BB FP	115111.00	1010.00	1018.93	1021.36	1026.81	0.014228	22.59	5182.81	1023.20	1.67
SCR	42430	Rev BB FP	115111.00	1008.00	1017.64	1019.62	1024.35	0.011522	20.83	5543.00	940.48	1.51
SCR	42215	Rev BB FP	115111.00	1006.00	1020.27	1017.68	1021.96	0.001717	10.44	11089.91	1310.38	0.62
SCR	41940	Rev BB FP	115111.00	1005.00	1019.29	1017.71	1021.37	0.002407	11.57	9983.36	1321.54	0.72
SCR	41730	Rev BB FP	115111.00	1004.00	1018.72	1016.50	1020.86	0.002272	11.75	9825.95	1229.51	0.71
SCR	41460	Rev BB FP	115111.00	1002.00	1018.21	1015.19	1020.27	0.002042	11.52	10032.38	1329.00	0.68
SCR	41280	Rev BB FP	115111.00	1001.00	1015.33	1015.33	1019.53	0.004491	16.45	7022.85	852.07	1.00
SCR	41080	Rev BB FP	115111.00	1000.00	1012.07	1013.56	1018.19	0.007468	19.90	5831.66	874.23	1.27
SCR	40825	Rev BB FP	115111.00	999.50	1010.96	1012.05	1016.00	0.007253	18.03	6438.62	1039.92	1.22
SCR	40585	Rev BB FP	115111.00	998.00	1009.71	1010.43	1014.18	0.006366	16.97	6789.33	1005.89	1.15
SCR	40335	Rev BB FP	115111.00	996.00	1010.45	1008.78	1012.35	0.002164	11.11	10609.98	1504.81	0.69
SCR	40130	Rev BB FP	115111.00	995.00	1010.11	1008.56	1011.91	0.001844	11.15	11289.76	1636.51	0.65
SCR	39945	Rev BB FP	115111.00	994.00	1010.06	1007.77	1011.51	0.001383	10.26	12565.23	1648.10	0.57
SCR	39755	Rev BB FP	115111.00	994.00	1007.49	1007.49	1010.91	0.003380	15.35	8268.30	1251.38	0.88
SCR	39605	Rev BB FP	115111.00	993.00	1004.42	1005.91	1010.00	0.006738	19.35	6391.72	1100.64	1.21
SCR	39310	Rev BB FP	115111.00	992.00	1004.42	1004.43	1007.98	0.003512	16.00	8178.22	1204.45	0.90
SCR	39100	Rev BB FP	115111.00	990.00	1004.09	1002.13	1006.32	0.001898	12.37	10137.42	1294.76	0.67
SCR	38925	Rev BB FP	115111.00	989.50	1003.99	1001.39	1005.92	0.001609	11.40	10622.64	1181.25	0.62
SCR	38710	Rev BB FP	115111.00	988.00	1003.86	1000.10	1005.55	0.001174	10.64	11255.51	1043.10	0.54
SCR	38475	Rev BB FP	115111.00	986.00	999.95	999.95	1004.77	0.004258	17.75	6650.60	755.44	1.00
SCR	38300	Rev BB FP	115111.00	985.50	995.32	997.52	1003.33	0.010251	22.72	5066.81	688.08	1.48
SCR	38065	Rev BB FP	115111.00	984.00	998.22	995.71	1001.30	0.002055	14.10	8164.12	678.33	0.72
SCR	37810	Rev BB FP	115111.00	983.00	995.23	995.23	1000.37	0.004288	18.18	6332.08	622.26	1.00
SCR	37655	Rev BB FP	115111.00	982.00	992.29	994.08	999.27	0.008545	21.19	5432.74	735.92	1.37
SCR	37390	Rev BB FP	115111.00	981.00	987.15	989.88	996.01	0.016577	23.93	4834.54	892.17	1.79
SCR	37135	Rev BB FP	115111.00	980.00	987.96	988.63	992.27	0.005950	17.03	6995.53	1088.87	1.12
SCR	36930	Rev BB FP	115111.00	978.00	985.90	987.06	990.89	0.006968	18.32	6620.06	1112.00	1.22
SCR	36735	Rev BB FP	115111.00	977.00	986.56	986.56	989.87	0.003887	15.01	8085.46	1195.65	0.95
SCR	36515	Rev BB FP	115111.00	975.00	984.57	985.42	988.79	0.005510	16.72	7222.58	1306.12	1.15
SCR	36265	Rev BB FP	115111.00	974.00	985.18	984.77	987.82	0.003461	13.04	8831.00	1373.13	0.91
SCR	36080	Rev BB FP	116236.00	973.00	984.66	984.08	987.09	0.003700	12.52	9300.75	1455.39	0.87
SCR	35845	Rev BB FP	116236.00	971.00	984.52	982.90	986.31	0.001825	10.87	11007.98	1496.24	0.68
SCR	35725	Rev BB FP	116236.00	970.00	982.95	982.95	985.91	0.003125	14.70	9008.65	1431.18	0.89
SCR	35515	Rev BB FP	116236.00	969.00	980.94	981.76	985.02	0.004605	17.09	7764.83	1353.35	1.05
SCR	35245	Rev BB FP	116236.00	968.00	980.49	980.49	983.46	0.003192	14.46	8982.03	1555.54	0.88
SCR	35040	Rev BB FP	116236.00	967.00	977.69	978.97	982.44	0.005403	19.45	7455.95	1355.85	1.12
SCR	34860	Rev BB FP	116236.00	966.00	976.05	977.44	981.12	0.008289	18.06	6434.79	1338.93	1.45
SCR	34720	Rev BB FP	116236.00	965.50	974.77	976.17	979.89	0.008895	18.15	6402.85	1411.51	1.50
SCR	34495	Rev BB FP	116236.00	964.00	972.85	974.28	977.92	0.008678	18.08	6430.24	1277.15	1.42
SCR	34310	Rev BB FP	116236.00	963.00	971.99	973.01	976.49	0.005449	17.60	7261.34	1280.76	1.11
SCR	34090	Rev BB FP	116236.00	962.00	970.59	971.64	975.16	0.006767	17.15	6777.33	1267.83	1.31
SCR	33880	Rev BB FP	116236.00	960.00	969.84	970.46	973.69	0.005376	15.75	7378.62	1310.60	1.17
SCR	33710	Rev BB FP	116236.00	959.00	968.38	969.29	972.62	0.006666	16.53	7033.51	1355.12	1.28
SCR	33500	Rev BB FP	116236.00	958.00	967.50	968.41	971.14	0.005805	15.77	7888.10	1474.27	1.09
SCR	33310	Rev BB FP	116236.00	957.00	966.06	967.01	969.97	0.006404	15.86	7329.57	1744.50	1.36
SCR	33115	Rev BB FP	116236.00	956.00	964.72	965.60	968.46	0.008533	15.52	7488.40	1573.15	1.25
SCR	32795	Rev BB FP	116236.00	954.00	964.95	964.63	967.26	0.003022	12.20	9528.82	1732.86	0.92
SCR	32605	Rev BB FP	116236.00	952.00	963.45	963.45	966.51	0.004030	14.05	8272.67	1344.60	1.00
SCR	32265	Rev BB FP	140776.00	950.00	960.23	961.30	964.55	0.007315	16.68	8441.17	1829.94	1.37
SCR	31875	Rev BB FP	140776.00	949.00	960.00	960.00	961.85	0.003638	10.91	12908.13	2482.20	0.84
SCR	31585	Rev BB FP	140776.00	946.00	955.82	956.99	960.09	0.008524	16.58	8491.87	2120.30	1.46
SCR	31360	Rev BB FP	140776.00	944.00	957.86	955.39	959.33	0.001452	9.77	14613.64	1884.43	0.60
SCR	31060	Rev BB FP	140776.00	942.00	957.92	953.29	958.88	0.000719	7.87	17898.38	1711.46	0.43
SCR	30720	Rev BB FP	140776.00	940.00	957.97	951.33	958.60	0.000397	6.40	22006.92	1891.72	0.33
SCR	30445	Rev BB FP	140776.00	938.00	957.92	949.57	958.49	0.000300	6.03	23359.04	1783.69	0.29
SCR	30095	Rev BB FP	140776.00	936.00	957.70	947.93	958.38	0.000278	6.61	21917.00	1730.34	0.28
SCR	29815	Rev BB FP	140776.00	935.00	957.38	948.10	958.27	0.000356	7.69	19642.02	1675.19	0.32
SCR	29565	Rev BB FP	140776.00	934.00	957.34	947.27	958.16	0.000326	7.37	20205.72	1717.44	0.32
SCR	29385	Rev BB FP	140776.00	933.00	956.99	948.97	958.07	0.000447	8.49	18042.34	1675.09	0.37
SCR	29140	Rev BB FP	140776.00	932.00	956.33	950.98	957.88	0.000774	10.06	14550.84	1557.60	0.50
SCR	28895	Rev BB FP	140776.00	930.00	952.39	952.39	957.25	0.002389	19.66	9168.94	1062.28	0.82
SCR	28695	Rev BB FP	140776.00	928.00	943.96	947.96	955.72	0.008766	27.52	5115.18	544.92	1.58
SCR	28500	Rev BB FP	140776.00	927.50	941.05	945.12	953.77	0.010388	28.62	4919.56	503.65	1.61
SCR	28280	Rev BB FP	140776.00	926.00	937.77	941.83	951.33	0.011163	29.67	4853.18	549.28	1.63
SCR	28080	Rev BB FP	140776.00	925.00	936.42	940.05	948.69	0.011257	28.14	5027.76	547.57	1.61
SCR	27925	Rev BB FP	140776.00	924.00	941.45	939.47	946.43	0.002376	17.95	7989.60	612.66	0.80

HEC-RAS Plan: Exist025 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	27725	Rev BB FP	140776.00	923.00	939.31	939.31	945.73	0.003230	20.54	7126.85	587.11	0.93
SCR	27545	Rev BB FP	140776.00	922.00	935.22	937.81	944.62	0.006843	24.72	5836.41	613.02	1.30
SCR	27335	Rev BB FP	140776.00	921.00	932.95	936.26	942.99	0.008302	25.48	5614.41	691.02	1.43
SCR	27155	Rev BB FP	140776.00	920.50	933.67	935.89	940.99	0.005311	22.28	6835.79	856.59	1.15
SCR	26990	Rev BB FP	140776.00	920.00	931.16	933.85	939.67	0.010073	23.47	6088.49	1008.19	1.60
SCR	26780	Rev BB FP	140776.00	918.00	929.02	931.73	937.60	0.009537	23.94	6335.41	1131.68	1.49
SCR	26575	Rev BB FP	140776.00	917.00	928.01	929.98	934.86	0.012746	21.01	6701.47	1216.43	1.57
SCR	26355	Rev BB FP	140776.00	916.00	929.42	929.42	933.07	0.003461	15.83	9559.47	1282.38	0.93
SCR	26170	Rev BB FP	140776.00	915.00	927.98	928.71	932.32	0.003988	17.96	9212.09	1347.94	0.97
SCR	25965	Rev BB FP	140776.00	914.00	927.00	927.74	931.48	0.004061	17.92	8960.72	1288.34	0.98
SCR	25785	Rev BB FP	140776.00	913.50	925.20	926.55	930.53	0.005499	19.54	8264.34	1336.94	1.12
SCR	25600	Rev BB FP	140776.00	912.50	923.79	925.47	929.42	0.006077	20.55	8274.40	1596.52	1.22
SCR	25425	Rev BB FP	140776.00	911.00	922.33	924.23	928.17	0.007953	20.02	7791.92	1773.81	1.45
SCR	25215	Rev BB FP	140776.00	910.00	923.61	923.61	926.64	0.003392	14.51	10667.78	1748.60	0.91
SCR	25000	Rev BB FP	140776.00	909.00	921.22	922.50	925.58	0.005503	17.42	9139.37	2103.24	1.17
SCR	24795	Rev BB FP	140776.00	908.00	919.43	920.87	924.26	0.006914	18.97	9060.11	2311.66	1.32
SCR	24550	Rev BB FP	140776.00	906.00	916.77	918.41	922.31	0.009115	21.33	8402.41	2227.03	1.61
SCR	24335	Rev BB FP	140776.00	905.00	918.13	918.13	920.69	0.003234	14.49	11895.55	2089.54	0.88
SCR	24115	Rev BB FP	140776.00	904.00	915.09	916.28	919.48	0.007920	18.83	9045.64	2015.76	1.28
SCR	23975	Rev BB FP	140776.00	903.50	913.66	914.88	918.15	0.008173	19.03	8772.57	1913.65	1.36
SCR	23755	Rev BB FP	140776.00	902.00	912.91	913.54	916.35	0.005642	16.73	9905.28	1935.37	1.16
SCR	23565	Rev BB FP	140776.00	900.00	912.71	912.71	915.32	0.003871	14.47	11321.84	2039.50	0.98
SCR	23365	Rev BB FP	140776.00	900.00	910.76	911.37	914.32	0.005655	17.04	9677.26	1781.35	1.14
SCR	23180	Rev BB FP	140776.00	899.00	910.83	909.87	912.71	0.002065	13.16	13743.03	2084.20	0.71
SCR	23000	Rev BB FP	140776.00	898.00	911.00	908.40	912.22	0.001301	8.88	15943.92	2069.07	0.55
SCR	22790	Rev BB FP	140776.00	897.50	910.57	908.15	911.92	0.001363	9.35	15109.43	1949.00	0.58
SCR	22600	Rev BB FP	140776.00	896.00	910.06	907.78	911.63	0.001473	11.36	14637.21	1865.20	0.62
SCR	22415	Rev BB FP	140776.00	895.50	909.56	907.11	911.33	0.001596	11.77	13743.30	1705.56	0.65
SCR	22195	Rev BB FP	141426.00	894.00	907.70	906.79	910.76	0.002704	14.10	10265.56	1322.24	0.83
SCR	22010	Rev BB FP	141426.00	892.00	906.38	906.38	910.15	0.003030	15.99	9665.26	1328.02	0.87
SCR	21790	Rev BB FP	141426.00	891.50	903.07	904.87	909.03	0.005884	19.68	7429.43	1145.70	1.16
SCR	21615	Rev BB FP	141426.00	892.00	900.50	903.04	907.59	0.010112	21.40	6678.16	1161.25	1.52
SCR	21440	Rev BB FP	141426.00	890.00	899.69	901.59	905.74	0.007634	20.12	7633.81	1574.63	1.29
SCR	21225	Rev BB FP	141426.00	888.00	898.62	900.27	903.89	0.007531	19.45	8509.78	2217.71	1.27
SCR	21020	Rev BB FP	141426.00	887.00	895.89	897.85	902.14	0.008670	20.80	7679.38	1676.42	1.37
SCR	20845	Rev BB FP	141426.00	886.00	896.38	897.38	900.20	0.005510	17.07	9870.72	2369.34	1.13
SCR	20595	Rev BB FP	141426.00	885.00	895.93	896.42	898.91	0.003386	15.17	11611.25	2463.72	0.88
SCR	20435	Rev BB FP	141426.00	884.00	896.23	895.77	898.29	0.002186	12.93	13821.87	2582.65	0.72
SCR	20280	Rev BB FP	141426.00	883.70	895.55	895.55	897.86	0.002944	13.96	13014.40	2589.59	0.82
SCR	20070	Rev BB FP	141426.00	882.00	891.22	893.00	896.57	0.008994	20.19	8211.27	1767.50	1.37
SCR	19855	Rev BB FP	141426.00	880.50	890.43	891.49	894.67	0.005944	17.83	9393.73	1975.10	1.14
SCR	19630	Rev BB FP	141426.00	880.00	888.94	890.05	893.30	0.006239	17.86	9074.12	1836.22	1.18
SCR	19440	Rev BB FP	141426.00	878.00	890.13	889.11	892.07	0.001973	11.94	13611.33	2095.28	0.70
SCR	19240	Rev BB FP	141426.00	877.50	888.88	888.88	891.51	0.003097	13.92	11714.43	2091.68	0.88
SCR	19050	Rev BB FP	141426.00	876.00	888.85	887.51	890.49	0.001803	10.96	14382.18	2160.84	0.67
SCR	18830	Rev BB FP	141426.00	874.00	888.56	886.80	890.10	0.001579	10.67	14781.82	2094.37	0.64
SCR	18650	Rev BB FP	141426.00	873.50	888.48	886.00	889.80	0.001087	9.89	16256.74	2022.74	0.53
SCR	18475	Rev BB FP	141426.00	872.00	888.57	884.72	889.53	0.000774	8.07	18194.47	1944.40	0.45
SCR	18290	Rev BB FP	141426.00	871.50	888.27	884.54	889.37	0.000832	8.69	17186.39	1843.67	0.47
SCR	18025	Rev BB FP	141426.00	870.00	888.21	882.91	889.13	0.000573	7.83	18485.26	1610.91	0.40
SCR	17785	Rev BB FP	141426.00	868.00	887.78	882.81	888.95	0.000788	8.71	16382.46	1417.47	0.44
SCR	17510	Rev BB FP	141426.00	867.50	885.46	883.72	888.44	0.001981	13.95	10512.58	1243.63	0.75
SCR	17360	Rev BB FP	141426.00	866.50	883.40	883.40	887.90	0.003623	17.03	8326.59	936.59	1.00
SCR	17110	Rev BB FP	141426.00	864.00	879.37	881.59	886.46	0.006287	21.70	7106.91	1274.30	1.26
SCR	16970	Rev BB FP	141426.00	863.70	877.33	880.05	885.35	0.008185	22.92	6449.08	1125.59	1.47
SCR	16720	Rev BB FP	141426.00	863.50	872.47	875.45	882.24	0.018432	25.15	5735.17	1404.63	2.00
SCR	16515	Rev BB FP	141426.00	862.00	871.52	873.72	878.33	0.012326	21.45	7010.27	1622.64	1.67
SCR	16305	Rev BB FP	141426.00	860.00	869.61	871.44	875.64	0.011136	21.47	7604.36	1812.82	1.64
SCR	16130	Rev BB FP	141426.00	860.00	870.19	870.71	873.47	0.005291	16.06	10039.66	1945.14	1.17
SCR	15960	Rev BB FP	141426.00	859.00	868.27	869.21	872.12	0.010630	15.80	8986.11	2180.88	1.37
SCR	15745	Rev BB FP	141426.00	858.00	868.57	867.78	870.42	0.002999	10.93	12967.71	2278.98	0.82
SCR	15540	Rev BB FP	141426.00	857.50	868.06	867.17	869.80	0.002688	11.03	13523.49	2324.20	0.78
SCR	15335	Rev BB FP	141426.00	856.00	866.50	866.50	869.00	0.004731	12.68	11164.20	2302.06	1.01
SCR	15125	Rev BB FP	142475.00	854.00	863.64	864.54	867.69	0.006528	16.15	8838.57	1618.47	1.21
SCR	14900	Rev BB FP	142475.00	853.00	863.42	863.42	866.43	0.004130	14.54	10443.91	1704.50	0.99
SCR	14720	Rev BB FP	142475.00	852.00	861.25	862.19	865.34	0.007984	16.84	8931.26	1763.49	1.25
SCR	14480	Rev BB FP	142475.00	850.50	860.73	860.73	863.62	0.004264	14.25	10759.99	1801.68	0.95
SCR	14315	Rev BB FP	142475.00	850.00	859.35	859.82	862.74	0.006080	14.79	9631.06	1868.05	1.15
SCR	14090	Rev BB FP	142475.00	849.71	858.67	858.67	861.61	0.004639	13.75	10362.56	1766.78	1.00
SCR	13850	Rev BB FP	142475.00	848.00	856.44	857.11	860.23	0.006745	15.61	9128.71	1727.26	1.20
SCR	13635	Rev BB FP	142475.00	846.00	856.32	856.32	859.30	0.003797	15.41	10784.75	1691.89	0.92
SCR	13425	Rev BB FP	142475.00	845.00	853.32	854.58	857.95	0.009231	17.28	8245.16	1854.35	1.44
SCR	13190	Rev BB FP	142475.00	844.00	853.50	852.81	855.77	0.003210	12.22	11882.13	1847.29	0.83
SCR	13030	Rev BB FP	142475.00	843.00	852.58	852.27	855.21	0.003375	14.20	11409.44	1763.01	0.87
SCR	12835	Rev BB FP	142475.00	842.00	852.13	851.23	854.54	0.002745	13.33	11764.70	1607.52	0.79
SCR	12615	Rev BB FP	142475.00	841.00	851.89	850.08	853.94	0.001885	12.39	12717.39	1471.01	0.67
SCR	12395	Rev BB FP	142475.00	840.00	851.51	849.52	853.56	0.001691	12.30	12903.96	1438.40	0.65
SCR	12195	Rev BB FP	142475.00	838.98	851.52	848.24	853.15	0.001176	10.57	14261.92	1389.31	0.54

HEC-RAS Plan: Exist025 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	11995	Rev BB FP	142475.00	837.00	850.66	848.45	852.83	0.001570	12.69	12550.93	1281.09	0.63
SCR	11780	Rev BB FP	142475.00	836.00	850.43	848.15	852.47	0.001415	12.50	13224.83	1400.85	0.61
SCR	11605	Rev BB FP	142475.00	835.50	849.24	847.41	852.11	0.001889	14.05	11187.38	1282.91	0.70
SCR	11405	Rev BB FP	142475.00	834.00	849.07	846.17	851.69	0.001520	13.18	11445.85	1130.21	0.64
SCR	11180	Rev BB FP	142475.00	833.00	846.89	845.65	851.10	0.002564	16.60	8864.64	835.68	0.82
SCR	11015	Rev BB FP	142475.00	831.50	844.78	844.78	850.43	0.003842	19.08	7493.10	679.39	0.99
SCR	10835	Rev BB FP	142475.00	831.00	841.87	843.71	849.32	0.007252	21.91	6502.00	790.38	1.35
SCR	10575	Rev BB FP	142475.00	830.00	837.48	840.15	846.52	0.015561	24.13	5904.16	1108.84	1.84
SCR	10390	Rev BB FP	142475.00	828.00	836.77	839.07	843.84	0.008394	22.72	7222.47	1247.06	1.37
SCR	10225	Rev BB FP	142475.00	827.50	837.04	837.97	841.97	0.006870	17.83	8045.11	1373.79	1.26
SCR	10000	Rev BB FP	142475.00	826.00	837.14	837.14	840.54	0.003943	14.90	9785.52	1488.00	0.96
SCR	9820	Rev BB FP	142475.00	824.00	833.97	835.33	839.34	0.008494	18.59	7663.39	1336.56	1.37
SCR	9595	Rev BB FP	142475.00	823.80	834.13	834.13	837.42	0.004885	14.56	9782.42	1619.67	1.00
SCR	9385	Rev BB FP	142475.00	823.00	832.49	833.19	836.23	0.006100	15.78	9290.53	1770.37	1.19
SCR	9220	Rev BB FP	142475.00	822.00	830.86	831.81	835.03	0.007826	16.39	8703.86	1771.40	1.29
SCR	9025	Rev BB FP	142475.00	821.00	829.91	830.57	833.69	0.005308	15.90	9468.27	1736.85	1.09

HEC-RAS Plan: Exist085 River: Reach #1 Reach: SCR Profile: Rev BB FP

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	46195	Rev BB FP	115111.00	1035.00	1063.12	1054.04	1064.77	0.006261	10.67	11871.29	750.83	0.40
SCR	46020	Rev BB FP	115111.00	1032.00	1062.02	1052.44	1063.64	0.006544	10.21	11277.79	570.22	0.40
SCR	45545	Rev BB FP	115111.00	1030.00	1057.85	1049.24	1059.95	0.008982	11.63	9899.97	524.21	0.47
SCR	45030	Rev BB FP	115111.00	1025.00	1054.23	1044.56	1055.89	0.006629	10.33	11145.02	557.97	0.41
SCR	44585	Rev BB FP	115111.00	1022.00	1050.60	1043.05	1052.39	0.009283	10.74	10717.84	654.38	0.47
SCR	44210	Rev BB FP	115111.00	1020.00	1047.82	1038.72	1049.37	0.006715	9.97	11549.51	619.95	0.41
SCR	43820	Rev BB FP	115111.00	1018.00	1042.08	1037.47	1045.21	0.017543	14.19	8110.90	528.66	0.64
SCR	43610	Rev BB FP	115111.00	1017.00	1038.23	1034.06	1041.46	0.018865	14.41	7990.36	536.80	0.66
SCR	43410	Rev BB FP	115111.00	1016.00	1035.79	1031.12	1038.20	0.012067	13.28	9810.14	728.75	0.55
SCR	43200	Rev BB FP	115111.00	1014.00	1033.10	1029.61	1035.55	0.014949	13.11	9560.66	778.14	0.59
SCR	42975	Rev BB FP	115111.00	1012.00	1030.64	1026.26	1032.42	0.011936	11.00	11112.26	949.35	0.52
SCR	42815	Rev BB FP	115111.00	1011.00	1029.16	1024.33	1030.46	0.009556	9.36	12874.92	1127.61	0.46
SCR	42590	Rev BB FP	115111.00	1010.00	1027.80	1021.36	1028.70	0.005956	7.80	15371.44	1205.17	0.37
SCR	42430	Rev BB FP	115111.00	1008.00	1026.93	1019.62	1027.77	0.005204	7.44	16206.52	1593.65	0.35
SCR	42215	Rev BB FP	115111.00	1006.00	1026.19	1017.68	1026.77	0.003645	6.26	20044.60	1904.81	0.29
SCR	41940	Rev BB FP	115111.00	1005.00	1025.09	1017.71	1025.71	0.004124	6.42	19333.12	2049.42	0.31
SCR	41730	Rev BB FP	115111.00	1004.00	1024.06	1016.50	1024.77	0.004683	6.87	18440.44	2164.96	0.33
SCR	41460	Rev BB FP	115111.00	1002.00	1022.64	1015.18	1023.41	0.005518	7.24	17710.12	2183.35	0.35
SCR	41280	Rev BB FP	115111.00	1001.00	1021.22	1015.33	1022.26	0.007076	8.63	16094.58	2294.98	0.40
SCR	41080	Rev BB FP	115111.00	1000.00	1019.74	1013.55	1020.85	0.006827	8.89	15634.13	2172.37	0.40
SCR	40825	Rev BB FP	115111.00	999.50	1018.37	1012.05	1019.19	0.005782	7.57	17645.24	2239.26	0.36
SCR	40585	Rev BB FP	115111.00	998.00	1017.08	1010.42	1017.84	0.005226	7.28	17989.01	2061.94	0.34
SCR	40335	Rev BB FP	115111.00	996.00	1016.13	1008.78	1016.69	0.003834	6.20	20457.69	2218.13	0.29
SCR	40130	Rev BB FP	115111.00	995.00	1015.32	1008.56	1015.88	0.003905	6.45	20672.41	2115.35	0.30
SCR	39945	Rev BB FP	115111.00	994.00	1014.62	1007.77	1015.16	0.003858	6.47	20759.36	2018.84	0.30
SCR	39755	Rev BB FP	115111.00	994.00	1013.33	1007.49	1014.22	0.005833	8.18	16831.67	1788.58	0.37
SCR	39605	Rev BB FP	115111.00	993.00	1012.55	1005.91	1013.37	0.005051	7.89	17084.59	1638.17	0.35
SCR	39310	Rev BB FP	115111.00	992.00	1011.07	1004.44	1011.82	0.004731	7.73	18174.40	1730.23	0.34
SCR	39100	Rev BB FP	115111.00	990.00	1010.28	1002.13	1010.91	0.003664	6.80	19174.54	1585.97	0.30
SCR	38925	Rev BB FP	115111.00	989.50	1009.52	1001.39	1010.21	0.004043	6.99	18003.52	1446.05	0.31
SCR	38710	Rev BB FP	115111.00	988.00	1008.51	1000.08	1009.31	0.004299	7.44	16801.26	1304.10	0.32
SCR	38475	Rev BB FP	115111.00	986.00	1006.48	999.95	1007.90	0.007873	9.88	12669.19	1018.58	0.43
SCR	38300	Rev BB FP	115111.00	985.50	1005.29	997.52	1006.56	0.006503	9.17	13133.02	960.65	0.40
SCR	38065	Rev BB FP	115111.00	984.00	1003.52	995.71	1004.95	0.007045	9.63	12273.74	874.51	0.41
SCR	37810	Rev BB FP	115111.00	983.00	1000.30	995.23	1002.47	0.012995	11.87	9947.29	823.90	0.55
SCR	37655	Rev BB FP	115111.00	982.00	998.34	994.09	1000.34	0.013555	11.43	10339.29	894.21	0.55
SCR	37390	Rev BB FP	115111.00	981.00	996.69	989.88	997.72	0.006129	8.27	14332.26	1035.91	0.38
SCR	37135	Rev BB FP	115111.00	980.00	995.19	988.63	996.12	0.005987	7.92	14972.85	1117.41	0.37
SCR	36930	Rev BB FP	115111.00	978.00	994.19	987.06	995.00	0.004805	7.46	16289.70	1209.91	0.34
SCR	36735	Rev BB FP	115111.00	977.00	993.22	986.56	994.02	0.005066	7.43	16245.29	1249.96	0.35
SCR	36515	Rev BB FP	115111.00	975.00	992.29	985.40	992.98	0.004355	6.91	17517.05	1353.36	0.32
SCR	36265	Rev BB FP	115111.00	974.00	991.10	984.77	991.81	0.005105	6.78	16998.81	1387.76	0.34
SCR	36080	Rev BB FP	116236.00	973.00	990.12	984.08	990.82	0.005500	6.74	17361.72	1498.29	0.34
SCR	35845	Rev BB FP	116236.00	971.00	988.91	982.89	989.59	0.004952	6.77	17844.10	1607.80	0.34
SCR	35725	Rev BB FP	116236.00	970.00	988.13	982.95	988.93	0.005766	7.75	16788.09	1538.48	0.37
SCR	35515	Rev BB FP	116236.00	969.00	986.78	981.76	987.67	0.006368	8.25	16123.33	1500.16	0.39
SCR	35245	Rev BB FP	116236.00	968.00	984.99	980.49	985.88	0.006898	8.13	16034.87	1580.23	0.40
SCR	35040	Rev BB FP	116236.00	967.00	983.56	978.97	984.47	0.006715	8.80	15960.86	1491.62	0.40
SCR	34860	Rev BB FP	116236.00	966.00	982.28	977.44	983.21	0.007849	7.71	15078.16	1431.69	0.42
SCR	34720	Rev BB FP	116236.00	965.50	981.27	976.17	982.13	0.007058	7.40	15699.07	1450.12	0.40
SCR	34495	Rev BB FP	116236.00	964.00	979.81	974.28	980.61	0.006439	7.20	16154.47	1462.53	0.38
SCR	34310	Rev BB FP	116236.00	963.00	978.54	973.01	979.43	0.006027	8.07	15893.00	1355.84	0.37
SCR	34090	Rev BB FP	116236.00	962.00	977.14	971.64	978.04	0.006788	7.61	15265.48	1316.20	0.39
SCR	33880	Rev BB FP	116236.00	960.00	975.73	970.46	976.59	0.006962	7.46	15582.75	1451.55	0.40
SCR	33710	Rev BB FP	116236.00	959.00	974.64	969.23	975.40	0.006435	6.97	16665.52	1616.75	0.38
SCR	33500	Rev BB FP	116236.00	958.00	973.40	968.41	974.09	0.005844	7.08	17819.12	1720.16	0.36
SCR	33310	Rev BB FP	116236.00	957.00	972.42	967.01	973.03	0.005153	6.27	18547.85	1783.33	0.34
SCR	33115	Rev BB FP	116236.00	956.00	971.47	965.60	972.01	0.004945	5.92	19667.02	1895.57	0.32
SCR	32795	Rev BB FP	116236.00	954.00	969.69	964.63	970.32	0.005717	6.40	18225.40	1917.68	0.36
SCR	32605	Rev BB FP	116236.00	952.00	968.69	963.45	969.24	0.005196	6.07	20132.55	2407.26	0.34
SCR	32265	Rev BB FP	140776.00	950.00	967.14	961.37	967.61	0.004485	5.50	25619.94	2839.88	0.32
SCR	31875	Rev BB FP	140776.00	949.00	965.55	960.00	965.98	0.003821	5.24	27028.75	2630.09	0.28
SCR	31585	Rev BB FP	140776.00	946.00	964.67	956.96	965.05	0.002681	4.95	28485.89	2405.38	0.25
SCR	31360	Rev BB FP	140776.00	944.00	963.99	955.41	964.44	0.002664	5.44	26576.91	1962.49	0.25
SCR	31060	Rev BB FP	140776.00	942.00	963.32	953.29	963.71	0.002122	5.02	28168.09	2195.09	0.24
SCR	30720	Rev BB FP	140776.00	940.00	962.76	951.33	963.08	0.001535	4.52	31325.84	2122.23	0.20
SCR	30445	Rev BB FP	140776.00	938.00	962.37	949.57	962.68	0.001361	4.49	32047.45	2314.72	0.19
SCR	30095	Rev BB FP	140776.00	936.00	961.79	947.93	962.18	0.001460	5.12	30221.52	2339.56	0.20
SCR	29815	Rev BB FP	140776.00	935.00	961.20	948.10	961.71	0.001932	5.96	27202.58	2243.56	0.23
SCR	29565	Rev BB FP	140776.00	934.00	960.71	947.27	961.22	0.001942	5.88	26958.88	2280.34	0.23
SCR	29385	Rev BB FP	140776.00	933.00	960.13	948.97	960.79	0.002694	6.78	24110.69	2215.01	0.27
SCR	29140	Rev BB FP	140776.00	932.00	958.97	950.98	959.94	0.004808	8.05	19093.65	1894.25	0.36
SCR	28895	Rev BB FP	140776.00	930.00	955.75	952.39	958.06	0.011883	14.28	13601.27	1544.41	0.55
SCR	28695	Rev BB FP	140776.00	928.00	954.27	947.96	955.72	0.009038	9.67	14565.01	1446.39	0.54
SCR	28500	Rev BB FP	140776.00	927.50	952.08	945.08	953.95	0.008598	11.42	14381.67	1474.34	0.47
SCR	28280	Rev BB FP	140776.00	926.00	950.52	941.85	952.30	0.006462	11.35	15008.82	1365.30	0.42
SCR	28080	Rev BB FP	140776.00	925.00	949.28	940.04	951.00	0.006263	10.94	14982.78	1251.50	0.41
SCR	27925	Rev BB FP	140776.00	924.00	947.70	939.47	949.86	0.007984	12.13	13253.13	1194.87	0.46

HEC-RAS Plan: Exist085 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	27725	Rev BB FP	140776.00	923.00	945.26	939.31	947.94	0.010900	13.69	11869.05	1095.99	0.53
SCR	27545	Rev BB FP	140776.00	922.00	943.64	937.81	945.96	0.010086	12.76	12472.57	1144.65	0.51
SCR	27335	Rev BB FP	140776.00	921.00	942.09	936.26	943.91	0.008367	11.43	13966.56	1090.51	0.46
SCR	27155	Rev BB FP	140776.00	920.50	940.45	935.90	942.27	0.009256	11.73	14150.62	1201.24	0.48
SCR	26990	Rev BB FP	140776.00	920.00	939.34	933.85	940.67	0.008023	9.51	15709.68	1279.99	0.44
SCR	26780	Rev BB FP	140776.00	918.00	938.08	931.73	939.15	0.005879	8.93	17692.21	1339.59	0.38
SCR	26575	Rev BB FP	140776.00	917.00	936.99	929.98	937.93	0.005756	7.85	18224.55	1342.33	0.36
SCR	26355	Rev BB FP	140776.00	916.00	935.58	929.42	936.61	0.006173	8.54	17754.09	1376.67	0.39
SCR	26170	Rev BB FP	140776.00	915.00	934.47	928.71	935.49	0.006034	8.90	18074.60	1385.31	0.38
SCR	25965	Rev BB FP	140776.00	914.00	932.91	927.74	934.11	0.007349	9.58	16859.15	1407.92	0.42
SCR	25785	Rev BB FP	140776.00	913.50	931.49	926.55	932.67	0.007808	9.64	17323.82	1620.23	0.43
SCR	25600	Rev BB FP	140776.00	912.50	930.39	925.47	931.28	0.006236	8.59	19924.65	1924.40	0.39
SCR	25425	Rev BB FP	140776.00	911.00	929.54	924.28	930.20	0.005044	7.06	22168.16	2056.40	0.34
SCR	25215	Rev BB FP	140776.00	910.00	927.82	923.53	928.79	0.008126	8.48	18780.94	2121.76	0.43
SCR	25000	Rev BB FP	140776.00	909.00	926.32	922.50	927.11	0.006991	7.83	20977.36	2377.04	0.40
SCR	24795	Rev BB FP	140776.00	908.00	924.94	920.87	925.64	0.006301	7.42	21853.30	2329.84	0.38
SCR	24550	Rev BB FP	140776.00	906.00	923.85	918.41	924.38	0.004427	6.44	24258.73	2252.87	0.32
SCR	24335	Rev BB FP	140776.00	905.00	922.58	918.12	923.30	0.006264	7.63	21215.25	2105.65	0.38
SCR	24115	Rev BB FP	140776.00	904.00	921.37	916.28	922.04	0.005674	7.22	21770.86	2035.28	0.35
SCR	23975	Rev BB FP	140776.00	903.50	920.41	914.88	921.07	0.005319	7.00	21786.51	1940.51	0.35
SCR	23755	Rev BB FP	140776.00	902.00	919.31	913.54	919.93	0.004854	6.81	22570.77	2021.77	0.33
SCR	23565	Rev BB FP	140776.00	900.00	918.41	912.73	919.00	0.004714	6.64	23145.30	2111.49	0.33
SCR	23365	Rev BB FP	140776.00	900.00	917.59	911.37	918.13	0.004130	6.49	24160.49	2110.81	0.31
SCR	23180	Rev BB FP	140776.00	899.00	916.98	909.87	917.43	0.002980	6.28	26872.75	2188.46	0.27
SCR	23000	Rev BB FP	140776.00	898.00	916.50	908.40	916.91	0.002668	5.18	27717.50	2208.07	0.25
SCR	22790	Rev BB FP	140776.00	897.50	915.82	908.15	916.30	0.003103	5.58	25614.63	2052.66	0.27
SCR	22600	Rev BB FP	140776.00	896.00	915.10	907.78	915.65	0.003568	6.61	24212.95	1944.52	0.30
SCR	22415	Rev BB FP	140776.00	895.50	914.24	907.11	914.91	0.004404	7.19	22223.89	1868.49	0.33
SCR	22195	Rev BB FP	141426.00	894.00	912.53	906.79	913.67	0.007227	8.75	17295.44	1597.29	0.42
SCR	22010	Rev BB FP	141426.00	892.00	910.70	906.38	912.13	0.009118	10.16	15737.52	1819.81	0.47
SCR	21790	Rev BB FP	141426.00	891.50	908.38	904.87	909.95	0.010764	10.65	15383.26	2121.00	0.50
SCR	21615	Rev BB FP	141426.00	892.00	907.07	903.04	908.13	0.008280	8.76	18572.14	2207.92	0.44
SCR	21440	Rev BB FP	141426.00	890.00	905.72	901.59	906.68	0.007672	8.62	19330.02	2168.70	0.42
SCR	21225	Rev BB FP	141426.00	888.00	904.25	900.27	905.04	0.007187	8.16	22063.44	2868.73	0.40
SCR	21020	Rev BB FP	141426.00	887.00	903.17	897.78	903.78	0.004839	7.21	24970.26	2894.26	0.33
SCR	20845	Rev BB FP	141426.00	886.00	902.34	897.38	902.89	0.004944	6.90	25539.38	2955.11	0.34
SCR	20595	Rev BB FP	141426.00	885.00	901.14	896.42	901.71	0.004763	7.07	25535.02	2931.69	0.33
SCR	20435	Rev BB FP	141426.00	884.00	900.30	895.77	900.90	0.005083	7.27	24746.88	2825.53	0.34
SCR	20280	Rev BB FP	141426.00	883.70	899.33	895.55	899.99	0.006412	7.64	23039.58	2730.97	0.38
SCR	20070	Rev BB FP	141426.00	882.00	898.37	893.00	898.90	0.004321	6.63	25460.53	2597.82	0.31
SCR	19855	Rev BB FP	141426.00	880.50	897.57	891.50	898.03	0.003550	6.27	27221.95	2688.90	0.29
SCR	19630	Rev BB FP	141426.00	880.00	896.84	890.05	897.28	0.003165	6.01	28170.25	2778.54	0.27
SCR	19440	Rev BB FP	141426.00	878.00	896.29	889.11	896.70	0.002745	5.70	29140.07	2906.48	0.26
SCR	19240	Rev BB FP	141426.00	877.50	895.68	888.88	896.12	0.003010	5.84	27751.57	2599.60	0.27
SCR	19050	Rev BB FP	141426.00	876.00	895.20	887.51	895.59	0.002518	5.36	29006.32	2425.30	0.25
SCR	18830	Rev BB FP	141426.00	874.00	894.61	886.80	895.03	0.002641	5.53	27892.40	2225.08	0.25
SCR	18650	Rev BB FP	141426.00	873.50	894.15	886.00	894.58	0.002435	5.66	27923.98	2093.66	0.25
SCR	18475	Rev BB FP	141426.00	872.00	893.77	884.72	894.16	0.002201	5.13	28384.30	1978.73	0.23
SCR	18290	Rev BB FP	141426.00	871.50	893.26	884.54	893.72	0.002543	5.62	26476.96	1877.78	0.25
SCR	18025	Rev BB FP	141426.00	870.00	892.57	882.91	893.05	0.002398	5.66	25578.77	1642.50	0.25
SCR	17785	Rev BB FP	141426.00	868.00	891.70	882.82	892.35	0.003488	6.51	22017.32	1458.06	0.29
SCR	17510	Rev BB FP	141426.00	867.50	889.57	883.72	890.92	0.007690	9.58	15878.49	1354.91	0.44
SCR	17360	Rev BB FP	141426.00	866.50	887.45	883.40	889.41	0.012589	11.39	13139.27	1272.15	0.55
SCR	17110	Rev BB FP	141426.00	864.00	884.24	881.59	886.16	0.013233	11.94	13804.07	1428.48	0.56
SCR	16970	Rev BB FP	141426.00	863.70	881.85	880.06	883.98	0.016799	12.41	13059.54	1534.19	0.63
SCR	16720	Rev BB FP	141426.00	863.50	879.51	875.45	880.65	0.009318	8.94	17147.30	1726.61	0.46
SCR	16515	Rev BB FP	141426.00	862.00	878.00	873.72	878.88	0.007623	7.94	19233.76	1934.26	0.41
SCR	16305	Rev BB FP	141426.00	860.00	876.79	871.44	877.46	0.005570	7.17	22049.88	2111.77	0.36
SCR	16130	Rev BB FP	141426.00	860.00	875.68	870.71	876.37	0.006258	7.02	21366.03	2125.00	0.38
SCR	15960	Rev BB FP	141426.00	859.00	874.73	869.21	875.30	0.005341	6.12	23312.65	2250.07	0.33
SCR	15745	Rev BB FP	141426.00	858.00	873.76	867.77	874.26	0.004319	5.66	24841.35	2297.25	0.31
SCR	15540	Rev BB FP	141426.00	857.50	872.83	867.17	873.34	0.004545	5.91	24661.45	2348.37	0.32
SCR	15335	Rev BB FP	141426.00	856.00	871.75	866.50	872.32	0.005341	6.09	23340.41	2337.46	0.34
SCR	15125	Rev BB FP	142475.00	854.00	870.49	864.50	871.17	0.005517	6.68	21922.78	2195.20	0.35
SCR	14900	Rev BB FP	142475.00	853.00	869.11	863.42	869.84	0.006090	7.34	21835.14	2363.67	0.37
SCR	14720	Rev BB FP	142475.00	852.00	868.11	862.17	868.79	0.005661	7.00	22080.85	2123.96	0.35
SCR	14480	Rev BB FP	142475.00	850.50	866.84	860.73	867.50	0.005032	6.80	22113.92	1903.92	0.33
SCR	14315	Rev BB FP	142475.00	850.00	866.05	859.82	866.68	0.004845	6.37	22413.72	1938.14	0.33
SCR	14090	Rev BB FP	142475.00	849.71	864.84	858.67	865.53	0.005192	6.69	21422.24	1813.83	0.34
SCR	13850	Rev BB FP	142475.00	848.00	863.69	857.11	864.36	0.004758	6.57	21800.31	1769.55	0.33
SCR	13635	Rev BB FP	142475.00	846.00	862.65	856.32	863.33	0.004705	7.28	21990.27	1806.91	0.33
SCR	13425	Rev BB FP	142475.00	845.00	861.91	854.58	862.43	0.003526	5.80	24660.66	1936.16	0.28
SCR	13190	Rev BB FP	142475.00	844.00	861.23	852.81	861.68	0.002766	5.48	26772.91	2028.03	0.25
SCR	13030	Rev BB FP	142475.00	843.00	860.75	852.27	861.22	0.002892	6.09	26656.37	2060.86	0.26
SCR	12835	Rev BB FP	142475.00	842.00	860.14	851.23	860.64	0.002947	6.23	26293.16	2064.81	0.27
SCR	12615	Rev BB FP	142475.00	841.00	859.40	850.08	859.97	0.003127	6.72	24621.62	1866.17	0.28
SCR	12395	Rev BB FP	142475.00	840.00	858.68	849.52	859.30	0.003225	6.93	23816.79	1753.66	0.28
SCR	12195	Rev BB FP	142475.00	838.98	858.07	848.24	858.68	0.002883	6.53	23531.59	1569.29	0.27

HEC-RAS Plan: Exist085 River: Reach #1 Reach: SCR Profile: Rev BB FP (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SCR	11995	Rev BB FP	142475.00	837.00	857.33	848.45	858.03	0.003457	7.35	21781.52	1445.69	0.30
SCR	11780	Rev BB FP	142475.00	836.00	856.60	848.15	857.30	0.003393	7.35	22101.86	1459.15	0.29
SCR	11605	Rev BB FP	142475.00	835.50	855.77	847.41	856.63	0.004096	8.01	20215.42	1423.31	0.32
SCR	11405	Rev BB FP	142475.00	834.00	854.64	846.17	855.71	0.004789	8.61	17818.79	1156.11	0.35
SCR	11180	Rev BB FP	142475.00	833.00	852.65	845.62	854.33	0.007767	10.74	14423.92	1022.07	0.44
SCR	11015	Rev BB FP	142475.00	831.50	850.24	844.78	852.64	0.011974	12.57	11808.85	850.99	0.54
SCR	10835	Rev BB FP	142475.00	831.00	848.06	843.71	850.34	0.013460	12.24	12146.95	1068.77	0.57
SCR	10575	Rev BB FP	142475.00	830.00	846.12	840.16	847.40	0.007982	9.13	15863.63	1311.49	0.43
SCR	10390	Rev BB FP	142475.00	828.00	845.08	839.07	846.06	0.005761	8.70	18840.71	1492.14	0.37
SCR	10225	Rev BB FP	142475.00	827.50	844.10	838.16	845.05	0.006398	7.95	18566.19	1545.15	0.38
SCR	10000	Rev BB FP	142475.00	826.00	842.55	837.14	843.54	0.006984	8.14	18351.28	1626.01	0.40
SCR	9820	Rev BB FP	142475.00	824.00	841.35	835.33	842.31	0.006527	7.91	18387.28	1648.84	0.39
SCR	9595	Rev BB FP	142475.00	823.80	839.87	834.13	840.80	0.006938	7.76	18438.71	1719.61	0.39
SCR	9385	Rev BB FP	142475.00	823.00	838.58	833.19	839.36	0.006233	7.21	20157.16	1799.30	0.37
SCR	9220	Rev BB FP	142475.00	822.00	837.62	831.80	838.34	0.005586	6.82	21094.14	1853.43	0.35
SCR	9025	Rev BB FP	142475.00	821.00	836.62	830.57	837.33	0.005004	7.02	21529.03	1822.90	0.34

Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.2

Proposed Condition HEC-RAS Output

Plan	***Description***
FinalProp025	***Fluvial Model, Proposed Conditions, n=0.025, subcritical flow***
FinalProp085	***Fluvial Model, Proposed Conditions, n=0.085, subcritical flow***
Pr025LevCode	***Approved Model, Proposed Conditions, n=0.025, mixed flow***
Pr085LevCode	***Approved Model, Proposed Conditions, n=0.085, mixed flow***
FinalPr085Q2	***Approved Model, Proposed Conditions, n=0.085, mixed flow***

HEC-RAS model modified for fluvial use. See section 4.1.1B for model assembly. For unmodified, mixed flow regimes used in report, refer also to HEC-RAS Modeling Report prepared by PACE, concurrently submitted to LACDPW.

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

HEC-RAS Plan: FinalProp025 River: SCR Reach: Project Profile: Rev BB

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	46195	Rev BB	115111.00	1035.00	1054.30	1054.30	1060.32	0.004006	19.69	5847.54	483.37	1.00
Project	46020	Rev BB	115111.00	1032.00	1052.44	1052.44	1058.13	0.004154	19.14	6013.48	531.51	1.00
Project	45545	Rev BB	115111.00	1030.00	1049.24	1049.24	1055.65	0.004022	20.32	5664.17	446.75	1.01
Project	45030	Rev BB	115111.00	1025.00	1045.55	1044.56	1050.46	0.003177	17.78	6472.44	521.46	0.89
Project	44585	Rev BB	115111.00	1022.00	1043.05	1043.05	1048.75	0.004190	19.17	6004.20	531.91	1.01
Project	44210	Rev BB	115111.00	1020.00	1041.58	1038.72	1044.97	0.001990	14.77	7793.25	585.85	0.71
Project	43820	Rev BB	115111.00	1018.00	1037.47	1037.47	1043.62	0.004072	19.90	5785.10	476.52	1.01
Project	43610	Rev BB	115111.00	1017.00	1034.08	1034.08	1040.13	0.004047	19.74	5832.04	483.67	1.00
Project	43410	Rev BB	115111.00	1016.00	1030.73	1030.73	1035.85	0.004279	18.14	6344.39	623.58	1.00
Project	43200	Rev BB	115111.00	1014.00	1029.33	1029.33	1033.92	0.004457	17.19	6697.33	738.00	1.01
Project	42975	Rev BB	115111.00	1012.00	1026.13	1026.13	1030.25	0.004579	16.29	7064.89	860.57	1.00
Project	42815	Rev BB	115111.00	1011.00	1024.36	1024.36	1028.02	0.004808	15.35	7496.97	1037.15	1.01
Project	42590	Rev BB	115111.00	1010.00	1021.50	1021.50	1025.01	0.004851	15.05	7649.36	1098.81	1.01
Project	42430	Rev BB	115111.00	1008.00	1020.26	1020.26	1024.03	0.004681	15.58	7396.51	1011.86	1.00
Project	42215	Rev BB	115111.00	1006.00	1019.73	1018.65	1022.25	0.003063	12.73	9040.32	1182.74	0.81
Project	41940	Rev BB	115111.00	1005.00	1019.28	1017.68	1021.36	0.002488	11.57	9945.28	1284.28	0.73
Project	41730	Rev BB	115111.00	1004.00	1018.65	1016.46	1020.82	0.002417	11.83	9727.36	1189.05	0.73
Project	41460	Rev BB	115111.00	1002.00	1018.12	1015.18	1020.22	0.001971	11.65	9876.94	1057.29	0.67
Project	41280	Rev BB	115111.00	1001.00	1015.34	1015.34	1019.50	0.004582	16.37	7032.47	852.22	1.00
Project	41080	Rev BB	115111.00	1000.00	1013.58	1013.58	1017.58	0.004593	16.04	7175.77	899.51	1.00
Project	40825	Rev BB	115111.00	999.50	1012.10	1012.10	1015.60	0.004938	15.00	7673.93	1122.98	1.01
Project	40585	Rev BB	115111.00	998.00	1010.59	1010.59	1014.03	0.004892	14.87	7741.09	1139.82	1.01
Project	40335	Rev BB	115111.00	996.00	1010.95	1008.70	1012.73	0.001840	10.69	10770.98	1248.81	0.64
Project	40130	Rev BB	115111.00	995.00	1010.41	1008.27	1012.32	0.001960	11.09	10380.24	1194.95	0.66
Project	39945	Rev BB	115111.00	994.00	1010.17	1007.59	1011.94	0.001684	10.67	10785.01	1172.47	0.62
Project	39755	Rev BB	115111.00	994.00	1007.18	1007.18	1011.21	0.004631	16.12	7140.66	893.31	1.00
Project	39605	Rev BB	115111.00	993.00	1005.78	1005.78	1009.87	0.004594	16.23	7091.77	873.24	1.00
Project	39310	Rev BB	115111.00	992.00	1004.36	1004.36	1008.29	0.004683	15.92	7232.22	929.34	1.01
Project	39100	Rev BB	115111.00	990.00	1003.74	1002.09	1006.89	0.002587	14.23	8088.07	788.26	0.78
Project	38925	Rev BB	115111.00	989.50	1003.74	1001.54	1006.30	0.002114	12.85	8958.42	873.34	0.71
Project	38710	Rev BB	115111.00	988.00	1003.55	1000.32	1005.82	0.001584	12.07	9534.83	820.16	0.62
Project	38475	Rev BB	115111.00	986.00	1000.04	1000.04	1004.98	0.004338	17.83	6455.50	659.76	1.00
Project	38300	Rev BB	115111.00	985.50	997.87	997.87	1002.71	0.004334	17.65	6520.77	677.19	1.00
Project	38065	Rev BB	115111.00	984.00	998.04	995.74	1001.32	0.002212	14.54	7917.91	658.42	0.74
Project	37810	Rev BB	115111.00	983.00	995.22	995.22	1000.37	0.004276	18.21	6321.28	618.24	1.00
Project	37655	Rev BB	115111.00	982.00	994.10	994.10	998.80	0.004442	17.39	6619.75	713.56	1.01
Project	37390	Rev BB	115111.00	981.00	991.46	990.10	994.58	0.002779	14.17	8124.66	840.59	0.80
Project	37135	Rev BB	115111.00	980.00	989.31	989.31	993.58	0.004549	16.58	6941.62	821.44	1.01
Project	36930	Rev BB	115111.00	978.00	987.92	987.46	991.71	0.003820	15.63	7364.69	834.69	0.93
Project	36735	Rev BB	115111.00	977.00	986.85	986.85	990.85	0.004582	16.06	7167.57	896.97	1.00
Project	36515	Rev BB	115111.00	975.00	987.04	985.39	989.58	0.002466	12.79	8997.40	994.80	0.75
Project	36265	Rev BB	115111.00	974.00	986.48	985.22	988.84	0.003073	12.33	9335.36	1176.00	0.77
Project	36080	Rev BB	116236.00	973.00	984.63	984.63	987.98	0.005710	14.69	7914.07	1176.00	1.00
Project	35845	Rev BB	116236.00	971.00	984.09	982.87	986.24	0.002731	11.74	9897.11	1385.15	0.76
Project	35725	Rev BB	116236.00	970.00	982.61	982.61	985.70	0.004997	14.11	8236.80	1374.87	1.00
Project	35515	Rev BB	116236.00	969.00	981.34	981.34	984.38	0.003984	14.00	8305.35	1363.56	1.00
Project	35245	Rev BB	116236.00	968.00	980.17	980.17	983.10	0.005053	13.71	8476.11	1553.65	1.00
Project	35040	Rev BB	116236.00	967.00	978.33	978.33	981.35	0.005109	13.94	8335.53	1400.46	1.01
Project	34860	Rev BB	116236.00	966.00	977.40	977.40	980.48	0.004124	14.07	8261.68	1362.38	1.01
Project	34720	Rev BB	116236.00	965.50	976.17	976.17	979.16	0.004168	13.87	8382.56	1419.56	1.01
Project	34495	Rev BB	116236.00	964.00	974.28	974.28	977.32	0.004209	13.98	8314.11	1380.43	1.00
Project	34310	Rev BB	116236.00	963.00	972.64	972.64	975.81	0.005099	14.28	8141.11	1311.42	1.01
Project	34090	Rev BB	116236.00	962.00	971.59	971.59	974.73	0.004069	14.21	8178.26	1312.61	1.00
Project	33880	Rev BB	116236.00	960.00	970.25	970.25	973.34	0.004192	14.12	8232.70	1343.51	1.01
Project	33710	Rev BB	116236.00	959.00	969.25	969.25	972.29	0.004184	14.00	8301.62	1377.88	1.01
Project	33500	Rev BB	116236.00	958.00	968.06	968.06	970.72	0.005489	13.08	8884.50	1720.67	1.01
Project	33310	Rev BB	116236.00	957.00	966.96	966.96	969.53	0.003818	12.88	9026.38	1780.29	1.01
Project	33115	Rev BB	116236.00	956.00	966.60	965.32	968.27	0.002770	10.36	11217.64	1847.27	0.74
Project	32795	Rev BB	116236.00	954.00	964.56	964.56	967.18	0.003570	12.99	8949.41	1735.59	1.01
Project	32605	Rev BB	116236.00	952.00	963.61	963.61	966.27	0.003728	13.08	8889.37	1766.10	1.00
Project	32265	Rev BB	140776.00	950.00	961.33	961.33	964.12	0.004082	13.40	10505.64	1941.10	1.02
Project	31875	Rev BB	140776.00	949.00	959.38	959.38	961.76	0.005507	12.38	11368.08	2409.14	1.00
Project	31585	Rev BB	140776.00	946.00	957.27	956.99	959.54	0.004462	12.10	11630.56	2178.50	0.92
Project	31360	Rev BB	140776.00	944.00	956.57	955.40	958.64	0.003098	11.54	12197.85	1866.19	0.80
Project	31060	Rev BB	140776.00	942.00	956.59	953.29	957.85	0.001200	9.01	15628.46	1701.29	0.52
Project	30720	Rev BB	140776.00	940.00	956.60	951.33	957.42	0.000665	7.25	19427.36	1882.31	0.40
Project	30445	Rev BB	140776.00	938.00	956.52	949.57	957.23	0.000483	6.75	20869.51	1771.80	0.35
Project	30095	Rev BB	140776.00	936.00	956.31	947.93	957.06	0.000474	6.95	20255.18	1619.47	0.35
Project	29815	Rev BB	140776.00	935.00	955.93	948.10	956.89	0.000611	7.87	17894.76	1430.05	0.39
Project	29565	Rev BB	140776.00	934.00	955.81	947.31	956.74	0.000520	7.74	18197.69	1320.30	0.37
Project	29385	Rev BB	140776.00	933.00	955.46	949.39	956.61	0.000672	8.60	16378.75	1233.03	0.42
Project	29140	Rev BB	140776.00	932.00	954.76	949.95	956.37	0.000994	10.18	13831.13	1082.52	0.50
Project	28895	Rev BB	140776.00	930.00	951.29	951.29	955.65	0.004486	16.75	8406.99	966.73	1.00
Project	28695	Rev BB	140776.00	928.00	948.27	945.72	951.01	0.001962	13.28	10604.18	929.93	0.69

HEC-RAS Plan: FinalProp025 River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	28500	Rev BB	140776.00	927.50	945.99	945.99	950.30	0.004557	16.65	8456.66	998.18	1.01
Project	28280	Rev BB	140776.00	926.00	943.37	939.86	945.58	0.001474	11.94	11789.80	976.23	0.61
Project	28080	Rev BB	140776.00	925.00	943.39	938.17	945.23	0.001004	10.88	12937.54	923.44	0.51
Project	27925	Rev BB	140776.00	924.00	942.60	938.71	944.99	0.001424	12.41	11347.95	863.96	0.60
Project	27725	Rev BB	140776.00	923.00	939.26	939.26	944.27	0.004292	17.96	7836.66	784.78	1.00
Project	27545	Rev BB	140776.00	922.00	937.62	937.62	943.27	0.004131	19.08	7378.13	656.25	1.00
Project	27335	Rev BB	140776.00	921.00	936.15	936.15	940.86	0.004392	17.42	8079.14	865.36	1.00
Project	27155	Rev BB	140776.00	920.50	935.27	935.27	939.88	0.004380	17.23	8170.77	888.23	1.00
Project	26990	Rev BB	140776.00	920.00	933.70	933.70	938.05	0.004510	16.73	8413.85	976.89	1.00
Project	26780	Rev BB	140776.00	918.00	931.32	931.32	935.44	0.004591	16.27	8650.56	1062.31	1.00
Project	26575	Rev BB	140776.00	917.00	930.42	929.95	933.79	0.003886	14.72	9560.94	1203.73	0.92
Project	26355	Rev BB	140776.00	916.00	929.13	929.13	932.81	0.004778	15.40	9144.23	1256.77	1.01
Project	26170	Rev BB	140776.00	915.00	928.17	928.16	931.80	0.004729	15.28	9212.38	1267.86	1.00
Project	25965	Rev BB	140776.00	914.00	927.26	927.21	930.82	0.004663	15.15	9292.56	1281.80	0.99
Project	25785	Rev BB	140776.00	913.50	926.78	926.18	929.97	0.003660	14.35	9809.35	1224.04	0.89
Project	25600	Rev BB	140776.00	912.50	925.76	925.21	929.25	0.003734	15.00	9384.78	1112.87	0.91
Project	25425	Rev BB	140776.00	911.00	925.28	924.40	928.57	0.003288	14.56	9667.52	1090.05	0.86
Project	25215	Rev BB	140776.00	910.00	924.72	923.65	927.87	0.003073	14.23	9894.10	1097.30	0.84
Project	25000	Rev BB	140776.00	909.00	924.47	922.49	927.15	0.002252	13.13	10725.52	1062.40	0.73
Project	24795	Rev BB	140776.00	908.00	923.60	921.79	926.64	0.002430	13.99	10061.45	957.43	0.76
Project	24550	Rev BB	140776.00	906.00	922.49	920.91	925.97	0.002629	14.97	9403.51	856.09	0.80
Project	24335	Rev BB	140776.00	905.00	920.03	920.03	925.11	0.004254	18.10	7779.37	764.96	1.00
Project	24115	Rev BB	140776.00	904.00	918.66	918.66	923.80	0.004273	18.20	7736.79	757.86	1.00
Project	23975	Rev BB	140776.00	903.50	917.68	917.68	922.69	0.004306	17.96	7837.58	789.45	1.00
Project	23755	Rev BB	140776.00	902.00	916.75	916.75	921.65	0.004327	17.75	7930.29	816.51	1.00
Project	23565	Rev BB	140776.00	900.00	915.57	915.57	920.26	0.004363	17.38	8100.02	867.04	1.00
Project	23365	Rev BB	140776.00	900.00	914.40	914.40	918.85	0.004458	16.92	8320.34	939.52	1.00
Project	23180	Rev BB	140776.00	899.00	913.20	912.61	917.17	0.003607	15.99	8806.14	926.00	0.91
Project	23000	Rev BB	140776.00	898.00	912.81	911.12	916.46	0.003290	15.34	9177.96	784.00	0.79
Project	22790	Rev BB	140776.00	897.50	910.47	910.47	915.48	0.005111	17.96	7838.51	784.00	1.00
Project	22600	Rev BB	140776.00	896.00	909.60	909.60	913.89	0.004591	16.62	8469.77	1007.62	1.01
Project	22415	Rev BB	140776.00	895.50	907.97	907.97	912.10	0.004576	16.31	8630.14	1052.83	1.00
Project	22195	Rev BB	141426.00	894.00	907.47	906.87	910.61	0.003724	14.21	9951.36	1281.58	0.90
Project	22010	Rev BB	141426.00	892.00	906.10	906.10	909.78	0.004698	15.38	9195.89	1252.29	1.00
Project	21790	Rev BB	141426.00	891.50	904.77	904.77	908.11	0.004855	14.67	9642.87	1507.80	1.00
Project	21615	Rev BB	141426.00	892.00	902.80	902.80	906.20	0.004803	14.80	9557.40	1401.11	1.00
Project	21440	Rev BB	141426.00	890.00	901.57	901.57	905.07	0.004769	15.01	9424.54	1342.59	1.00
Project	21225	Rev BB	141426.00	888.00	900.52	900.52	903.69	0.004968	14.30	9886.64	1563.91	1.00
Project	21020	Rev BB	141426.00	887.00	899.97	898.94	902.33	0.003046	12.34	11464.58	1568.45	0.80
Project	20845	Rev BB	141426.00	886.00	898.39	898.39	901.57	0.004961	14.31	9883.42	1561.02	1.00
Project	20595	Rev BB	141426.00	885.00	898.33	896.46	900.25	0.002128	11.13	12703.95	1548.09	0.68
Project	20435	Rev BB	141426.00	884.00	898.08	895.80	899.89	0.001872	10.78	13124.39	1524.83	0.65
Project	20280	Rev BB	141426.00	883.70	896.01	896.01	899.29	0.005069	14.53	9735.55	1527.35	1.01
Project	20070	Rev BB	141426.00	882.00	894.29	894.29	897.53	0.005010	14.44	9793.63	1537.65	1.01
Project	19855	Rev BB	141426.00	880.50	892.65	892.65	895.81	0.005043	14.26	9916.93	1593.11	1.01
Project	19630	Rev BB	141426.00	880.00	891.48	890.46	894.67	0.003143	14.35	9854.55	1098.59	0.84
Project	19440	Rev BB	141426.00	878.00	891.37	889.68	893.96	0.002469	12.92	10950.06	1194.62	0.75
Project	19240	Rev BB	141426.00	877.50	889.40	889.40	893.18	0.004749	15.60	9068.42	1219.41	1.01
Project	19050	Rev BB	141426.00	876.00	889.38	887.89	891.70	0.002632	12.21	11580.60	1442.64	0.76
Project	18830	Rev BB	141426.00	874.00	888.82	887.50	891.10	0.002798	12.12	11667.44	1538.23	0.78
Project	18650	Rev BB	141426.00	873.50	888.72	886.68	890.53	0.002006	10.78	13119.62	1607.26	0.66
Project	18475	Rev BB	141426.00	872.00	888.91	885.02	890.10	0.001016	8.76	16151.21	1621.67	0.49
Project	18290	Rev BB	141426.00	871.50	888.50	885.07	889.87	0.001262	9.40	15041.49	1594.70	0.54
Project	18025	Rev BB	141426.00	870.00	888.57	882.91	889.51	0.000633	7.79	18154.44	1520.48	0.40
Project	17785	Rev BB	141426.00	868.00	888.25	882.79	889.34	0.000722	8.38	16870.97	1398.41	0.43
Project	17510	Rev BB	141426.00	868.00	887.46	883.42	889.03	0.001273	10.07	14045.60	1353.64	0.55
Project	17360	Rev BB	141426.00	868.00	883.98	883.98	888.42	0.004472	16.91	8364.98	944.54	1.00
Project	17110	Rev BB	141426.00	864.00	881.08	881.08	884.88	0.004682	15.65	9039.19	1191.88	1.00
Project	16970	Rev BB	141426.00	863.70	879.57	879.57	883.40	0.004698	15.72	8997.01	1180.24	1.00
Project	16720	Rev BB	141426.00	863.50	875.41	875.41	879.35	0.004709	15.94	8873.56	1146.54	1.01
Project	16515	Rev BB	141426.00	862.00	873.88	873.85	877.54	0.004720	15.36	9209.61	1259.97	1.00
Project	16305	Rev BB	141426.00	860.00	874.53	872.03	876.44	0.001769	11.08	12765.90	1360.42	0.64
Project	16130	Rev BB	141426.00	860.00	872.23	872.23	875.79	0.004840	15.15	9332.88	1325.97	1.01
Project	15960	Rev BB	141426.00	859.00	871.57	870.96	874.47	0.003673	13.67	10347.30	1395.60	0.88
Project	15745	Rev BB	141426.00	858.00	871.32	869.77	873.67	0.002505	12.30	11500.92	1363.87	0.75
Project	15540	Rev BB	141426.00	857.50	871.22	868.50	872.95	0.001594	10.54	13415.28	1426.97	0.61
Project	15335	Rev BB	141426.00	856.00	868.08	868.08	872.16	0.005518	16.21	8723.27	1064.14	1.00
Project	15125	Rev BB	142475.00	854.00	866.25	866.25	870.52	0.005571	16.58	8594.49	1005.21	1.00
Project	14900	Rev BB	142475.00	853.00	864.18	864.18	868.31	0.004518	16.29	8744.60	1681.96	1.00
Project	14720	Rev BB	142475.00	852.00	863.25	863.25	867.16	0.004589	15.87	8988.33	1754.84	1.00
Project	14480	Rev BB	142475.00	850.50	860.78	860.75	864.04	0.004765	14.50	9824.86	1761.86	0.99
Project	14315	Rev BB	142475.00	850.00	860.12	860.12	863.17	0.004972	14.01	10170.99	1883.64	1.00
Project	14090	Rev BB	142475.00	850.00	858.71	858.71	861.64	0.005088	13.74	10369.15	1774.74	1.00
Project	13850	Rev BB	142475.00	848.00	857.10	857.10	860.08	0.005085	13.85	10284.52	1738.35	1.00

HEC-RAS Plan: FinalProp025 River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	13635	Rev BB	142475.00	846.00	855.96	855.96	858.98	0.004582	13.95	10211.78	1703.12	1.00
Project	13425	Rev BB	142475.00	845.00	854.24	854.24	857.06	0.004529	13.47	10578.16	1897.18	1.01
Project	13190	Rev BB	142475.00	844.00	853.32	852.74	855.68	0.003742	12.34	11549.85	1846.11	0.87
Project	13030	Rev BB	142475.00	843.00	852.86	851.95	855.08	0.003185	11.96	11909.27	1766.79	0.81
Project	12835	Rev BB	142475.00	842.00	852.34	851.01	854.49	0.002668	11.77	12100.72	1610.12	0.76
Project	12615	Rev BB	142475.00	841.00	852.03	849.82	853.92	0.001904	11.02	12926.14	1472.31	0.66
Project	12395	Rev BB	142475.00	840.00	851.67	849.16	853.50	0.001752	10.85	13135.39	1440.65	0.63
Project	12195	Rev BB	142475.00	838.98	851.58	848.08	853.12	0.001248	9.95	14313.41	1384.21	0.55
Project	11995	Rev BB	142475.00	837.00	850.88	848.04	852.79	0.001627	11.11	12823.25	1283.08	0.62
Project	11780	Rev BB	142475.00	836.00	850.70	847.66	852.39	0.001520	10.44	13642.49	1424.15	0.59
Project	11605	Rev BB	142475.00	835.50	849.96	847.34	852.05	0.001993	11.60	12285.52	1341.91	0.68
Project	11405	Rev BB	142475.00	834.00	849.37	846.23	851.65	0.001801	12.11	11766.04	1116.35	0.66
Project	11180	Rev BB	142475.00	833.00	847.48	845.64	851.07	0.002263	15.22	9359.01	861.14	0.81
Project	11015	Rev BB	142475.00	831.50	844.86	844.86	850.40	0.003816	18.88	7546.81	680.73	1.00
Project	10835	Rev BB	142475.00	831.00	843.79	843.79	848.64	0.003827	17.68	8059.51	834.48	1.00
Project	10575	Rev BB	142475.00	830.00	840.16	840.16	844.13	0.004323	15.99	8907.77	1127.45	1.00
Project	10390	Rev BB	142475.00	828.00	839.75	838.53	842.26	0.002882	12.70	11218.28	1408.98	0.79
Project	10225	Rev BB	142475.00	827.50	838.21	838.21	841.57	0.004878	14.72	9676.62	1447.21	1.00
Project	10000	Rev BB	142475.00	826.00	837.14	837.14	840.43	0.003961	14.56	9788.33	1488.06	1.00
Project	9820	Rev BB	142475.00	824.00	835.36	835.36	838.82	0.004314	14.94	9537.68	1450.92	1.00
Project	9595	Rev BB	142475.00	823.80	834.15	834.15	837.42	0.004846	14.53	9808.52	1620.11	1.00
Project	9385	Rev BB	142475.00	823.00	833.09	833.09	836.04	0.005132	13.78	10337.67	1773.60	1.01
Project	9220	Rev BB	142475.00	822.00	831.82	831.82	834.72	0.004516	13.66	10429.99	1814.14	1.00
Project	9025	Rev BB	142475.00	821.00	830.39	830.39	833.36	0.004263	13.82	10307.78	1751.03	1.00

HEC-RAS Plan: FinalProp085 River: SCR Reach: Project Profile: Rev BB

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	46195	Rev BB	115111.00	1035.00	1063.47	1054.30	1064.87	0.007341	9.49	12131.56	752.82	0.42
Project	46020	Rev BB	115111.00	1032.00	1062.02	1052.44	1063.64	0.006543	10.21	11278.49	570.25	0.40
Project	45545	Rev BB	115111.00	1030.00	1057.85	1049.24	1059.95	0.008978	11.63	9901.38	524.22	0.47
Project	45030	Rev BB	115111.00	1025.00	1054.23	1044.56	1055.89	0.006624	10.33	11148.02	558.00	0.41
Project	44585	Rev BB	115111.00	1022.00	1050.61	1043.05	1052.40	0.009260	10.73	10726.47	654.45	0.47
Project	44210	Rev BB	115111.00	1020.00	1047.85	1038.72	1049.39	0.006689	9.95	11564.12	620.11	0.41
Project	43820	Rev BB	115111.00	1018.00	1042.18	1037.47	1045.27	0.017205	14.10	8166.67	530.01	0.63
Project	43610	Rev BB	115111.00	1017.00	1038.67	1034.08	1041.71	0.017230	13.99	8227.50	539.45	0.63
Project	43410	Rev BB	115111.00	1016.00	1036.61	1030.73	1038.51	0.011821	11.06	10407.01	734.51	0.52
Project	43200	Rev BB	115111.00	1014.00	1033.78	1029.33	1035.80	0.014294	11.41	10091.65	785.15	0.56
Project	42975	Rev BB	115111.00	1012.00	1031.27	1026.13	1032.77	0.011383	9.83	11714.26	961.37	0.50
Project	42815	Rev BB	115111.00	1011.00	1029.95	1024.36	1031.07	0.008590	8.49	13555.60	1123.09	0.43
Project	42590	Rev BB	115111.00	1010.00	1028.69	1021.50	1029.49	0.005332	7.17	16066.51	1248.66	0.35
Project	42430	Rev BB	115111.00	1008.00	1027.84	1020.26	1028.57	0.005587	6.91	17118.29	1596.16	0.35
Project	42215	Rev BB	115111.00	1006.00	1026.89	1018.65	1027.51	0.004188	6.31	18233.84	1375.77	0.31
Project	41940	Rev BB	115111.00	1005.00	1025.82	1017.68	1026.42	0.003813	6.23	18490.49	1328.21	0.29
Project	41730	Rev BB	115111.00	1004.00	1024.84	1016.46	1025.54	0.004347	6.69	17201.33	1222.58	0.31
Project	41460	Rev BB	115111.00	1002.00	1023.44	1015.18	1024.26	0.005190	7.30	15773.56	1122.33	0.34
Project	41280	Rev BB	115111.00	1001.00	1022.21	1015.34	1023.16	0.007140	7.84	14689.39	1195.76	0.39
Project	41080	Rev BB	115111.00	1000.00	1020.85	1013.58	1021.79	0.006509	7.77	14810.43	1139.40	0.38
Project	40825	Rev BB	115111.00	999.50	1019.54	1012.10	1020.30	0.004962	6.98	16487.71	1214.08	0.33
Project	40585	Rev BB	115111.00	998.00	1018.42	1010.59	1019.12	0.004550	6.73	17110.93	1249.11	0.32
Project	40335	Rev BB	115111.00	996.00	1017.57	1008.70	1018.14	0.003259	6.01	19166.52	1289.69	0.27
Project	40130	Rev BB	115111.00	995.00	1016.78	1008.27	1017.40	0.003782	6.33	18185.41	1266.60	0.29
Project	39945	Rev BB	115111.00	994.00	1016.05	1007.59	1016.70	0.003847	6.47	17791.94	1214.29	0.30
Project	39755	Rev BB	115111.00	994.00	1014.76	1007.18	1015.73	0.006323	7.91	14562.19	1096.92	0.38
Project	39605	Rev BB	115111.00	993.00	1013.91	1005.78	1014.86	0.005477	7.85	14763.11	1083.20	0.36
Project	39310	Rev BB	115111.00	992.00	1012.32	1004.36	1013.25	0.005319	7.77	14818.98	977.78	0.35
Project	39100	Rev BB	115111.00	990.00	1011.14	1002.09	1012.17	0.005052	8.16	14158.82	850.63	0.35
Project	38925	Rev BB	115111.00	989.50	1010.35	1001.54	1011.28	0.004789	7.75	14843.71	906.85	0.34
Project	38710	Rev BB	115111.00	988.00	1009.19	1000.32	1010.20	0.005036	8.09	14224.74	844.23	0.35
Project	38475	Rev BB	115111.00	986.00	1006.99	1000.04	1008.64	0.008697	10.31	11167.84	695.45	0.45
Project	38300	Rev BB	115111.00	985.50	1005.78	997.87	1007.19	0.007044	9.56	12043.94	716.83	0.41
Project	38065	Rev BB	115111.00	984.00	1004.14	995.74	1005.56	0.006775	9.56	12036.74	691.32	0.40
Project	37810	Rev BB	115111.00	983.00	1001.39	995.22	1003.36	0.010602	11.26	10228.44	648.53	0.50
Project	37655	Rev BB	115111.00	982.00	999.90	994.10	1001.66	0.010464	10.62	10834.10	739.02	0.49
Project	37390	Rev BB	115111.00	981.00	998.49	990.10	999.52	0.005339	8.15	14131.07	869.25	0.36
Project	37135	Rev BB	115111.00	980.00	996.84	989.31	998.01	0.006512	8.67	13273.15	864.25	0.39
Project	36930	Rev BB	115111.00	978.00	995.75	987.46	996.75	0.005471	8.01	14378.93	926.41	0.36
Project	36735	Rev BB	115111.00	977.00	994.66	986.85	995.64	0.005652	7.97	14443.30	963.48	0.36
Project	36515	Rev BB	115111.00	975.00	993.64	985.37	994.48	0.004699	7.33	15700.20	1032.84	0.33
Project	36265	Rev BB	115111.00	974.00	992.27	985.22	993.06	0.006888	7.13	16149.47	1176.00	0.34
Project	36080	Rev BB	116236.00	973.00	990.65	984.63	991.59	0.008983	7.75	14999.86	1176.00	0.38
Project	35845	Rev BB	116236.00	971.00	989.14	982.87	989.89	0.005586	6.95	16718.71	1512.86	0.35
Project	35725	Rev BB	116236.00	970.00	988.33	982.61	989.15	0.006539	7.30	15919.91	1489.98	0.38
Project	35515	Rev BB	116236.00	969.00	987.05	981.34	987.85	0.005995	7.20	16145.45	1503.16	0.37
Project	35245	Rev BB	116236.00	968.00	985.20	980.17	986.04	0.007449	7.36	15792.43	1581.24	0.39
Project	35040	Rev BB	116236.00	967.00	983.73	978.33	984.52	0.007010	7.17	16215.62	1493.00	0.38
Project	34860	Rev BB	116236.00	966.00	982.28	977.40	983.21	0.007849	7.71	15077.98	1431.69	0.42
Project	34720	Rev BB	116236.00	965.50	981.27	976.17	982.13	0.007059	7.40	15698.80	1450.12	0.40
Project	34495	Rev BB	116236.00	964.00	979.81	974.28	980.61	0.006440	7.20	16154.11	1462.52	0.38
Project	34310	Rev BB	116236.00	963.00	978.58	972.64	979.39	0.006581	7.21	16112.75	1388.30	0.37
Project	34090	Rev BB	116236.00	962.00	977.05	971.59	977.93	0.006750	7.49	15517.16	1371.20	0.39
Project	33880	Rev BB	116236.00	960.00	975.68	970.25	976.50	0.006734	7.27	15989.40	1483.22	0.39
Project	33710	Rev BB	116236.00	959.00	974.59	969.25	975.34	0.006419	6.93	16763.53	1638.24	0.38
Project	33500	Rev BB	116236.00	958.00	973.35	968.06	974.00	0.006109	6.43	18080.31	1755.79	0.35
Project	33310	Rev BB	116236.00	957.00	972.33	966.96	972.93	0.005176	6.21	18719.75	1828.22	0.34
Project	33115	Rev BB	116236.00	956.00	971.42	965.32	971.93	0.004618	5.75	20262.43	1927.27	0.31
Project	32795	Rev BB	116236.00	954.00	969.71	964.56	970.33	0.005520	6.33	18411.74	1921.08	0.36
Project	32605	Rev BB	116236.00	952.00	968.73	963.61	969.28	0.005123	6.04	20231.14	2407.57	0.34
Project	32265	Rev BB	140776.00	950.00	967.22	961.33	967.68	0.004388	5.45	25825.19	2840.45	0.32
Project	31875	Rev BB	140776.00	949.00	965.64	959.38	966.07	0.003807	5.22	27033.89	2594.16	0.28
Project	31585	Rev BB	140776.00	946.00	964.73	956.99	965.10	0.002884	4.92	28606.50	2377.72	0.25
Project	31360	Rev BB	140776.00	944.00	964.01	955.40	964.44	0.002856	5.30	26583.39	1959.81	0.25
Project	31060	Rev BB	140776.00	942.00	963.24	953.29	963.64	0.002469	5.05	27851.26	1976.23	0.24
Project	30720	Rev BB	140776.00	940.00	962.60	951.33	962.93	0.001689	4.57	30819.70	1911.83	0.20
Project	30445	Rev BB	140776.00	938.00	962.16	949.57	962.48	0.001559	4.53	31093.12	1842.15	0.19
Project	30095	Rev BB	140776.00	936.00	961.53	947.93	961.90	0.001737	4.90	28752.99	1637.52	0.21
Project	29815	Rev BB	140776.00	935.00	960.83	948.10	961.33	0.002377	5.64	24945.23	1445.25	0.24
Project	29565	Rev BB	140776.00	934.00	960.18	947.31	960.72	0.002432	5.87	24002.03	1334.60	0.24
Project	29385	Rev BB	140776.00	933.00	959.53	949.39	960.20	0.003234	6.57	21423.61	1248.62	0.28
Project	29140	Rev BB	140776.00	932.00	958.17	949.95	959.17	0.005290	8.02	17548.01	1094.18	0.35
Project	28895	Rev BB	140776.00	930.00	954.62	951.29	956.89	0.017865	12.08	11651.29	981.60	0.62
Project	28695	Rev BB	140776.00	928.00	953.10	945.72	954.44	0.007151	9.29	15147.15	952.31	0.41

HEC-RAS Plan: FinalProp085 River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	28500	Rev BB	140776.00	927.50	951.00	945.99	952.67	0.011472	10.35	13606.97	1041.16	0.50
Project	28280	Rev BB	140776.00	926.00	950.17	939.86	951.07	0.003943	7.60	18528.58	1005.15	0.31
Project	28080	Rev BB	140776.00	925.00	949.41	938.17	950.31	0.003613	7.58	18572.27	946.60	0.30
Project	27925	Rev BB	140776.00	924.00	948.51	938.71	949.63	0.004894	8.52	16518.98	886.47	0.35
Project	27725	Rev BB	140776.00	923.00	946.74	939.26	948.35	0.007913	10.18	13823.56	814.27	0.44
Project	27545	Rev BB	140776.00	922.00	944.98	937.62	946.75	0.009932	10.70	13156.60	854.99	0.48
Project	27335	Rev BB	140776.00	921.00	943.42	936.15	944.83	0.007683	9.56	14721.97	939.21	0.43
Project	27155	Rev BB	140776.00	920.50	941.86	935.27	943.34	0.008754	9.78	14398.34	980.49	0.45
Project	26990	Rev BB	140776.00	920.00	940.62	933.70	941.93	0.007507	9.18	15333.37	1021.74	0.42
Project	26780	Rev BB	140776.00	918.00	939.53	931.32	940.52	0.005306	8.01	17571.72	1107.51	0.35
Project	26575	Rev BB	140776.00	917.00	938.72	929.95	939.51	0.004216	7.14	19724.69	1244.26	0.32
Project	26355	Rev BB	140776.00	916.00	937.83	929.13	938.58	0.004073	6.95	20261.90	1295.29	0.31
Project	26170	Rev BB	140776.00	915.00	937.12	928.16	937.83	0.003833	6.80	20700.37	1301.90	0.30
Project	25965	Rev BB	140776.00	914.00	936.38	927.21	937.07	0.003632	6.67	21119.28	1313.87	0.29
Project	25785	Rev BB	140776.00	913.50	935.72	926.18	936.42	0.003567	6.74	20899.07	1257.60	0.29
Project	25600	Rev BB	140776.00	912.50	934.94	925.21	935.73	0.003778	7.12	19783.70	1150.59	0.30
Project	25425	Rev BB	140776.00	911.00	934.27	924.40	935.07	0.003763	7.16	19676.46	1139.17	0.30
Project	25215	Rev BB	140776.00	910.00	933.49	923.65	934.28	0.003774	7.15	19675.54	1134.33	0.30
Project	25000	Rev BB	140776.00	909.00	932.66	922.49	933.46	0.003681	7.20	19553.49	1094.28	0.30
Project	24795	Rev BB	140776.00	908.00	931.68	921.79	932.64	0.004300	7.85	17926.30	987.02	0.32
Project	24550	Rev BB	140776.00	906.00	930.28	920.91	931.46	0.005239	8.69	16197.81	887.76	0.36
Project	24335	Rev BB	140776.00	905.00	928.76	920.03	930.20	0.006433	9.63	14619.51	801.23	0.40
Project	24115	Rev BB	140776.00	904.00	927.27	918.66	928.75	0.006654	9.77	14414.92	794.39	0.40
Project	23975	Rev BB	140776.00	903.50	926.43	917.68	927.81	0.006247	9.43	14928.26	829.53	0.39
Project	23755	Rev BB	140776.00	902.00	925.02	916.75	926.36	0.006964	9.29	15158.33	941.12	0.41
Project	23565	Rev BB	140776.00	900.00	923.80	915.57	925.07	0.006358	9.02	15604.61	942.91	0.39
Project	23365	Rev BB	140776.00	900.00	922.66	914.40	923.82	0.005909	8.65	16278.47	988.72	0.38
Project	23180	Rev BB	140776.00	899.00	921.68	912.61	922.76	0.005147	8.35	16869.25	976.84	0.35
Project	23000	Rev BB	140776.00	898.00	920.17	911.12	921.55	0.008753	9.42	14947.76	784.00	0.38
Project	22790	Rev BB	140776.00	897.50	917.71	910.47	919.39	0.011776	10.42	13511.74	784.00	0.44
Project	22600	Rev BB	140776.00	896.00	916.14	909.60	917.47	0.008004	9.25	15211.94	1052.34	0.43
Project	22415	Rev BB	140776.00	895.50	914.82	907.97	916.03	0.007157	8.81	15982.03	1093.93	0.41
Project	22195	Rev BB	141426.00	894.00	913.51	906.87	914.43	0.006693	7.70	18363.87	1466.03	0.38
Project	22010	Rev BB	141426.00	892.00	911.96	906.10	913.01	0.008584	8.23	17188.55	1803.93	0.43
Project	21790	Rev BB	141426.00	891.50	910.41	904.77	911.26	0.006915	7.52	19320.02	1781.74	0.39
Project	21615	Rev BB	141426.00	892.00	909.33	902.80	910.10	0.006037	7.05	20056.92	1690.87	0.36
Project	21440	Rev BB	141426.00	890.00	908.27	901.57	909.05	0.005983	7.09	19960.76	1656.11	0.36
Project	21225	Rev BB	141426.00	888.00	907.08	900.52	907.83	0.005424	6.97	20279.11	1603.39	0.35
Project	21020	Rev BB	141426.00	887.00	906.08	898.94	906.78	0.004697	6.68	21188.20	1610.45	0.32
Project	20845	Rev BB	141426.00	886.00	905.18	898.39	905.90	0.005127	6.85	20644.44	1607.47	0.34
Project	20595	Rev BB	141426.00	885.00	904.07	896.46	904.73	0.004338	6.51	21721.47	1608.91	0.31
Project	20435	Rev BB	141426.00	884.00	903.31	895.80	903.99	0.004686	6.63	21321.67	1627.73	0.32
Project	20280	Rev BB	141426.00	883.70	902.35	896.01	903.15	0.006133	7.17	19767.98	1749.06	0.36
Project	20070	Rev BB	141426.00	882.00	901.17	894.29	901.87	0.005844	6.74	20986.95	1849.69	0.35
Project	19855	Rev BB	141426.00	880.50	900.16	892.65	900.78	0.004249	6.33	22462.36	1851.55	0.31
Project	19630	Rev BB	141426.00	880.00	899.23	890.46	899.83	0.004178	6.23	22797.11	1871.07	0.30
Project	19440	Rev BB	141426.00	878.00	898.40	889.68	898.98	0.004680	6.12	23122.45	2019.07	0.32
Project	19240	Rev BB	141426.00	877.50	897.28	889.40	897.97	0.005271	6.69	21152.97	1747.11	0.34
Project	19050	Rev BB	141426.00	876.00	896.50	887.89	897.09	0.003878	6.16	22999.78	1762.81	0.30
Project	18830	Rev BB	141426.00	874.00	895.62	887.50	896.22	0.004004	6.23	22683.43	1690.74	0.30
Project	18650	Rev BB	141426.00	873.50	894.96	886.68	895.53	0.003602	6.04	23403.52	1688.66	0.29
Project	18475	Rev BB	141426.00	872.00	894.47	885.02	894.95	0.002736	5.59	25295.13	1667.77	0.25
Project	18290	Rev BB	141426.00	871.50	893.84	885.07	894.40	0.003329	5.98	23665.47	1633.61	0.28
Project	18025	Rev BB	141426.00	870.00	893.11	882.91	893.60	0.002558	5.62	25143.79	1559.41	0.25
Project	17785	Rev BB	141426.00	868.00	892.29	882.79	892.90	0.003271	6.25	22632.10	1447.29	0.28
Project	17510	Rev BB	141426.00	868.00	890.81	883.42	891.70	0.005886	7.59	18654.98	1414.71	0.36
Project	17360	Rev BB	141426.00	868.00	888.82	883.98	890.35	0.013569	9.95	14215.52	1305.45	0.53
Project	17110	Rev BB	141426.00	864.00	885.85	881.08	887.26	0.010933	9.55	14814.13	1232.51	0.49
Project	16970	Rev BB	141426.00	863.70	884.19	879.57	885.67	0.011338	9.76	14491.26	1196.81	0.49
Project	16720	Rev BB	141426.00	863.50	882.37	875.41	883.44	0.006539	8.31	17010.13	1187.95	0.39
Project	16515	Rev BB	141426.00	862.00	881.31	873.85	882.19	0.005350	7.54	18766.93	1306.21	0.35
Project	16305	Rev BB	141426.00	860.00	880.45	872.03	881.16	0.004085	6.76	20922.92	1395.94	0.31
Project	16130	Rev BB	141426.00	860.00	879.49	872.23	880.34	0.005368	7.40	19112.35	1369.50	0.35
Project	15960	Rev BB	141426.00	859.00	878.70	870.96	879.45	0.004570	6.91	20452.81	1438.39	0.32
Project	15745	Rev BB	141426.00	858.00	877.73	869.77	878.48	0.004476	6.94	20373.34	1402.37	0.32
Project	15540	Rev BB	141426.00	857.50	876.91	868.50	877.56	0.004066	6.49	22408.43	2361.93	0.30
Project	15335	Rev BB	141426.00	856.00	875.11	868.08	876.29	0.009480	8.73	16198.42	1064.14	0.39
Project	15125	Rev BB	142475.00	854.00	872.68	866.25	874.03	0.011555	9.34	15249.43	1053.51	0.43
Project	14900	Rev BB	142475.00	853.00	870.38	864.18	871.63	0.009216	8.97	15881.59	2238.73	0.45
Project	14720	Rev BB	142475.00	852.00	868.64	863.25	869.90	0.010452	9.02	15810.26	2022.13	0.47
Project	14480	Rev BB	142475.00	850.50	867.05	860.75	867.91	0.006131	7.43	19187.13	1853.66	0.37
Project	14315	Rev BB	142475.00	850.00	866.10	860.12	866.88	0.005923	7.08	20111.41	1942.36	0.36
Project	14090	Rev BB	142475.00	850.00	864.88	858.71	865.56	0.005375	6.64	21464.46	1816.59	0.34
Project	13850	Rev BB	142475.00	848.00	863.69	857.10	864.35	0.004893	6.52	21855.87	1775.36	0.33

HEC-RAS Plan: FinalProp085 River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	13635	Rev BB	142475.00	846.00	862.66	855.96	863.31	0.004619	6.49	22131.17	1820.37	0.32
Project	13425	Rev BB	142475.00	845.00	861.97	854.24	862.46	0.003252	5.61	25397.52	1936.85	0.27
Project	13190	Rev BB	142475.00	844.00	861.29	852.74	861.74	0.002835	5.37	26541.57	1912.15	0.25
Project	13030	Rev BB	142475.00	843.00	860.83	851.95	861.29	0.002789	5.40	26405.92	1864.73	0.25
Project	12835	Rev BB	142475.00	842.00	860.25	851.01	860.73	0.002859	5.54	25707.76	1777.11	0.26
Project	12615	Rev BB	142475.00	841.00	859.56	849.82	860.09	0.002907	5.85	24347.79	1569.00	0.26
Project	12395	Rev BB	142475.00	840.00	858.89	849.16	859.44	0.003000	5.97	23856.91	1549.44	0.27
Project	12195	Rev BB	142475.00	838.98	858.30	848.08	858.85	0.002869	5.98	23808.84	1469.16	0.26
Project	11995	Rev BB	142475.00	837.00	857.55	848.04	858.19	0.003608	6.44	22107.60	1450.22	0.29
Project	11780	Rev BB	142475.00	836.00	856.80	847.66	857.43	0.003467	6.35	22449.24	1462.33	0.29
Project	11605	Rev BB	142475.00	835.50	856.01	847.34	856.75	0.004360	6.88	20711.16	1419.08	0.32
Project	11405	Rev BB	142475.00	834.00	854.76	846.23	855.75	0.005373	7.98	17861.03	1145.60	0.36
Project	11180	Rev BB	142475.00	833.00	852.84	845.64	854.31	0.007515	9.72	14662.38	1010.63	0.45
Project	11015	Rev BB	142475.00	831.50	850.47	844.86	852.66	0.011939	11.87	12004.65	852.64	0.56
Project	10835	Rev BB	142475.00	831.00	848.29	843.79	850.42	0.013047	11.76	12400.58	1074.47	0.57
Project	10575	Rev BB	142475.00	830.00	846.33	840.16	847.54	0.007986	8.84	16140.29	1323.35	0.43
Project	10390	Rev BB	142475.00	828.00	845.30	838.53	846.14	0.005968	7.35	19375.22	1517.90	0.36
Project	10225	Rev BB	142475.00	827.50	844.20	838.21	845.10	0.006835	7.61	18716.44	1545.61	0.39
Project	10000	Rev BB	142475.00	826.00	842.62	837.11	843.54	0.006877	7.72	18453.52	1626.59	0.40
Project	9820	Rev BB	142475.00	824.00	841.41	835.36	842.34	0.006465	7.71	18478.98	1650.05	0.39
Project	9595	Rev BB	142475.00	823.80	839.92	834.15	840.84	0.006985	7.70	18513.50	1720.36	0.39
Project	9385	Rev BB	142475.00	823.00	838.61	833.09	839.38	0.006487	7.05	20207.47	1799.40	0.37
Project	9220	Rev BB	142475.00	822.00	837.64	831.82	838.35	0.005584	6.74	21127.86	1853.53	0.35
Project	9025	Rev BB	142475.00	821.00	836.65	830.39	837.32	0.005004	6.60	21582.88	1823.02	0.34

HEC-RAS Plan: Pr025LevCode River: SCR Reach: Project Profile: Rev BB

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	46195	Rev BB	115111.00	1035.00	1053.14	1054.04	1060.43	0.005006	21.67	5313.11	452.97	1.11
Project	46020	Rev BB	115111.00	1032.00	1050.08	1052.47	1059.13	0.008742	24.14	4768.34	520.89	1.41
Project	45545	Rev BB	115111.00	1030.00	1049.23	1049.27	1055.65	0.004027	20.33	5661.39	446.68	1.01
Project	45030	Rev BB	115111.00	1025.00	1041.51	1044.56	1052.09	0.010535	26.10	4410.21	492.54	1.54
Project	44585	Rev BB	115111.00	1022.00	1043.05	1043.07	1048.75	0.004190	19.17	6004.20	531.91	1.01
Project	44210	Rev BB	115111.00	1020.00	1035.36	1038.72	1045.99	0.009463	26.16	4399.47	452.62	1.48
Project	43820	Rev BB	115111.00	1018.00	1037.47	1037.48	1043.62	0.004072	19.90	5785.33	476.53	1.01
Project	43610	Rev BB	115111.00	1017.00	1030.80	1034.06	1041.87	0.010066	26.70	4311.38	450.58	1.52
Project	43410	Rev BB	115111.00	1016.00	1027.33	1031.12	1039.61	0.011140	28.76	4308.81	583.44	1.61
Project	43200	Rev BB	115111.00	1014.00	1026.42	1029.64	1036.81	0.010596	26.11	4615.62	689.16	1.54
Project	42975	Rev BB	115111.00	1012.00	1022.84	1026.28	1033.82	0.016327	26.63	4368.54	735.12	1.82
Project	42815	Rev BB	115111.00	1011.00	1021.72	1024.45	1030.58	0.015830	23.92	4840.30	864.26	1.76
Project	42590	Rev BB	115111.00	1010.00	1019.24	1021.61	1026.97	0.013663	22.43	5239.45	1013.12	1.64
Project	42430	Rev BB	115111.00	1008.00	1018.67	1020.25	1024.62	0.009146	19.57	5880.86	915.78	1.36
Project	42215	Rev BB	115111.00	1006.00	1017.22	1018.65	1022.53	0.008689	18.48	6228.87	1018.99	1.32
Project	41940	Rev BB	115111.00	1005.00	1019.27	1017.69	1021.36	0.002429	11.60	9938.85	1284.24	0.73
Project	41730	Rev BB	115111.00	1004.00	1018.69	1016.46	1020.85	0.002298	11.79	9782.67	1190.92	0.71
Project	41460	Rev BB	115111.00	1002.00	1018.18	1015.18	1020.26	0.002007	11.56	9955.93	1093.49	0.68
Project	41280	Rev BB	115111.00	1001.00	1015.35	1015.35	1019.53	0.004463	16.42	7036.47	852.28	1.00
Project	41080	Rev BB	115111.00	1000.00	1012.06	1013.54	1018.19	0.007501	19.93	5822.75	874.06	1.27
Project	40825	Rev BB	115111.00	999.50	1010.97	1012.14	1016.00	0.007233	18.02	6444.40	1040.35	1.22
Project	40585	Rev BB	115111.00	998.00	1009.70	1010.42	1014.18	0.006378	16.98	6785.22	1005.81	1.15
Project	40335	Rev BB	115111.00	996.00	1011.09	1008.70	1012.81	0.001736	10.54	10937.81	1249.57	0.63
Project	40130	Rev BB	115111.00	995.00	1010.49	1008.34	1012.42	0.001793	11.30	10477.71	1195.64	0.64
Project	39945	Rev BB	115111.00	994.00	1010.29	1007.73	1012.07	0.001542	11.00	10919.88	1173.27	0.60
Project	39755	Rev BB	115111.00	994.00	1007.28	1007.28	1011.39	0.004003	16.46	7234.94	894.45	0.96
Project	39605	Rev BB	115111.00	993.00	1004.51	1005.87	1010.45	0.006872	19.70	6001.74	849.68	1.23
Project	39310	Rev BB	115111.00	992.00	1004.65	1004.65	1008.62	0.003630	16.53	7501.51	931.10	0.92
Project	39100	Rev BB	115111.00	990.00	1000.40	1002.12	1007.21	0.008939	20.94	5496.16	761.14	1.37
Project	38925	Rev BB	115111.00	989.50	1003.76	1001.55	1006.31	0.002096	12.82	8981.87	873.49	0.70
Project	38710	Rev BB	115111.00	988.00	1003.58	1000.32	1005.83	0.001571	12.04	9558.11	820.29	0.62
Project	38475	Rev BB	115111.00	986.00	1000.04	1000.04	1005.00	0.004280	17.89	6451.15	659.72	1.00
Project	38300	Rev BB	115111.00	985.50	995.78	997.87	1003.64	0.009518	22.51	5114.38	666.28	1.43
Project	38065	Rev BB	115111.00	984.00	998.04	995.74	1001.32	0.002214	14.54	7914.65	658.41	0.74
Project	37810	Rev BB	115111.00	983.00	995.22	995.22	1000.37	0.004276	18.21	6321.20	618.24	1.00
Project	37655	Rev BB	115111.00	982.00	992.54	994.10	999.31	0.008065	20.88	5511.72	706.72	1.32
Project	37390	Rev BB	115111.00	981.00	987.53	990.11	996.27	0.015047	23.73	4850.91	823.78	1.72
Project	37135	Rev BB	115111.00	980.00	989.30	989.33	993.58	0.004550	16.58	6941.42	821.44	1.01
Project	36930	Rev BB	115111.00	978.00	986.10	987.49	992.18	0.008097	19.79	5815.33	812.44	1.30
Project	36735	Rev BB	115111.00	977.00	986.84	986.84	990.86	0.004540	16.10	7161.17	896.91	1.00
Project	36515	Rev BB	115111.00	975.00	987.02	985.36	989.58	0.002443	12.85	8981.37	994.69	0.75
Project	36265	Rev BB	115111.00	974.00	986.48	985.22	988.84	0.003072	12.33	9335.94	1176.00	0.77
Project	36080	Rev BB	116236.00	973.00	984.63	984.63	987.98	0.005713	14.69	7912.71	1176.00	1.00
Project	35845	Rev BB	116236.00	971.00	984.64	982.88	986.50	0.002139	10.95	10632.07	1401.71	0.68
Project	35725	Rev BB	116236.00	970.00	982.95	982.95	986.05	0.003627	14.96	8689.93	1377.89	0.90
Project	35515	Rev BB	116236.00	969.00	981.00	981.77	985.11	0.004566	17.10	7670.88	1354.77	1.04
Project	35245	Rev BB	116236.00	968.00	979.34	980.44	983.69	0.005894	17.32	7329.53	1328.31	1.12
Project	35040	Rev BB	116236.00	967.00	977.65	978.97	982.46	0.005549	19.57	7402.76	1354.78	1.13
Project	34860	Rev BB	116236.00	966.00	975.96	977.40	981.22	0.008614	18.40	6315.84	1285.71	1.46
Project	34720	Rev BB	116236.00	965.50	974.72	976.17	979.96	0.009180	18.37	6328.08	1411.20	1.53
Project	34495	Rev BB	116236.00	964.00	973.04	974.28	977.75	0.009172	17.42	6673.93	1283.85	1.35
Project	34310	Rev BB	116236.00	963.00	972.28	973.00	976.33	0.004852	16.76	7668.82	1308.50	1.03
Project	34090	Rev BB	116236.00	962.00	970.57	971.59	975.05	0.006730	16.98	6843.72	1295.50	1.30
Project	33880	Rev BB	116236.00	960.00	969.33	970.25	973.60	0.006606	16.57	7013.99	1318.43	1.27
Project	33710	Rev BB	116236.00	959.00	968.71	969.25	972.38	0.005499	15.39	7555.15	1372.11	1.16
Project	33500	Rev BB	116236.00	958.00	967.26	967.96	971.11	0.006549	16.18	7665.86	1495.98	1.14
Project	33310	Rev BB	116236.00	957.00	966.03	966.96	969.89	0.006423	15.77	7371.77	1770.35	1.36
Project	33115	Rev BB	116236.00	956.00	966.60	965.32	968.27	0.002770	10.36	11217.41	1847.27	0.74
Project	32795	Rev BB	116236.00	954.00	964.56	964.56	967.18	0.003570	12.99	8949.52	1735.59	1.01
Project	32605	Rev BB	116236.00	952.00	963.12	963.61	966.33	0.004754	14.38	8080.57	1699.92	1.13
Project	32265	Rev BB	140776.00	950.00	960.46	961.32	964.38	0.006433	15.88	8862.89	1853.19	1.28
Project	31875	Rev BB	140776.00	949.00	959.38	959.38	961.76	0.005505	12.38	11368.96	2409.15	1.00
Project	31585	Rev BB	140776.00	946.00	957.85	956.96	959.70	0.003160	10.91	12900.93	2182.22	0.79
Project	31360	Rev BB	140776.00	944.00	957.45	955.41	959.09	0.001898	10.28	13848.11	1878.67	0.64
Project	31060	Rev BB	140776.00	942.00	957.49	953.29	958.54	0.000883	8.20	17165.15	1708.18	0.46
Project	30720	Rev BB	140776.00	940.00	957.52	951.33	958.21	0.000503	6.65	21153.55	1888.61	0.35
Project	30445	Rev BB	140776.00	938.00	957.46	949.57	958.06	0.000373	6.25	22524.41	1779.71	0.31
Project	30095	Rev BB	140776.00	936.00	957.25	947.93	957.94	0.000304	6.72	21778.32	1622.72	0.29
Project	29815	Rev BB	140776.00	935.00	956.93	948.10	957.82	0.000390	7.74	19323.91	1433.15	0.33
Project	29565	Rev BB	140776.00	934.00	956.88	947.30	957.70	0.000380	7.40	19609.21	1323.79	0.32
Project	29385	Rev BB	140776.00	933.00	956.59	949.37	957.61	0.000483	8.28	17777.02	1237.37	0.36
Project	29140	Rev BB	140776.00	932.00	956.13	949.97	957.44	0.000712	9.19	15319.17	1087.20	0.43
Project	28895	Rev BB	140776.00	930.00	952.50	952.50	956.86	0.002171	18.80	9575.46	972.12	0.78
Project	28695	Rev BB	140776.00	928.00	942.01	945.73	954.96	0.024913	28.87	4876.24	899.40	2.18

HEC-RAS Plan: Pr025LevCode River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	28500	Rev BB	140776.00	927.50	943.62	946.10	951.41	0.005568	22.39	6287.19	552.17	1.17
Project	28280	Rev BB	140776.00	926.00	936.76	940.42	949.18	0.012736	29.59	5431.96	944.52	1.71
Project	28080	Rev BB	140776.00	925.00	944.09	938.55	945.83	0.000816	11.26	13583.41	926.37	0.48
Project	27925	Rev BB	140776.00	924.00	943.26	939.25	945.62	0.001091	13.09	11919.32	866.57	0.55
Project	27725	Rev BB	140776.00	923.00	939.71	939.71	945.00	0.002680	19.03	8197.14	786.61	0.85
Project	27545	Rev BB	140776.00	922.00	936.05	937.70	944.07	0.005424	22.89	6357.92	643.23	1.16
Project	27335	Rev BB	140776.00	921.00	933.30	936.32	942.60	0.007749	24.55	5857.59	703.53	1.35
Project	27155	Rev BB	140776.00	920.50	935.29	935.76	940.56	0.003283	19.09	8183.45	888.43	0.92
Project	26990	Rev BB	140776.00	920.00	931.45	933.72	939.36	0.010995	22.60	6251.25	922.34	1.51
Project	26780	Rev BB	140776.00	918.00	929.28	931.66	937.27	0.009096	23.11	6501.43	1043.32	1.42
Project	26575	Rev BB	140776.00	917.00	928.11	929.98	934.77	0.011845	20.70	6801.06	1187.27	1.52
Project	26355	Rev BB	140776.00	916.00	929.39	929.39	933.05	0.003824	15.86	9475.99	1260.40	0.93
Project	26170	Rev BB	140776.00	915.00	928.48	928.73	932.37	0.003357	16.99	9605.44	1269.04	0.90
Project	25965	Rev BB	140776.00	914.00	926.88	927.72	931.53	0.004261	18.22	8811.74	1281.32	1.00
Project	25785	Rev BB	140776.00	913.50	925.60	926.63	930.65	0.004882	18.93	8376.91	1219.65	1.07
Project	25600	Rev BB	140776.00	912.50	924.93	925.64	929.69	0.004574	18.53	8467.08	1109.36	1.03
Project	25425	Rev BB	140776.00	911.00	923.47	924.43	928.67	0.006886	18.30	7702.49	1082.21	1.20
Project	25215	Rev BB	140776.00	910.00	924.72	923.68	927.87	0.003051	14.27	9886.47	1097.27	0.83
Project	25000	Rev BB	140776.00	909.00	924.48	922.49	927.16	0.002226	13.17	10726.62	1062.41	0.73
Project	24795	Rev BB	140776.00	908.00	923.60	921.80	926.66	0.002399	14.05	10060.99	957.43	0.76
Project	24550	Rev BB	140776.00	906.00	922.50	920.91	926.00	0.002585	15.05	9407.90	856.12	0.79
Project	24335	Rev BB	140776.00	905.00	920.00	920.00	925.14	0.004222	18.23	7758.55	764.84	1.00
Project	24115	Rev BB	140776.00	904.00	917.79	918.66	923.97	0.005627	19.97	7075.98	754.15	1.14
Project	23975	Rev BB	140776.00	903.50	916.36	917.71	923.05	0.006734	20.79	6802.82	783.24	1.23
Project	23755	Rev BB	140776.00	902.00	916.70	916.70	921.73	0.004144	18.07	7883.57	815.66	0.99
Project	23565	Rev BB	140776.00	900.00	914.30	915.55	920.61	0.006682	20.21	7009.72	850.93	1.22
Project	23365	Rev BB	140776.00	900.00	914.27	914.69	919.18	0.004225	18.44	8193.99	939.03	1.00
Project	23180	Rev BB	140776.00	899.00	911.64	913.14	918.15	0.005198	21.91	7362.50	916.60	1.13
Project	23000	Rev BB	140776.00	898.00	909.26	911.13	916.78	0.010007	22.01	6396.83	784.00	1.36
Project	22790	Rev BB	140776.00	897.50	910.49	910.49	915.48	0.005082	17.93	7853.44	784.00	1.00
Project	22600	Rev BB	140776.00	896.00	908.75	909.83	914.38	0.005814	19.84	7611.16	998.99	1.15
Project	22415	Rev BB	140776.00	895.50	906.26	907.97	912.91	0.009659	21.28	6839.61	1039.08	1.42
Project	22195	Rev BB	141426.00	894.00	907.98	906.82	910.85	0.002733	13.64	10506.24	1309.62	0.79
Project	22010	Rev BB	141426.00	892.00	906.34	906.34	910.19	0.003231	16.12	9490.52	1254.05	0.88
Project	21790	Rev BB	141426.00	891.50	903.06	904.80	909.04	0.005997	19.71	7416.01	1144.54	1.16
Project	21615	Rev BB	141426.00	892.00	900.54	902.67	907.53	0.011263	21.25	6724.20	1162.96	1.50
Project	21440	Rev BB	141426.00	890.00	900.97	901.64	905.59	0.004781	17.47	8486.12	1286.09	1.04
Project	21225	Rev BB	141426.00	888.00	899.73	900.84	904.50	0.005437	18.05	8659.23	1558.99	1.10
Project	21020	Rev BB	141426.00	887.00	896.71	898.87	903.05	0.007282	20.26	7028.37	902.97	1.26
Project	20845	Rev BB	141426.00	886.00	898.73	898.73	902.00	0.003234	15.09	10415.32	1563.68	0.87
Project	20595	Rev BB	141426.00	885.00	898.44	896.85	900.55	0.001741	12.43	12879.93	1548.78	0.65
Project	20435	Rev BB	141426.00	884.00	898.29	896.35	900.24	0.001485	12.07	13441.56	1528.26	0.61
Project	20280	Rev BB	141426.00	883.70	896.49	896.49	899.77	0.003240	15.58	10469.12	1531.27	0.87
Project	20070	Rev BB	141426.00	882.00	893.08	894.65	898.66	0.006088	19.34	7950.22	1526.62	1.17
Project	19855	Rev BB	141426.00	880.50	890.72	892.94	897.11	0.007654	20.60	7256.29	1205.44	1.29
Project	19630	Rev BB	141426.00	880.00	888.85	890.50	895.26	0.008984	20.59	7022.63	1060.31	1.37
Project	19440	Rev BB	141426.00	878.00	891.37	889.70	894.01	0.002361	13.14	10944.01	1194.54	0.74
Project	19240	Rev BB	141426.00	877.50	889.35	889.35	893.26	0.004288	15.89	9009.98	1216.93	0.97
Project	19050	Rev BB	141426.00	876.00	886.51	887.89	891.96	0.009085	18.83	7609.36	1321.43	1.35
Project	18830	Rev BB	141426.00	874.00	888.57	887.55	891.15	0.002730	13.26	11286.43	1531.54	0.79
Project	18650	Rev BB	141426.00	873.50	888.51	886.84	890.60	0.001837	12.07	12773.93	1604.48	0.66
Project	18475	Rev BB	141426.00	872.00	888.89	885.04	890.10	0.001001	8.89	16125.18	1621.53	0.49
Project	18290	Rev BB	141426.00	871.50	888.43	885.13	889.87	0.001213	9.80	14922.77	1594.15	0.54
Project	18025	Rev BB	141426.00	870.00	888.54	882.94	889.50	0.000621	7.92	18109.90	1520.22	0.40
Project	17785	Rev BB	141426.00	868.00	888.22	882.78	889.33	0.000704	8.45	16839.22	1398.14	0.42
Project	17510	Rev BB	141426.00	868.00	887.23	883.27	889.02	0.001136	10.97	13735.28	1350.70	0.54
Project	17360	Rev BB	141426.00	868.00	883.91	883.91	888.45	0.004427	17.10	8296.49	943.23	1.00
Project	17110	Rev BB	141426.00	864.00	879.19	881.42	886.72	0.007499	22.29	6796.11	1175.37	1.30
Project	16970	Rev BB	141426.00	863.70	877.25	879.83	885.42	0.010272	23.07	6337.44	1066.97	1.48
Project	16720	Rev BB	141426.00	863.50	872.70	875.43	881.94	0.018711	24.39	5801.39	1122.93	1.88
Project	16515	Rev BB	141426.00	862.00	872.36	873.86	878.20	0.010048	19.44	7302.33	1249.88	1.41
Project	16305	Rev BB	141426.00	860.00	874.55	872.14	876.49	0.001716	11.59	12787.87	1360.53	0.64
Project	16130	Rev BB	141426.00	860.00	872.31	872.31	875.86	0.004579	15.67	9439.97	1326.45	0.99
Project	15960	Rev BB	141426.00	859.00	869.97	870.98	874.69	0.008166	17.65	8113.94	1385.96	1.27
Project	15745	Rev BB	141426.00	858.00	871.32	869.77	873.67	0.002505	12.30	11500.58	1363.87	0.75
Project	15540	Rev BB	141426.00	857.50	871.22	868.50	872.95	0.001597	10.55	13406.47	1426.61	0.61
Project	15335	Rev BB	141426.00	856.00	868.08	868.08	872.16	0.005521	16.21	8721.97	1064.14	1.00
Project	15125	Rev BB	142475.00	854.00	865.62	866.25	870.59	0.007031	17.89	7966.16	1000.47	1.12
Project	14900	Rev BB	142475.00	853.00	862.77	864.23	868.54	0.008996	19.28	7389.85	1626.46	1.35
Project	14720	Rev BB	142475.00	852.00	861.80	862.97	866.83	0.007951	18.07	7995.80	1722.27	1.27
Project	14480	Rev BB	142475.00	850.50	859.35	860.83	864.69	0.009831	19.03	7857.43	1726.69	1.39
Project	14315	Rev BB	142475.00	850.00	859.90	859.99	862.93	0.005287	13.99	10186.13	1880.98	1.02
Project	14090	Rev BB	142475.00	850.00	858.47	858.71	861.66	0.005810	14.34	9937.41	1772.81	1.06
Project	13850	Rev BB	142475.00	848.00	857.69	857.10	860.17	0.003694	12.62	11299.46	1741.62	0.87

HEC-RAS Plan: Pr025LevCode River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	13635	Rev BB	142475.00	846.00	856.29	856.29	859.29	0.003837	15.47	10777.84	1705.84	0.93
Project	13425	Rev BB	142475.00	845.00	852.82	854.24	857.85	0.010659	18.00	7915.99	1850.66	1.53
Project	13190	Rev BB	142475.00	844.00	853.52	852.80	855.78	0.003254	12.17	11923.29	1847.43	0.82
Project	13030	Rev BB	142475.00	843.00	852.58	852.23	855.21	0.003379	14.20	11406.11	1762.99	0.87
Project	12835	Rev BB	142475.00	842.00	852.13	851.20	854.54	0.002769	13.31	11761.95	1607.50	0.79
Project	12615	Rev BB	142475.00	841.00	851.86	850.10	853.94	0.001918	12.46	12681.30	1470.78	0.68
Project	12395	Rev BB	142475.00	840.00	851.49	849.52	853.55	0.001708	12.32	12873.68	1438.10	0.65
Project	12195	Rev BB	142475.00	838.98	851.49	848.24	853.14	0.001192	10.62	14191.69	1383.66	0.55
Project	11995	Rev BB	142475.00	837.00	850.60	848.45	852.80	0.001625	12.80	12474.09	1280.52	0.64
Project	11780	Rev BB	142475.00	836.00	850.37	848.11	852.44	0.001447	12.59	13173.69	1422.19	0.61
Project	11605	Rev BB	142475.00	835.50	849.29	847.46	852.08	0.001869	13.90	11381.14	1325.50	0.69
Project	11405	Rev BB	142475.00	834.00	849.07	846.17	851.69	0.001519	13.18	11428.21	1114.61	0.64
Project	11180	Rev BB	142475.00	833.00	846.89	845.65	851.10	0.002564	16.60	8864.64	835.68	0.82
Project	11015	Rev BB	142475.00	831.50	844.78	844.78	850.43	0.003842	19.08	7493.10	679.39	0.99
Project	10835	Rev BB	142475.00	831.00	841.87	843.71	849.32	0.007252	21.91	6502.00	790.38	1.35
Project	10575	Rev BB	142475.00	830.00	837.47	840.16	846.52	0.015567	24.13	5903.48	1108.84	1.84
Project	10390	Rev BB	142475.00	828.00	836.77	839.04	843.84	0.008452	22.72	7220.95	1247.02	1.37
Project	10225	Rev BB	142475.00	827.50	837.05	838.17	841.96	0.006830	17.80	8061.12	1374.14	1.26
Project	10000	Rev BB	142475.00	826.00	837.14	837.14	840.54	0.003942	14.90	9785.79	1488.00	0.96
Project	9820	Rev BB	142475.00	824.00	833.98	835.33	839.33	0.008466	18.57	7671.79	1402.32	1.37
Project	9595	Rev BB	142475.00	823.80	834.12	834.12	837.42	0.004905	14.58	9770.14	1619.46	1.00
Project	9385	Rev BB	142475.00	823.00	832.49	833.15	836.23	0.006101	15.78	9289.78	1770.37	1.19
Project	9220	Rev BB	142475.00	822.00	830.86	831.81	835.03	0.007824	16.39	8704.29	1771.41	1.29
Project	9025	Rev BB	142475.00	821.00	829.91	830.56	833.69	0.005307	15.90	9468.91	1736.86	1.09

HEC-RAS Plan: Pr085LevCode River: SCR Reach: Project Profile: Rev BB

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	46195	Rev BB	115111.00	1035.00	1063.12	1054.04	1064.77	0.006261	10.67	11871.29	750.83	0.40
Project	46020	Rev BB	115111.00	1032.00	1062.02	1052.44	1063.64	0.006544	10.21	11277.79	570.22	0.40
Project	45545	Rev BB	115111.00	1030.00	1057.85	1049.24	1059.95	0.008982	11.63	9900.10	524.21	0.47
Project	45030	Rev BB	115111.00	1025.00	1054.23	1044.56	1055.89	0.006629	10.33	11145.16	557.97	0.41
Project	44585	Rev BB	115111.00	1022.00	1050.60	1043.05	1052.39	0.009283	10.74	10717.92	654.38	0.47
Project	44210	Rev BB	115111.00	1020.00	1047.83	1038.72	1049.37	0.006714	9.97	11549.74	619.95	0.41
Project	43820	Rev BB	115111.00	1018.00	1042.08	1037.47	1045.21	0.017534	14.19	8112.26	528.70	0.64
Project	43610	Rev BB	115111.00	1017.00	1038.25	1034.06	1041.46	0.018806	14.39	7998.42	536.89	0.66
Project	43410	Rev BB	115111.00	1016.00	1035.83	1031.12	1038.22	0.011970	13.25	9837.37	729.14	0.54
Project	43200	Rev BB	115111.00	1014.00	1033.24	1029.61	1035.63	0.014478	12.98	9662.58	779.49	0.58
Project	42975	Rev BB	115111.00	1012.00	1030.98	1026.26	1032.66	0.010954	10.71	11432.61	955.76	0.50
Project	42815	Rev BB	115111.00	1011.00	1029.67	1024.43	1030.90	0.008589	9.10	13242.80	1120.79	0.44
Project	42590	Rev BB	115111.00	1010.00	1028.42	1021.61	1029.28	0.005536	7.65	15735.26	1230.66	0.36
Project	42430	Rev BB	115111.00	1008.00	1027.53	1020.25	1028.39	0.005373	7.55	15955.86	1334.91	0.35
Project	42215	Rev BB	115111.00	1006.00	1026.68	1018.65	1027.34	0.004067	6.60	17936.38	1374.62	0.31
Project	41940	Rev BB	115111.00	1005.00	1025.62	1017.69	1026.25	0.003871	6.38	18230.06	1327.03	0.30
Project	41730	Rev BB	115111.00	1004.00	1024.63	1016.46	1025.35	0.004429	6.86	16939.62	1221.47	0.32
Project	41460	Rev BB	115111.00	1002.00	1023.17	1015.18	1024.03	0.005512	7.43	15483.49	1120.97	0.35
Project	41280	Rev BB	115111.00	1001.00	1021.79	1015.35	1022.90	0.006803	8.69	14194.24	1193.24	0.40
Project	41080	Rev BB	115111.00	1000.00	1020.52	1013.58	1021.61	0.006027	8.64	14443.03	1136.84	0.38
Project	40825	Rev BB	115111.00	999.50	1019.34	1012.13	1020.15	0.004966	7.34	16245.37	1212.96	0.34
Project	40585	Rev BB	115111.00	998.00	1018.25	1010.42	1018.99	0.004404	7.05	16893.35	1247.23	0.32
Project	40335	Rev BB	115111.00	996.00	1017.43	1008.70	1018.01	0.003313	6.09	18980.28	1288.56	0.28
Project	40130	Rev BB	115111.00	995.00	1016.61	1008.34	1017.27	0.003693	6.64	17974.92	1264.54	0.30
Project	39945	Rev BB	115111.00	994.00	1015.89	1007.73	1016.57	0.003832	6.82	17605.07	1212.34	0.30
Project	39755	Rev BB	115111.00	994.00	1014.56	1007.28	1015.64	0.005781	8.58	14340.28	1088.09	0.37
Project	39605	Rev BB	115111.00	993.00	1013.74	1005.87	1014.80	0.005317	8.49	14586.36	1074.69	0.36
Project	39310	Rev BB	115111.00	992.00	1012.22	1004.65	1013.22	0.005130	8.42	14723.69	977.30	0.35
Project	39100	Rev BB	115111.00	990.00	1011.11	1002.09	1012.15	0.005092	8.18	14069.44	831.46	0.35
Project	38925	Rev BB	115111.00	989.50	1010.31	1001.54	1011.25	0.004818	7.77	14815.54	906.70	0.34
Project	38710	Rev BB	115111.00	988.00	1009.15	1000.32	1010.17	0.005022	8.12	14194.81	844.08	0.35
Project	38475	Rev BB	115111.00	986.00	1006.95	1000.04	1008.63	0.008448	10.43	11138.93	695.26	0.45
Project	38300	Rev BB	115111.00	985.50	1005.77	997.87	1007.19	0.007052	9.56	12039.52	716.81	0.41
Project	38065	Rev BB	115111.00	984.00	1004.13	995.74	1005.55	0.006785	9.57	12028.87	691.25	0.40
Project	37810	Rev BB	115111.00	983.00	1001.38	995.22	1003.35	0.010638	11.27	10217.52	648.42	0.50
Project	37655	Rev BB	115111.00	982.00	999.88	994.10	1001.64	0.010523	10.64	10815.11	738.91	0.49
Project	37390	Rev BB	115111.00	981.00	998.45	990.10	999.49	0.005379	8.16	14098.28	869.10	0.36
Project	37135	Rev BB	115111.00	980.00	996.79	989.31	997.96	0.006585	8.70	13225.00	863.67	0.39
Project	36930	Rev BB	115111.00	978.00	995.67	987.49	996.71	0.005428	8.25	14200.96	923.68	0.36
Project	36735	Rev BB	115111.00	977.00	994.61	986.84	995.61	0.005534	8.08	14397.32	963.18	0.36
Project	36515	Rev BB	115111.00	975.00	993.62	985.36	994.47	0.004637	7.39	15678.21	1032.73	0.33
Project	36265	Rev BB	115111.00	974.00	992.27	985.22	993.06	0.006897	7.13	16142.37	1176.00	0.34
Project	36080	Rev BB	116236.00	973.00	990.64	984.63	991.58	0.009003	7.75	14989.02	1176.00	0.38
Project	35845	Rev BB	116236.00	971.00	989.14	982.87	989.89	0.005531	6.98	16713.90	1512.83	0.35
Project	35725	Rev BB	116236.00	970.00	988.29	982.95	989.16	0.006293	8.01	15871.91	1488.92	0.38
Project	35515	Rev BB	116236.00	969.00	986.85	981.77	987.82	0.006633	8.45	15243.73	1501.04	0.39
Project	35245	Rev BB	116236.00	968.00	984.99	980.44	985.93	0.007356	8.26	15487.04	1580.25	0.40
Project	35040	Rev BB	116236.00	967.00	983.55	978.97	984.46	0.006763	8.81	15947.66	1491.55	0.40
Project	34860	Rev BB	116236.00	966.00	982.27	977.40	983.19	0.007889	7.72	15053.43	1431.50	0.42
Project	34720	Rev BB	116236.00	965.50	981.25	976.17	982.11	0.007109	7.42	15663.31	1449.93	0.40
Project	34495	Rev BB	116236.00	964.00	979.74	974.28	980.55	0.006712	7.24	16056.04	1461.49	0.38
Project	34310	Rev BB	116236.00	963.00	978.44	973.00	979.33	0.006216	8.12	15915.74	1384.94	0.38
Project	34090	Rev BB	116236.00	962.00	977.04	971.59	977.91	0.006781	7.50	15494.22	1371.03	0.39
Project	33880	Rev BB	116236.00	960.00	975.66	970.25	976.48	0.006784	7.29	15950.57	1482.88	0.39
Project	33710	Rev BB	116236.00	959.00	974.55	969.25	975.30	0.006495	6.96	16700.10	1637.90	0.38
Project	33500	Rev BB	116236.00	958.00	973.31	967.96	973.99	0.005863	6.99	17999.09	1755.45	0.35
Project	33310	Rev BB	116236.00	957.00	972.33	966.96	972.92	0.005184	6.21	18709.82	1828.18	0.34
Project	33115	Rev BB	116236.00	956.00	971.41	965.32	971.93	0.004628	5.75	20248.08	1927.09	0.31
Project	32795	Rev BB	116236.00	954.00	969.69	964.56	970.32	0.005544	6.34	18385.59	1920.75	0.36
Project	32605	Rev BB	116236.00	952.00	968.71	963.61	969.26	0.005158	6.06	20182.80	2407.42	0.34
Project	32265	Rev BB	140776.00	950.00	967.18	961.33	967.65	0.004429	5.48	25728.28	2840.18	0.32
Project	31875	Rev BB	140776.00	949.00	965.59	959.38	966.01	0.003875	5.25	26887.78	2593.08	0.28
Project	31585	Rev BB	140776.00	946.00	964.66	956.96	965.04	0.002932	4.96	28433.09	2377.46	0.25
Project	31360	Rev BB	140776.00	944.00	963.92	955.41	964.37	0.002797	5.46	26418.22	1959.45	0.25
Project	31060	Rev BB	140776.00	942.00	963.17	953.29	963.57	0.002504	5.08	27711.47	1975.93	0.24
Project	30720	Rev BB	140776.00	940.00	962.52	951.33	962.85	0.001709	4.59	30668.14	1911.53	0.20
Project	30445	Rev BB	140776.00	938.00	962.08	949.57	962.41	0.001527	4.58	30947.53	1841.84	0.19
Project	30095	Rev BB	140776.00	936.00	961.46	947.93	961.86	0.001543	5.18	28649.25	1637.30	0.20
Project	29815	Rev BB	140776.00	935.00	960.83	948.10	961.36	0.002089	6.05	24935.54	1445.23	0.23
Project	29565	Rev BB	140776.00	934.00	960.26	947.30	960.81	0.002264	6.03	24109.24	1334.86	0.24
Project	29385	Rev BB	140776.00	933.00	959.64	949.37	960.33	0.003009	6.82	21565.54	1249.05	0.28
Project	29140	Rev BB	140776.00	932.00	958.42	949.97	959.39	0.005030	7.90	17821.87	1095.03	0.35
Project	28895	Rev BB	140776.00	930.00	953.81	952.50	957.09	0.017778	16.50	10852.34	977.96	0.66
Project	28695	Rev BB	140776.00	928.00	952.93	945.73	954.30	0.007405	9.39	14984.17	951.56	0.42

HEC-RAS Plan: Pr085LevCode River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	28500	Rev BB	140776.00	927.50	950.46	946.10	952.50	0.010938	11.99	13039.30	1039.52	0.51
Project	28280	Rev BB	140776.00	926.00	949.82	940.43	950.81	0.003962	8.71	18177.10	1003.89	0.32
Project	28080	Rev BB	140776.00	925.00	949.08	938.55	950.03	0.003667	8.32	18252.46	945.35	0.31
Project	27925	Rev BB	140776.00	924.00	948.08	939.25	949.34	0.004899	9.61	16137.12	884.88	0.36
Project	27725	Rev BB	140776.00	923.00	946.11	939.71	948.04	0.007805	11.87	13307.67	811.81	0.45
Project	27545	Rev BB	140776.00	922.00	944.30	937.76	946.51	0.009174	12.41	12580.74	852.53	0.49
Project	27335	Rev BB	140776.00	921.00	943.00	936.32	944.66	0.007204	10.87	14331.54	937.22	0.43
Project	27155	Rev BB	140776.00	920.50	941.47	935.68	943.23	0.008132	11.39	14013.66	978.05	0.45
Project	26990	Rev BB	140776.00	920.00	940.42	933.69	941.79	0.007553	9.43	15133.02	1020.89	0.42
Project	26780	Rev BB	140776.00	918.00	939.32	931.66	940.39	0.005229	8.76	17337.33	1106.54	0.36
Project	26575	Rev BB	140776.00	917.00	938.54	929.98	939.36	0.004267	7.26	19508.54	1243.55	0.32
Project	26355	Rev BB	140776.00	916.00	937.64	929.39	938.43	0.004072	7.43	20021.06	1294.51	0.32
Project	26170	Rev BB	140776.00	915.00	936.93	928.73	937.71	0.003759	7.69	20464.75	1301.20	0.31
Project	25965	Rev BB	140776.00	914.00	936.21	927.72	936.96	0.003524	7.51	20897.77	1313.23	0.30
Project	25785	Rev BB	140776.00	913.50	935.53	926.61	936.29	0.003475	7.49	20670.97	1256.91	0.30
Project	25600	Rev BB	140776.00	912.50	934.78	925.61	935.61	0.003744	7.77	19592.25	1149.92	0.31
Project	25425	Rev BB	140776.00	911.00	934.12	924.40	934.93	0.003804	7.28	19499.23	1138.28	0.31
Project	25215	Rev BB	140776.00	910.00	933.33	923.65	934.14	0.003786	7.28	19489.43	1133.64	0.31
Project	25000	Rev BB	140776.00	909.00	932.49	922.49	933.32	0.003701	7.33	19370.94	1093.78	0.30
Project	24795	Rev BB	140776.00	908.00	931.50	921.80	932.49	0.004350	8.01	17745.99	986.47	0.33
Project	24550	Rev BB	140776.00	906.00	930.07	920.91	931.29	0.005312	8.89	16012.83	887.13	0.36
Project	24335	Rev BB	140776.00	905.00	928.51	920.00	930.01	0.006539	9.87	14423.97	800.25	0.40
Project	24115	Rev BB	140776.00	904.00	927.00	918.67	928.55	0.006726	10.04	14198.88	793.23	0.41
Project	23975	Rev BB	140776.00	903.50	926.14	917.71	927.59	0.006337	9.71	14687.95	828.21	0.40
Project	23755	Rev BB	140776.00	902.00	924.71	916.73	926.18	0.006617	9.86	14864.52	939.24	0.41
Project	23565	Rev BB	140776.00	900.00	923.57	915.55	924.91	0.006257	9.40	15381.71	941.49	0.39
Project	23365	Rev BB	140776.00	900.00	922.44	914.69	923.69	0.005846	9.37	16064.14	987.42	0.38
Project	23180	Rev BB	140776.00	899.00	921.46	913.15	922.64	0.005042	9.55	16653.38	975.52	0.36
Project	23000	Rev BB	140776.00	898.00	920.04	911.13	921.44	0.008933	9.48	14845.64	784.00	0.38
Project	22790	Rev BB	140776.00	897.50	917.49	910.49	919.22	0.012226	10.55	13340.82	784.00	0.45
Project	22600	Rev BB	140776.00	896.00	915.78	909.80	917.24	0.008268	10.17	14841.19	1050.23	0.45
Project	22415	Rev BB	140776.00	895.50	914.43	908.00	915.72	0.007649	9.33	15555.24	1091.58	0.42
Project	22195	Rev BB	141426.00	894.00	913.05	906.82	914.10	0.006704	8.42	17691.91	1463.96	0.39
Project	22010	Rev BB	141426.00	892.00	911.36	906.34	912.70	0.008118	9.77	15883.23	1735.05	0.44
Project	21790	Rev BB	141426.00	891.50	909.92	904.80	911.00	0.006786	9.03	18446.60	1778.41	0.40
Project	21615	Rev BB	141426.00	892.00	908.91	902.67	909.82	0.005937	7.96	19349.10	1687.67	0.37
Project	21440	Rev BB	141426.00	890.00	907.84	901.64	908.76	0.005947	8.18	19246.72	1652.97	0.37
Project	21225	Rev BB	141426.00	888.00	906.65	900.86	907.52	0.005590	8.04	19593.15	1600.82	0.36
Project	21020	Rev BB	141426.00	887.00	905.64	898.87	906.47	0.004588	7.78	20476.53	1607.44	0.33
Project	20845	Rev BB	141426.00	886.00	904.74	898.73	905.59	0.005266	7.87	19957.19	1605.07	0.35
Project	20595	Rev BB	141426.00	885.00	903.62	896.85	904.38	0.004470	7.54	20997.42	1600.38	0.33
Project	20435	Rev BB	141426.00	884.00	902.82	896.35	903.63	0.004789	7.88	20533.92	1613.47	0.34
Project	20280	Rev BB	141426.00	883.70	901.75	896.49	902.72	0.006590	8.68	18742.02	1636.29	0.39
Project	20070	Rev BB	141426.00	882.00	900.58	894.65	901.48	0.005609	8.31	19907.01	1797.75	0.37
Project	19855	Rev BB	141426.00	880.50	899.60	892.94	900.37	0.004492	7.67	21440.38	1809.58	0.33
Project	19630	Rev BB	141426.00	880.00	898.64	890.50	899.40	0.004164	7.38	21715.34	1833.73	0.32
Project	19440	Rev BB	141426.00	878.00	897.86	889.68	898.60	0.004126	7.19	22046.05	1986.11	0.31
Project	19240	Rev BB	141426.00	877.50	896.87	889.35	897.70	0.004758	7.58	20444.11	1737.98	0.34
Project	19050	Rev BB	141426.00	876.00	896.19	887.89	896.86	0.003748	6.72	22459.06	1753.41	0.30
Project	18830	Rev BB	141426.00	874.00	895.35	887.44	896.02	0.003931	6.84	22235.02	1684.04	0.31
Project	18650	Rev BB	141426.00	873.50	894.72	886.84	895.34	0.003526	6.73	22990.32	1686.19	0.29
Project	18475	Rev BB	141426.00	872.00	894.25	885.04	894.75	0.002797	5.78	24928.99	1665.89	0.26
Project	18290	Rev BB	141426.00	871.50	893.60	885.13	894.19	0.003383	6.31	23260.68	1631.88	0.28
Project	18025	Rev BB	141426.00	870.00	892.85	882.94	893.37	0.002605	5.82	24748.10	1557.41	0.25
Project	17785	Rev BB	141426.00	868.00	892.02	882.78	892.66	0.003309	6.43	22237.59	1444.07	0.28
Project	17510	Rev BB	141426.00	868.00	890.43	883.27	891.45	0.005785	8.40	18121.15	1398.94	0.37
Project	17360	Rev BB	141426.00	868.00	888.28	883.91	890.13	0.012863	11.10	13512.13	1303.31	0.53
Project	17110	Rev BB	141426.00	864.00	885.50	881.46	887.17	0.010479	11.03	14389.15	1229.58	0.50
Project	16970	Rev BB	141426.00	863.70	883.96	879.78	885.60	0.010995	10.74	14212.17	1195.98	0.50
Project	16720	Rev BB	141426.00	863.50	882.28	875.41	883.38	0.006484	8.47	16891.55	1182.04	0.39
Project	16515	Rev BB	141426.00	862.00	881.23	873.86	882.13	0.005324	7.67	18660.39	1303.83	0.35
Project	16305	Rev BB	141426.00	860.00	880.38	872.14	881.10	0.004083	7.10	20814.07	1395.48	0.31
Project	16130	Rev BB	141426.00	860.00	879.38	872.31	880.25	0.005470	7.68	18966.94	1368.87	0.35
Project	15960	Rev BB	141426.00	859.00	878.56	870.96	879.32	0.004714	7.06	20250.69	1437.55	0.33
Project	15745	Rev BB	141426.00	858.00	877.56	869.77	878.32	0.004657	7.03	20125.55	1401.31	0.33
Project	15540	Rev BB	141426.00	857.50	876.69	868.51	877.36	0.004308	6.61	21873.23	2361.20	0.31
Project	15335	Rev BB	141426.00	856.00	874.77	868.08	876.01	0.010129	8.92	15846.59	1064.14	0.41
Project	15125	Rev BB	142475.00	854.00	871.99	866.25	873.49	0.013374	9.80	14531.32	1053.51	0.47
Project	14900	Rev BB	142475.00	853.00	869.74	864.23	870.94	0.008488	8.83	16644.53	2233.10	0.43
Project	14720	Rev BB	142475.00	852.00	868.35	862.97	869.45	0.008069	8.54	17440.60	2020.85	0.42
Project	14480	Rev BB	142475.00	850.50	866.91	860.83	867.72	0.005898	7.39	19912.22	1851.81	0.36
Project	14315	Rev BB	142475.00	850.00	866.04	859.99	866.75	0.005537	6.77	21071.02	1944.13	0.35
Project	14090	Rev BB	142475.00	850.00	864.80	858.71	865.50	0.005413	6.72	21309.57	1816.18	0.34
Project	13850	Rev BB	142475.00	848.00	863.60	857.10	864.27	0.004956	6.60	21684.38	1774.85	0.33

HEC-RAS Plan: Pr085LevCode River: SCR Reach: Project Profile: Rev BB (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	13635	Rev BB	142475.00	846.00	862.52	856.29	863.21	0.004839	7.34	21858.75	1817.99	0.34
Project	13425	Rev BB	142475.00	845.00	861.81	854.24	862.31	0.003346	5.70	25084.97	1936.05	0.28
Project	13190	Rev BB	142475.00	844.00	861.11	852.80	861.58	0.002886	5.56	26195.39	1911.13	0.26
Project	13030	Rev BB	142475.00	843.00	860.64	852.23	861.12	0.002842	6.01	26034.42	1863.68	0.26
Project	12835	Rev BB	142475.00	842.00	860.03	851.20	860.54	0.002909	6.16	25313.27	1775.13	0.27
Project	12615	Rev BB	142475.00	841.00	859.33	850.10	859.90	0.002952	6.51	23997.77	1566.52	0.27
Project	12395	Rev BB	142475.00	840.00	858.66	849.52	859.26	0.003032	6.71	23513.12	1542.96	0.28
Project	12195	Rev BB	142475.00	838.98	858.07	848.24	858.67	0.002825	6.46	23478.39	1463.74	0.27
Project	11995	Rev BB	142475.00	837.00	857.31	848.45	858.03	0.003521	7.40	21763.81	1448.52	0.30
Project	11780	Rev BB	142475.00	836.00	856.59	848.11	857.28	0.003385	7.33	22140.13	1460.82	0.29
Project	11605	Rev BB	142475.00	835.50	855.78	847.45	856.62	0.004035	7.93	20373.82	1417.47	0.32
Project	11405	Rev BB	142475.00	834.00	854.62	846.17	855.70	0.004843	8.65	17696.63	1144.88	0.35
Project	11180	Rev BB	142475.00	833.00	852.66	845.62	854.32	0.007682	10.68	14475.94	1009.18	0.44
Project	11015	Rev BB	142475.00	831.50	850.24	844.78	852.64	0.011984	12.57	11805.37	850.96	0.54
Project	10835	Rev BB	142475.00	831.00	848.05	843.71	850.33	0.013479	12.24	12146.77	1072.95	0.57
Project	10575	Rev BB	142475.00	830.00	846.10	840.15	847.39	0.008015	9.14	15843.91	1322.18	0.43
Project	10390	Rev BB	142475.00	828.00	845.09	839.04	846.04	0.005680	8.63	19054.95	1516.98	0.37
Project	10225	Rev BB	142475.00	827.50	844.10	838.16	845.05	0.006403	7.96	18553.74	1543.40	0.39
Project	10000	Rev BB	142475.00	826.00	842.55	837.14	843.54	0.006984	8.14	18351.48	1626.01	0.40
Project	9820	Rev BB	142475.00	824.00	841.35	835.33	842.31	0.006527	7.91	18387.37	1648.84	0.39
Project	9595	Rev BB	142475.00	823.80	839.87	834.12	840.80	0.006938	7.76	18438.52	1719.61	0.39
Project	9385	Rev BB	142475.00	823.00	838.58	833.15	839.36	0.006233	7.21	20157.06	1799.30	0.37
Project	9220	Rev BB	142475.00	822.00	837.62	831.81	838.34	0.005586	6.82	21094.14	1853.43	0.35
Project	9025	Rev BB	142475.00	821.00	836.62	830.56	837.33	0.005004	7.02	21529.03	1822.90	0.34

HEC-RAS Plan: FinalPr085Q2 River: SCR Reach: Project Profile: Old 2-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	46195	Old 2-Year	1890.00	1035.00	1037.91	1036.89	1038.13	0.015238	3.78	500.66	215.66	0.44
Project	46020	Old 2-Year	1890.00	1032.00	1036.93		1037.04	0.003252	2.65	712.22	162.70	0.22
Project	45545	Old 2-Year	1890.00	1030.00	1033.60		1033.93	0.018551	4.61	409.79	151.31	0.49
Project	45030	Old 2-Year	1890.00	1025.00	1029.15		1029.27	0.005278	2.71	696.88	222.55	0.27
Project	44585	Old 2-Year	1890.00	1022.00	1026.44		1026.61	0.006748	3.30	573.02	163.72	0.31
Project	44210	Old 2-Year	1890.00	1020.00	1024.34		1024.46	0.004860	2.74	690.38	204.32	0.26
Project	43820	Old 2-Year	1890.00	1018.00	1022.15		1022.28	0.006434	2.95	639.61	207.81	0.30
Project	43610	Old 2-Year	1890.00	1017.00	1020.53		1020.69	0.009508	3.13	604.25	242.11	0.35
Project	43410	Old 2-Year	1890.00	1016.00	1018.91		1019.01	0.007189	2.60	728.11	312.76	0.30
Project	43200	Old 2-Year	1890.00	1014.00	1017.48		1017.58	0.006627	2.55	741.60	308.38	0.29
Project	42975	Old 2-Year	1890.00	1012.00	1016.15		1016.22	0.005389	2.14	885.14	410.54	0.26
Project	42815	Old 2-Year	1890.00	1011.00	1014.97		1015.07	0.009716	2.63	718.89	380.39	0.34
Project	42590	Old 2-Year	1890.00	1010.00	1012.84		1012.93	0.009456	2.44	776.10	451.85	0.33
Project	42430	Old 2-Year	1890.00	1008.00	1011.51		1011.59	0.007090	2.25	841.78	445.90	0.29
Project	42215	Old 2-Year	1890.00	1006.00	1010.16		1010.23	0.005773	2.03	931.90	493.19	0.26
Project	41940	Old 2-Year	1890.00	1005.00	1008.54		1008.61	0.006087	2.13	887.58	454.20	0.27
Project	41730	Old 2-Year	1890.00	1004.00	1007.19		1007.27	0.006523	2.28	829.64	404.14	0.28
Project	41460	Old 2-Year	1890.00	1002.00	1005.76		1005.83	0.004561	2.13	887.64	365.67	0.24
Project	41280	Old 2-Year	1890.00	1001.00	1005.01		1005.07	0.003862	2.08	909.07	342.38	0.22
Project	41080	Old 2-Year	1890.00	1000.00	1004.20		1004.26	0.004239	1.95	967.43	429.50	0.23
Project	40825	Old 2-Year	1890.00	999.50	1003.20		1003.25	0.003716	1.88	1004.29	426.62	0.22
Project	40585	Old 2-Year	1890.00	998.00	1001.67		1001.78	0.011310	2.69	703.54	404.25	0.36
Project	40335	Old 2-Year	1890.00	996.00	1000.27		1000.32	0.003588	1.92	986.15	397.20	0.21
Project	40130	Old 2-Year	1890.00	995.00	999.43		999.51	0.004294	2.23	848.05	311.26	0.24
Project	39945	Old 2-Year	1890.00	994.00	998.41		998.51	0.006997	2.64	715.84	293.75	0.30
Project	39755	Old 2-Year	1890.00	994.00	997.40		997.48	0.004217	2.26	836.14	296.67	0.24
Project	39605	Old 2-Year	1890.00	993.00	996.67		996.75	0.005898	2.34	806.62	348.84	0.27
Project	39310	Old 2-Year	1890.00	992.00	994.61		994.72	0.007964	2.64	715.15	323.42	0.31
Project	39100	Old 2-Year	1890.00	990.00	993.54		993.60	0.003849	1.89	1002.44	436.50	0.22
Project	38925	Old 2-Year	1890.00	989.50	992.72		992.79	0.005552	2.13	886.43	422.32	0.26
Project	38710	Old 2-Year	1890.00	988.00	991.78		991.83	0.003563	1.92	986.07	394.93	0.21
Project	38475	Old 2-Year	1890.00	986.00	990.40		990.51	0.010472	2.70	698.92	375.05	0.35
Project	38300	Old 2-Year	1890.00	985.50	988.59		988.70	0.010144	2.59	729.16	407.55	0.34
Project	38065	Old 2-Year	1890.00	984.00	987.34		987.38	0.003437	1.64	1152.45	569.04	0.20
Project	37810	Old 2-Year	1890.00	983.00	986.36		986.41	0.004187	1.77	1069.34	546.75	0.22
Project	37655	Old 2-Year	1890.00	982.00	984.96		985.14	0.020993	3.43	551.19	348.91	0.48
Project	37390	Old 2-Year	1890.00	981.00	983.18		983.21	0.003538	1.44	1311.43	803.34	0.20
Project	37135	Old 2-Year	1890.00	980.00	981.39		981.50	0.017325	2.67	706.87	564.00	0.42
Project	36930	Old 2-Year	1890.00	978.00	980.01		980.05	0.003777	1.55	1222.97	708.31	0.21
Project	36735	Old 2-Year	1890.00	977.00	978.86		978.93	0.009234	2.11	894.38	633.76	0.31
Project	36515	Old 2-Year	1890.00	975.00	977.99		978.03	0.002321	1.50	1262.13	532.09	0.17
Project	36265	Old 2-Year	1890.00	974.00	977.31	975.21	977.36	0.003084	1.87	1012.76	358.97	0.20
Project	36080	Old 2-Year	2560.00	973.00	976.09	974.81	976.25	0.011403	3.25	786.96	326.32	0.37
Project	35845	Old 2-Year	2560.00	971.00	974.77	972.71	974.85	0.003562	2.21	1159.46	376.20	0.22
Project	35725	Old 2-Year	2560.00	970.00	974.29	972.29	974.37	0.004300	2.33	1098.42	378.19	0.24
Project	35515	Old 2-Year	2560.00	969.00	973.38	971.33	973.47	0.004507	2.37	1080.19	379.27	0.25
Project	35245	Old 2-Year	2560.00	968.00	971.89	970.49	971.99	0.006692	2.57	997.32	414.32	0.29
Project	35040	Old 2-Year	2560.00	967.00	970.93		970.99	0.003523	2.07	1239.42	440.94	0.22
Project	34860	Old 2-Year	2560.00	966.00	969.93		970.05	0.009090	2.76	926.06	432.92	0.33
Project	34720	Old 2-Year	2560.00	965.50	968.74		968.83	0.007930	2.47	1036.23	545.61	0.32
Project	34495	Old 2-Year	2560.00	964.00	966.78		966.89	0.009606	2.75	931.32	504.60	0.36
Project	34310	Old 2-Year	2560.00	963.00	965.77		965.81	0.003675	1.75	1458.94	684.48	0.21
Project	34090	Old 2-Year	2560.00	962.00	964.74		964.80	0.006084	1.93	1325.42	787.51	0.26
Project	33880	Old 2-Year	2560.00	960.00	963.55		963.61	0.005405	1.89	1354.42	761.04	0.25
Project	33710	Old 2-Year	2560.00	959.00	962.24		962.33	0.010559	2.36	1084.35	719.21	0.34
Project	33500	Old 2-Year	2560.00	958.00	960.64		960.70	0.005886	2.04	1255.57	666.42	0.26
Project	33310	Old 2-Year	2560.00	957.00	959.35		959.43	0.007811	2.31	1108.79	609.86	0.30
Project	33115	Old 2-Year	2560.00	956.00	958.44		958.48	0.003169	1.69	1512.33	667.75	0.20
Project	32795	Old 2-Year	2560.00	954.00	957.22		957.27	0.004740	1.88	1359.22	697.56	0.24
Project	32605	Old 2-Year	2560.00	952.00	956.11	954.72	956.18	0.006829	2.15	1189.09	652.84	0.28
Project	32265	Old 2-Year	2579.00	950.00	953.86		953.93	0.006524	2.14	1205.44	650.99	0.28
Project	31875	Old 2-Year	2579.00	949.00	951.51		951.58	0.005551	2.15	1196.97	562.04	0.26
Project	31585	Old 2-Year	2579.00	946.00	949.72		949.80	0.006960	2.22	1162.94	619.45	0.29
Project	31360	Old 2-Year	2579.00	944.00	948.39		948.45	0.005040	1.95	1324.53	672.21	0.24
Project	31060	Old 2-Year	2579.00	942.00	946.38		946.44	0.009465	2.04	1261.20	954.95	0.31
Project	30720	Old 2-Year	2579.00	940.00	944.28		944.33	0.004358	1.76	1462.57	772.68	0.23
Project	30445	Old 2-Year	2579.00	938.00	942.33		942.43	0.012745	2.53	1019.12	700.89	0.37
Project	30095	Old 2-Year	2579.00	936.00	940.09		940.14	0.003925	1.87	1379.29	617.14	0.22
Project	29815	Old 2-Year	2579.00	935.00	938.67		938.75	0.006532	2.28	1131.43	551.12	0.28
Project	29565	Old 2-Year	2579.00	934.00	937.89		937.94	0.001867	1.68	1535.99	461.78	0.16
Project	29385	Old 2-Year	2579.00	933.00	937.50		937.56	0.002342	1.94	1329.77	381.52	0.18
Project	29140	Old 2-Year	2579.00	932.00	936.43		936.61	0.007369	3.43	752.83	217.19	0.32
Project	28895	Old 2-Year	2579.00	930.00	934.06		934.32	0.012370	4.12	625.43	201.92	0.41
Project	28695	Old 2-Year	2579.00	928.00	932.41		932.55	0.006312	3.00	858.70	269.57	0.30

HEC-RAS Plan: FinalPr085Q2 River: SCR Reach: Project Profile: Old 2-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	28500	Old 2-Year	2579.00	927.50	930.64		930.83	0.013053	3.46	744.75	326.01	0.40
Project	28280	Old 2-Year	2579.00	926.00	929.34		929.42	0.003716	2.24	1153.51	379.14	0.23
Project	28080	Old 2-Year	2579.00	925.00	928.39		928.49	0.005850	2.47	1045.43	416.63	0.27
Project	27925	Old 2-Year	2579.00	924.00	927.29		927.41	0.008266	2.78	929.01	401.99	0.32
Project	27725	Old 2-Year	2579.00	923.00	926.41		926.48	0.002905	2.06	1251.38	386.18	0.20
Project	27545	Old 2-Year	2579.00	922.00	925.57		925.68	0.007542	2.68	962.13	409.60	0.31
Project	27335	Old 2-Year	2579.00	921.00	924.70		924.76	0.002863	1.98	1303.00	422.52	0.20
Project	27155	Old 2-Year	2579.00	920.50	924.11		924.18	0.003567	2.06	1253.19	452.43	0.22
Project	26990	Old 2-Year	2579.00	920.00	923.23		923.34	0.007365	2.58	998.42	440.86	0.30
Project	26780	Old 2-Year	2579.00	918.00	922.06		922.12	0.004625	2.09	1232.77	527.47	0.24
Project	26575	Old 2-Year	2579.00	917.00	921.36		921.41	0.002731	1.80	1428.90	513.48	0.19
Project	26355	Old 2-Year	2579.00	916.00	920.25		920.35	0.010678	2.55	1010.81	601.37	0.35
Project	26170	Old 2-Year	2579.00	915.00	918.95		919.03	0.004998	2.26	1138.73	457.77	0.25
Project	25965	Old 2-Year	2579.00	914.00	917.91		917.98	0.005300	2.11	1219.50	568.37	0.25
Project	25785	Old 2-Year	2579.00	913.50	916.92		916.99	0.005668	2.19	1180.20	550.88	0.26
Project	25600	Old 2-Year	2579.00	912.50	915.89		915.97	0.005355	2.27	1134.24	478.13	0.26
Project	25425	Old 2-Year	2579.00	911.00	915.17		915.24	0.003240	2.10	1227.81	399.76	0.21
Project	25215	Old 2-Year	2579.00	910.00	914.27		914.36	0.005813	2.40	1074.83	444.58	0.27
Project	25000	Old 2-Year	2579.00	909.00	912.98		913.07	0.005874	2.39	1079.92	453.08	0.27
Project	24795	Old 2-Year	2579.00	908.00	911.61		911.73	0.007563	2.73	944.18	391.43	0.31
Project	24550	Old 2-Year	2579.00	906.00	910.48		910.55	0.003221	2.25	1145.29	334.03	0.21
Project	24335	Old 2-Year	2579.00	905.00	909.47		909.59	0.006748	2.80	921.17	337.18	0.30
Project	24115	Old 2-Year	2579.00	904.00	908.17		908.26	0.005327	2.38	1081.54	422.65	0.26
Project	23975	Old 2-Year	2579.00	903.50	907.53		907.62	0.004000	2.35	1097.95	354.12	0.24
Project	23755	Old 2-Year	2579.00	902.00	906.40		906.52	0.006481	2.78	927.91	333.89	0.29
Project	23565	Old 2-Year	2579.00	900.00	905.26		905.37	0.005523	2.69	959.86	322.21	0.27
Project	23365	Old 2-Year	2579.00	900.00	903.62		903.79	0.012255	3.38	762.28	329.38	0.39
Project	23180	Old 2-Year	2579.00	899.00	902.44		902.52	0.004160	2.26	1140.20	400.70	0.24
Project	23000	Old 2-Year	2579.00	898.00	901.59	899.90	901.68	0.005269	2.36	1092.83	407.55	0.25
Project	22790	Old 2-Year	2579.00	897.50	900.64	898.70	900.71	0.004049	2.14	1205.95	425.48	0.22
Project	22600	Old 2-Year	2579.00	896.00	899.82		899.90	0.004491	2.35	1098.28	386.74	0.25
Project	22415	Old 2-Year	2579.00	895.50	898.79		898.89	0.006713	2.56	1008.46	422.32	0.29
Project	22195	Old 2-Year	2615.00	894.00	897.39	895.49	897.50	0.006042	2.62	997.20	371.33	0.28
Project	22010	Old 2-Year	2615.00	892.00	896.38	894.30	896.46	0.005123	2.27	1152.71	471.79	0.26
Project	21790	Old 2-Year	2615.00	891.50	895.21	893.51	895.28	0.005615	2.19	1192.80	549.87	0.26
Project	21615	Old 2-Year	2615.00	892.00	894.04	892.93	894.13	0.007898	2.41	1086.74	563.09	0.31
Project	21440	Old 2-Year	2615.00	890.00	893.15	891.46	893.20	0.003663	1.81	1441.09	638.87	0.21
Project	21225	Old 2-Year	2615.00	888.00	891.23		891.51	0.028226	4.25	615.04	352.44	0.57
Project	21020	Old 2-Year	2615.00	887.00	890.38		890.41	0.001985	1.48	1767.94	674.99	0.16
Project	20845	Old 2-Year	2615.00	886.00	889.71		889.79	0.007590	2.30	1137.99	613.69	0.30
Project	20595	Old 2-Year	2615.00	885.00	888.64		888.68	0.002939	1.60	1635.44	744.48	0.19
Project	20435	Old 2-Year	2615.00	884.00	888.20		888.24	0.002508	1.55	1694.90	765.16	0.18
Project	20280	Old 2-Year	2615.00	883.70	887.45		887.56	0.008806	2.74	953.06	439.60	0.33
Project	20070	Old 2-Year	2615.00	882.00	885.67		885.76	0.008458	2.39	1093.59	602.40	0.31
Project	19855	Old 2-Year	2615.00	880.50	883.89		883.98	0.008030	2.38	1098.93	585.89	0.31
Project	19630	Old 2-Year	2615.00	880.00	882.69		882.75	0.003932	1.86	1405.32	634.15	0.22
Project	19440	Old 2-Year	2615.00	878.00	881.58		881.67	0.008585	2.52	1038.97	536.33	0.32
Project	19240	Old 2-Year	2615.00	877.50	880.22		880.31	0.005501	2.37	1102.54	445.37	0.27
Project	19050	Old 2-Year	2615.00	876.00	879.24		879.32	0.004990	2.36	1106.97	418.07	0.26
Project	18830	Old 2-Year	2615.00	874.00	878.02		878.13	0.005974	2.71	964.36	338.85	0.28
Project	18650	Old 2-Year	2615.00	873.50	877.00		877.11	0.005378	2.62	996.29	339.65	0.27
Project	18475	Old 2-Year	2615.00	872.00	876.05		876.16	0.005337	2.63	995.12	336.63	0.27
Project	18290	Old 2-Year	2615.00	871.50	874.69		874.84	0.010316	3.10	843.58	365.13	0.36
Project	18025	Old 2-Year	2615.00	870.00	873.68		873.73	0.002122	1.89	1380.64	380.36	0.18
Project	17785	Old 2-Year	2615.00	868.00	872.98		873.06	0.003941	2.26	1154.93	389.34	0.23
Project	17510	Old 2-Year	2615.00	868.00	872.05		872.13	0.002996	2.24	1169.03	326.32	0.21
Project	17360	Old 2-Year	2615.00	868.00	871.07		871.31	0.012005	3.93	665.30	223.64	0.40
Project	17110	Old 2-Year	2615.00	864.00	868.91		869.08	0.006728	3.29	795.78	228.67	0.31
Project	16970	Old 2-Year	2615.00	863.70	868.19		868.31	0.004247	2.83	925.23	235.74	0.25
Project	16720	Old 2-Year	2615.00	863.50	866.70		866.87	0.008244	3.32	788.14	259.99	0.34
Project	16515	Old 2-Year	2615.00	862.00	865.03		865.19	0.008355	3.16	827.01	296.50	0.33
Project	16305	Old 2-Year	2615.00	860.00	864.16		864.24	0.002729	2.23	1170.34	304.58	0.20
Project	16130	Old 2-Year	2615.00	860.00	863.65		863.73	0.003146	2.28	1149.27	323.40	0.21
Project	15960	Old 2-Year	2615.00	859.00	862.83		862.96	0.006569	2.95	886.96	294.64	0.30
Project	15745	Old 2-Year	2615.00	858.00	861.57		861.69	0.005376	2.77	942.80	295.79	0.27
Project	15540	Old 2-Year	2615.00	857.50	860.42		860.54	0.005933	2.69	973.68	344.87	0.28
Project	15335	Old 2-Year	2615.00	856.00	858.93	857.51	859.06	0.008876	2.96	883.23	348.62	0.33
Project	15125	Old 2-Year	2860.00	854.00	857.46	855.66	857.55	0.005871	2.47	1157.62	437.27	0.27
Project	14900	Old 2-Year	2860.00	853.00	856.46	854.54	856.52	0.003502	1.93	1485.15	584.08	0.21
Project	14720	Old 2-Year	2860.00	852.00	855.59	853.72	855.68	0.006668	2.42	1180.14	532.85	0.29
Project	14480	Old 2-Year	2860.00	850.50	854.75	852.03	854.79	0.002326	1.49	1922.76	819.84	0.17
Project	14315	Old 2-Year	2860.00	850.00	854.21	851.61	854.25	0.004653	1.68	1700.67	1014.44	0.23
Project	14090	Old 2-Year	2860.00	850.00	852.66		852.75	0.010069	2.35	1218.98	787.44	0.33
Project	13850	Old 2-Year	2860.00	848.00	850.86		850.94	0.006075	2.27	1257.27	582.65	0.27

HEC-RAS Plan: FinalPr085Q2 River: SCR Reach: Project Profile: Old 2-Year (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Project	13635	Old 2-Year	2860.00	846.00	849.24		849.34	0.009079	2.49	1150.83	631.20	0.32
Project	13425	Old 2-Year	2860.00	845.00	847.99		848.06	0.004376	2.08	1376.44	576.31	0.24
Project	13190	Old 2-Year	2860.00	844.00	846.80		846.87	0.005939	2.08	1372.94	713.93	0.26
Project	13030	Old 2-Year	2860.00	843.00	845.94		846.00	0.004971	1.98	1447.37	712.89	0.24
Project	12835	Old 2-Year	2860.00	842.00	844.65		844.73	0.008829	2.24	1275.31	799.35	0.31
Project	12615	Old 2-Year	2860.00	841.00	843.18		843.24	0.005214	2.01	1441.76	741.83	0.25
Project	12395	Old 2-Year	2860.00	840.00	842.18		842.23	0.004143	1.84	1550.30	738.12	0.22
Project	12195	Old 2-Year	2860.00	838.98	841.22		841.27	0.005672	1.80	1586.99	990.77	0.25
Project	11995	Old 2-Year	2860.00	837.00	840.22		840.29	0.004132	2.02	1417.82	589.38	0.23
Project	11780	Old 2-Year	2860.00	836.00	839.08		839.17	0.006773	2.34	1223.34	590.36	0.29
Project	11605	Old 2-Year	2860.00	835.50	837.77		837.86	0.008568	2.51	1137.88	587.56	0.32
Project	11405	Old 2-Year	2860.00	834.00	836.57		836.64	0.004482	2.08	1372.55	579.74	0.24
Project	11180	Old 2-Year	2860.00	833.00	835.42		835.50	0.006001	2.27	1257.17	580.18	0.27
Project	11015	Old 2-Year	2860.00	831.50	834.75		834.81	0.002883	1.91	1494.85	519.83	0.20
Project	10835	Old 2-Year	2860.00	831.00	834.02		834.10	0.005665	2.35	1216.98	510.40	0.27
Project	10575	Old 2-Year	2860.00	830.00	831.82		831.96	0.013152	2.97	962.14	534.53	0.39
Project	10390	Old 2-Year	2860.00	828.00	831.18		831.22	0.001762	1.55	1842.61	598.09	0.16
Project	10225	Old 2-Year	2860.00	827.50	830.73		830.80	0.004206	2.00	1427.18	606.87	0.23
Project	10000	Old 2-Year	2860.00	826.00	829.55		829.62	0.006592	2.18	1309.06	685.26	0.28
Project	9820	Old 2-Year	2860.00	824.00	828.47	826.85	828.53	0.005488	1.97	1449.29	773.35	0.25
Project	9595	Old 2-Year	2860.00	823.80	827.53	825.68	827.58	0.003431	1.78	1604.52	698.10	0.21
Project	9385	Old 2-Year	2860.00	823.00	826.62		826.68	0.005423	2.05	1395.31	693.99	0.25
Project	9220	Old 2-Year	2860.00	822.00	825.09		825.22	0.015979	2.92	979.72	645.06	0.42
Project	9025	Old 2-Year	2860.00	821.00	823.54	822.03	823.62	0.005003	2.22	1290.81	537.58	0.25

Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.3

Modeling CD-ROM

1) HEC-RAS Existing Conditions In/Out File
2) HEC-RAS Proposed Conditions In/Out File
3) HEC-2 Existing Conditions In/Out File
4) HEC-2 Proposed Conditions In/Out File
5) SAM Existing Conditions In/Out File
6) SAM Proposed Conditions In/Out File
7) WSE at Santa Clara River Confluence Existing
8) WSE at Santa Clara River Confluence Proposed

PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

For Modeling CD contents, see
“Appendix Chapter 4.3” folder within
“PDF Files” folder.

Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.4

Existing & Proposed Conditions HEC-RAS Velocity And Water Surface Elevation

Proposed Conditions HEC-RAS To SAM **Conversion Analysis**

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A4.4A: Santa Clara River Existing & Proposed Conditions HEC-RAS Velocity & WSE [1]					
Subreach	HEC-RAS Station	Existing (QCAP) Velocity (fps)	Existing (QCAP) WSE (ft)	Proposed (QCAP) Velocity (fps)	Proposed (QCAP) WSE (ft)
SRA1	46195	19.7	1054.3	19.7	1054.3
	46020	19.1	1052.4	19.1	1052.4
	45545	20.3	1049.2	20.3	1049.2
	45030	17.8	1045.6	17.8	1045.6
	44585	19.2	1043.1	19.2	1043.1
	44210	14.8	1041.6	14.8	1041.6
SRA2	43820	19.9	1037.5	19.9	1037.5
	43610	19.7	1034.1	19.7	1034.1
	43410	18.2	1030.7	18.1	1030.7
	43200	17.3	1029.3	17.2	1029.3
	42975	16.3	1026.1	16.3	1026.1
	42815	15.3	1024.3	15.4	1024.4
	42590	15.0	1021.3	15.1	1021.5
	42430	15.5	1019.6	15.6	1020.3
	42215	10.2	1020.4	12.7	1019.7
	41940	11.2	1019.5	11.6	1019.3
	41730	11.4	1018.9	11.8	1018.7
	41460	11.3	1018.3	11.7	1018.1
SRA3	41280	16.4	1015.3	16.4	1015.3
	41080	16.1	1013.6	16.0	1013.6
	40825	14.8	1012.2	15.0	1012.1
	40585	14.8	1010.6	14.9	1010.6
	40335	11.0	1010.4	10.7	1011.0
	40130	10.4	1010.0	11.1	1010.4
	39945	9.5	1009.8	10.7	1010.2
	39755	14.4	1007.3	16.1	1007.2
	39605	14.7	1005.7	16.2	1005.8
	39310	14.7	1004.1	15.9	1004.4
	39100	11.2	1004.2	14.2	1003.7
	38925	10.9	1003.9	12.9	1003.7
SRA4	38710	10.4	1003.7	12.1	1003.6
	38475	16.7	1000.2	17.8	1000.0
	38300	16.5	998.1	17.7	997.9
	38065	14.1	998.2	14.5	998.0
	37810	18.2	995.2	18.2	995.2
	37655	16.8	994.2	17.4	994.1
	37390	15.7	989.9	14.2	991.5
	37135	15.1	988.6	16.6	989.3
	36930	13.3	987.7	15.6	987.9
	36735	14.6	986.4	16.1	986.9
	36515	12.1	986.3	12.8	987.0
	36265	13.1	985.2	12.3	986.5
SRB1	36080	13.7	984.1	14.7	984.6
	35845	11.6	983.9	11.7	984.1
	35725	13.8	982.6	14.1	982.6
	35515	14.0	981.3	14.0	981.3
	35245	13.8	980.1	13.7	980.2
	35040	13.8	978.4	13.9	978.3
	34860	14.0	977.4	14.1	977.4
	34720	13.9	976.2	13.9	976.2
	34495	14.0	974.3	14.0	974.3
	34310	14.3	972.7	14.3	972.6
	34090	14.3	971.6	14.2	971.6
SRB2	33880	14.2	970.5	14.1	970.3
	33710	14.1	969.3	14.0	969.3
	33500	13.1	968.2	13.1	968.1
	33310	12.9	967.0	12.9	967.0

1 - Velocities & WSEs reflect HEC-RAS model modified for fluvial purposes at subcritical flow n=0.025

Table A4.4A: Santa Clara River Existing & Proposed Conditions HEC-RAS Velocity & WSE [1] (ctd)					
	33115	11.3	966.4	10.4	966.6
	32795	12.2	965.0	13.0	964.6
	32605	14.1	963.5	13.1	963.6
SRC1	32265	13.3	961.4	13.4	961.3
	31875	10.9	960.0	12.4	959.4
	31585	11.3	957.7	12.1	957.3
	31360	10.5	957.2	11.5	956.6
	31060	8.4	957.2	9.0	956.6
	30720	6.8	957.3	7.3	956.6
	30445	6.4	957.2	6.8	956.5
	30095	6.8	957.0	7.0	956.3
	29815	7.7	956.6	7.9	955.9
	29565	7.5	956.5	7.7	955.8
	29385	8.5	956.1	8.6	955.5
SRC2	29140	11.5	954.7	10.2	954.8
	28895	16.8	951.6	16.8	951.3
	28695	18.8	947.9	13.3	948.3
	28500	19.8	945.1	16.7	946.0
	28280	20.1	941.7	11.9	943.4
	28080	16.7	942.3	10.9	943.4
	27925	19.1	940.4	12.4	942.6
	27725	19.8	939.3	18.0	939.3
	27545	19.0	937.7	19.1	937.6
	27335	17.3	936.2	17.4	936.2
	27155	16.4	935.4	17.2	935.3
SRC3	26990	15.8	933.7	16.7	933.7
	26780	15.5	931.4	16.3	931.3
	26575	14.2	930.6	14.7	930.4
	26355	15.2	929.2	15.4	929.1
	26170	13.5	928.9	15.3	928.2
	25965	15.2	927.2	15.2	927.3
	25785	15.0	926.1	14.4	926.8
	25600	13.9	924.9	15.0	925.8
	25425	10.3	925.4	14.6	925.3
	25215	13.8	923.3	14.2	924.7
	25000	12.6	922.1	13.1	924.5
SRC4	24795	12.6	920.4	14.0	923.6
	24550	9.7	919.5	15.0	922.5
	24335	13.0	917.6	18.1	920.0
	24115	13.1	915.9	18.2	918.7
	23975	13.3	914.6	18.0	917.7
	23755	13.3	913.3	17.8	916.8
	23565	13.2	912.4	17.4	915.6
	23365	13.6	911.1	16.9	914.4
	23180	10.1	911.0	16.0	913.2
	23000	9.0	910.9	15.3	912.8
	22790	9.5	910.4	18.0	910.5
	22600	9.5	910.1	16.6	909.6
	22415	10.1	909.7	16.3	908.0
SRD1	22195	15.4	906.9	14.2	907.5
	22010	15.1	906.2	15.4	906.1
	21790	14.4	904.9	14.7	904.8
	21615	13.7	903.1	14.8	902.8
	21440	14.6	901.2	15.0	901.6
	21225	12.6	899.8	14.3	900.5
	21020	13.8	897.4	12.3	900.0
	20845	12.5	897.0	14.3	898.4
	20595	11.0	896.4	11.1	898.3

1 - Velocities & WSEs reflect HEC-RAS model modified for fluvial purposes at subcritical flow n=0.025

Table A4.4A: Santa Clara River Existing & Proposed Conditions HEC-RAS Velocity & WSE [1] (ctd)					
	20435	10.3	896.2	10.8	898.1
	20280	12.1	895.0	14.5	896.0
	20070	12.4	892.7	14.4	894.3
SRD2	19855	13.1	891.1	14.3	892.7
	19630	13.2	889.8	14.4	891.5
	19440	10.8	889.9	12.9	891.4
	19240	12.1	888.9	15.6	889.4
	19050	9.6	889.0	12.2	889.4
	18830	9.3	888.7	12.1	888.8
	18650	8.5	888.7	10.8	888.7
	18475	7.7	888.7	8.8	888.9
	18290	8.1	888.4	9.4	888.5
	18025	7.6	888.3	7.8	888.6
	17785	8.5	887.9	8.4	888.3
SRD3	17510	12.3	886.2	10.1	887.5
	17360	16.9	883.4	16.9	884.0
	17110	15.0	881.1	15.7	881.1
	16970	14.4	879.7	15.7	879.6
	16720	14.2	875.3	15.9	875.4
	16515	13.4	873.5	15.4	873.9
	16305	12.6	871.6	11.1	874.5
	16130	13.3	870.5	15.2	872.2
	15960	12.8	869.2	13.7	871.6
	15745	10.9	868.6	12.3	871.3
	15540	10.4	868.1	10.5	871.2
	15335	12.6	866.5	16.2	868.1
SRE1	15125	13.7	864.5	16.6	866.3
	14900	14.0	863.3	16.3	864.2
	14720	13.7	862.1	15.9	863.3
	14480	13.7	860.5	14.5	860.8
	14315	13.5	859.9	14.0	860.1
	14090	13.7	858.7	13.7	858.7
	13850	13.8	857.1	13.9	857.1
	13635	14.0	856.0	14.0	856.0
	13425	13.4	854.6	13.5	854.2
	13190	12.7	853.1	12.3	853.3
SRE2	13030	12.3	852.7	12.0	852.9
	12835	12.1	852.1	11.8	852.3
	12615	11.3	851.8	11.0	852.0
	12395	11.1	851.5	10.9	851.7
	12195	10.1	851.4	10.0	851.6
	11995	11.3	850.7	11.1	850.9
	11780	10.7	850.5	10.4	850.7
	11605	12.0	849.7	11.6	850.0
	11405	12.0	849.4	12.1	849.4
	11180	15.0	847.6	15.2	847.5
SRE3	11015	18.9	844.8	18.9	844.9
	10835	17.7	843.8	17.7	843.8
	10575	16.0	840.2	16.0	840.2
	10390	13.2	839.5	12.7	839.8
	10225	14.7	838.2	14.7	838.2
	10000	14.6	837.1	14.6	837.1
	9820	15.0	835.4	14.9	835.4
	9595	14.6	834.1	14.5	834.2
	9385	13.7	833.1	13.8	833.1
	9220	13.7	831.8	13.7	831.8
	9025	13.8	830.4	13.8	830.4

1 - Velocities & WSEs reflect HEC-RAS model modified for fluvial purposes at subcritical flow n=0.025

It has been noted in the text that the conversion process from HEC-RAS to SAM is a powerful tool for fluvial analysis. This appendix presents, in part, the proposed conditions HEC-RAS to SAM conversion analysis in table format (Table A4.4B1-2). The tables compare the velocity and water surface elevation for the HEC-RAS mixed flow model, the HEC-RAS subcritical flow model, the HEC-RAS model processed for HEC-2 conversion, the HEC-2 model, and the HEC-2 model imported into HEC-RAS. At most sections the differences between steps in the conversion process is only a few percent. The few locations where the difference between steps is high generally result from the supercritical nature of the flow in the HEC-RAS mixed flow model. Several pertinent points should be addressed here. First, the observed differences are a result of the conversion process itself. The most appropriate use of SAM is to include the available data from the hydraulic modeling. As noted in Section 4.1.1, the T95 file produced by HEC-2 is read directly into the SAM model. This is preferable to attempting to consider each section as hydraulically independent from others in the system. A T95 file is not produced in HEC-RAS so the RAS model that is used for hydraulic analysis is down converted to HEC-2 format, as described above. Second, the supercritical nature of the model is the result of the low Manning's number (n=0.025) used, as required by LACDPW criteria. In the River during an actual event a Manning's number this low is not expected for an entire cross-section or an entire reach. In instances where the Manning's number exceeds approximately n=0.035 supercritical flow does not occur in the River for the Q_{CAP} discharge, and Manning's values in the River are expected to be at least n=0.035 or higher during an actual event. Finally, in the final phase of the analysis HEC-6 numerical modeling will be employed to analyze the fluvial mechanics of the River system. The affect of this modeling is to fine tune the SAM analysis presented in the present phase, and HEC-6 modeling will use expected Manning's values as parameters. For these reasons, any differences in water surface elevation or velocity resulting from modeled flow regime presented in Table A4.4B1-2 are not expected to impact analysis or final design.

Table A4.4B1 Santa Clara River Proposed Condition HEC-RAS to HEC-2 Conversion n=0.025									
		HEC-RAS Mixed	HEC-RAS Subcritical	Fluvial HEC-RAS Subcritical	Δ (%)	Fluvial HEC2	Δ (%)	Fluvial HEC2 IMPORT Subcritical	Δ (%)
	HEC-RAS Station	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft %)	Depth (ft)	Depth (ft %)	Depth (ft)	Depth (ft %)
SRA1	46195	18.1	19.0	19.3	**-1%**	19.3	**0%**	19.3	**0%**
	46020	18.1	20.4	20.4	**0%**	20.3	**1%**	20.4	**-1%**
	45545	19.2	19.2	19.2	**0%**	19.2	**0%**	19.2	**0%**
	45030	16.5	20.6	20.6	**0%**	20.3	**1%**	20.5	**-1%**
	44585	21.1	21.1	21.1	**0%**	21.1	**0%**	21.1	**0%**
	44210	15.4	21.6	21.6	**0%**	21.1	**2%**	21.6	**-2%**
SRA2	43820	19.5	19.5	19.5	**0%**	19.5	**0%**	19.5	**0%**
	43610	13.8	17.1	17.1	**0%**	17.1	**0%**	17.1	**0%**
	43410	11.3	15.1	14.7	**3%**	14.8	**0%**	14.7	**0%**
	43200	12.4	15.6	15.3	**2%**	15.3	**0%**	15.3	**0%**
	42975	10.8	14.3	14.1	**1%**	14.1	**1%**	14.1	**-1%**
	42815	10.7	13.4	13.4	**1%**	13.3	**0%**	13.4	**0%**
	42590	9.2	11.6	11.5	**1%**	11.5	**0%**	11.5	**0%**
	42430	10.7	12.3	12.3	**0%**	12.3	**0%**	12.3	**0%**
	42215	11.2	13.7	13.7	**0%**	13.3	**3%**	13.7	**-3%**
	41940	14.3	14.3	14.3	**0%**	14.0	**2%**	14.3	**-2%**
	41730	14.7	14.7	14.7	**0%**	14.3	**3%**	14.7	**-3%**
	41460	16.2	16.2	16.1	**0%**	15.8	**2%**	16.1	**-2%**
SRA3	41280	14.4	14.4	14.3	**0%**	14.3	**1%**	14.3	**-1%**
	41080	12.1	13.6	13.6	**0%**	13.5	**1%**	13.6	**-1%**
	40825	11.5	12.6	12.6	**0%**	12.6	**0%**	12.6	**0%**
	40585	11.7	12.4	12.6	**-1%**	12.6	**0%**	12.6	**0%**
	40335	15.1	15.1	15.0	**1%**	14.7	**2%**	15.0	**-2%**
	40130	15.5	15.5	15.4	**1%**	15.1	**2%**	15.4	**-2%**
	39945	16.3	16.3	16.2	**1%**	15.9	**2%**	16.2	**-2%**
	39755	13.3	13.3	13.2	**1%**	13.1	**0%**	13.2	**0%**
	39605	11.5	12.9	12.8	**1%**	12.7	**0%**	12.8	**0%**
	39310	12.7	12.7	12.4	**2%**	12.4	**0%**	12.4	**0%**
	39100	10.4	13.8	13.7	**0%**	12.6	**8%**	13.7	**-9%**
	38925	14.3	14.3	14.2	**0%**	13.7	**4%**	14.2	**-4%**
SRA4	38710	15.6	15.6	15.6	**0%**	15.2	**2%**	15.6	**-3%**
	38475	14.0	14.0	14.0	**0%**	14.1	**0%**	14.0	**0%**
	38300	10.3	12.4	12.4	**0%**	12.3	**0%**	12.4	**0%**
	38065	14.0	14.0	14.0	**0%**	13.7	**2%**	14.0	**-2%**
	37810	12.2	12.2	12.2	**0%**	12.2	**0%**	12.2	**0%**
	37655	10.5	12.1	12.1	**0%**	12.1	**0%**	12.1	**0%**
	37390	6.5	10.5	10.5	**0%**	10.2	**2%**	10.5	**-2%**
	37135	9.3	9.3	9.3	**0%**	9.3	**0%**	9.3	**0%**
	36930	8.1	9.7	9.9	**-3%**	9.9	**1%**	9.9	**0%**
	36735	9.8	9.8	9.9	**0%**	9.8	**0%**	9.9	**0%**
	36515	12.0	12.0	12.0	**0%**	11.5	**5%**	11.7	**-2%**
	36265	12.5	12.5	12.5	**0%**	12.1	**3%**	12.2	**-1%**
SRB1	36080	11.6	11.6	11.6	**0%**	11.5	**2%**	11.5	**-1%**
	35845	13.6	13.6	13.1	**4%**	12.9	**1%**	13.1	**-1%**
	35725	13.0	13.0	12.6	**3%**	12.5	**1%**	12.6	**-1%**
	35515	12.0	12.8	12.3	**3%**	12.6	**-2%**	12.5	**1%**
	35245	11.3	12.4	12.2	**2%**	12.1	**1%**	12.2	**-1%**
	35040	10.7	12.0	11.3	**5%**	11.5	**-2%**	11.5	**0%**
	34860	10.0	11.4	11.4	**0%**	11.4	**0%**	11.4	**0%**
	34720	9.2	10.7	10.7	**0%**	10.6	**0%**	10.7	**0%**
	34495	9.0	10.3	10.3	**0%**	10.2	**0%**	10.3	**0%**
	34310	9.3	10.0	9.6	**4%**	9.8	**-1%**	9.7	**0%**
	34090	8.6	9.6	9.6	**0%**	9.5	**0%**	9.6	**0%**
SRB2	33880	9.3	10.3	10.3	**0%**	10.2	**0%**	10.2	**0%**
	33710	9.7	10.3	10.3	**0%**	10.3	**0%**	10.2	**0%**
	33500	9.3	10.0	10.1	**-1%**	10.1	**0%**	10.1	**0%**
	33310	9.0	10.0	10.0	**0%**	10.0	**0%**	10.0	**0%**
	33115	10.6	10.6	10.6	**0%**	10.6	**0%**	10.7	**-1%**
	32795	10.6	10.6	10.6	**0%**	10.9	**-3%**	11.0	**-1%**
	32605	11.1	11.6	11.6	**0%**	11.6	**0%**	11.6	**0%**
SRC1	32265	10.5	11.3	11.3	**0%**	11.2	**1%**	11.3	**-1%**
	31875	10.4	10.4	10.4	**0%**	10.3	**1%**	10.4	**-1%**
	31585	11.9	11.9	11.3	**5%**	11.2	**1%**	11.3	**-1%**
	31360	13.5	13.5	12.6	**7%**	11.4	**9%**	12.6	**-10%**
	31060	15.5	15.5	14.6	**6%**	14.1	**4%**	14.6	**-4%**
	30720	17.5	17.5	16.6	**5%**	16.3	**2%**	16.6	**-2%**
	30445	19.5	19.5	18.5	**5%**	18.2	**2%**	18.5	**-2%**
	30095	21.3	21.3	20.3	**4%**	20.0	**2%**	20.3	**-2%**
	29815	21.9	21.9	20.9	**5%**	20.6	**2%**	20.9	**-2%**
	29565	22.9	22.9	21.8	**5%**	21.5	**1%**	21.8	**-1%**
	29385	23.6	23.6	22.5	**5%**	22.2	**1%**	22.5	**-1%**
SRC2	29140	24.1	24.1	22.8	**6%**	22.4	**1%**	22.8	**-1%**
	28895	22.5	22.5	21.3	**5%**	21.1	**1%**	21.3	**-1%**
	28695	14.0	21.1	20.3	**4%**	20.0	**1%**	20.3	**-1%**
	28500	16.1	18.6	18.5	**1%**	18.5	**0%**	18.5	**0%**
	28280	10.8	18.0	17.4	**3%**	16.8	**3%**	17.4	**-3%**
	28080	19.1	19.1	18.4	**4%**	18.0	**2%**	18.4	**-2%**
	27925	19.3	19.3	18.6	**3%**	18.2	**2%**	18.6	**-2%**
	27725	16.7	16.7	16.3	**3%**	16.2	**1%**	16.3	**-1%**
	27545	14.1	15.8	15.6	**1%**	15.5	**1%**	15.6	**-1%**
	27335	12.3	15.3	15.2	**1%**	15.1	**0%**	15.2	**0%**
	27155	14.8	15.2	14.8	**3%**	14.7	**0%**	14.8	**0%**
SRC3	26990	11.5	13.7	13.7	**0%**	13.7	**0%**	13.7	**0%**
	26780	11.3	13.7	13.3	**2%**	13.3	**0%**	13.3	**0%**
	26575	11.1	13.9	13.4	**3%**	13.4	**0%**	13.4	**0%**
	26355	13.4	13.4	13.1	**2%**	13.1	**0%**	13.1	**0%**
	26170	13.5	13.7	13.2	**4%**	13.2	**0%**	13.2	**0%**
	25965	12.9	13.7	13.3	**3%**	13.2	**1%**	13.3	**-1%**
	25785	12.1	13.1	13.3	**-1%**	13.2	**1%**	13.3	**-1%**
	25600	12.4	13.1	13.3	**-1%**	12.9	**3%**	13.3	**-3%**
	25425	12.5	14.3	14.3	**0%**	14.0	**2%**	14.3	**-2%**
	25215	14.7	14.7	14.7	**0%**	14.1	**4%**	14.7	**-5%**
	25000	15.5	15.5	15.5	**0%**	15.3	**1%**	15.5	**-2%**

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A4.4B1 HEC-RAS to HEC-2 Conversion SCR Proposed n=0.025 continued									
		HEC-RAS Mixed	HEC-RAS Subcritical	Fluvial HEC-RAS Subcritical	Δ (%)	Fluvial HEC2	Δ (%)	Fluvial HEC2 IMPORT Subcritical	Δ (%)
Subreach	HEC-RAS Station	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft %)	Depth (ft)	Depth (ft %)	Depth (ft)	Depth (ft %)
SRC4	24795	15.6	15.6	15.6	**0%**	15.4	**2%**	15.6	**-2%**
	24550	16.5	16.5	16.5	**0%**	16.2	**2%**	16.5	**-2%**
	24335	15.0	15.0	15.0	**0%**	15.0	**1%**	15.0	**-1%**
	24115	13.8	14.7	14.7	**0%**	14.6	**0%**	14.7	**0%**
	23975	12.9	14.2	14.2	**0%**	14.2	**0%**	14.2	**0%**
	23755	14.7	14.7	14.8	**0%**	14.7	**0%**	14.8	**0%**
	23565	14.3	15.6	15.6	**0%**	15.5	**0%**	15.6	**0%**
	23365	14.3	14.7	14.4	**2%**	14.3	**1%**	14.4	**-1%**
	23180	12.6	14.1	14.2	**0%**	13.6	**4%**	13.6	**0%**
	23000	11.3	14.8	14.8	**0%**	14.0	**5%**	14.2	**-2%**
	22790	13.0	13.0	13.0	**0%**	12.8	**1%**	12.9	**-1%**
	22600	12.8	13.8	13.6	**1%**	13.6	**0%**	13.6	**0%**
	22415	10.8	12.5	12.5	**0%**	12.4	**0%**	12.5	**0%**
SRD1	22195	14.0	14.0	13.5	**4%**	13.3	**1%**	13.5	**-1%**
	22010	14.3	14.3	14.1	**2%**	14.0	**1%**	14.1	**-1%**
	21790	11.6	13.3	13.3	**0%**	13.2	**1%**	13.3	**-1%**
	21615	8.5	10.7	10.8	**-1%**	10.8	**0%**	10.8	**0%**
	21440	11.0	11.6	11.6	**1%**	11.5	**1%**	11.6	**-1%**
	21225	11.7	12.9	12.5	**3%**	12.5	**0%**	12.5	**0%**
	21020	9.7	12.2	13.0	**-6%**	12.8	**1%**	13.0	**-1%**
	20845	12.7	12.7	12.4	**3%**	12.3	**1%**	12.3	**0%**
	20595	13.4	13.4	13.3	**1%**	13.1	**2%**	13.3	**-2%**
	20435	14.3	14.3	14.1	**1%**	13.9	**2%**	14.1	**-2%**
	20280	12.8	12.8	12.3	**4%**	12.3	**0%**	12.3	**0%**
	20070	11.1	12.7	12.3	**3%**	12.3	**0%**	12.3	**0%**
SRD2	19855	10.2	12.4	12.2	**2%**	12.1	**0%**	12.2	**0%**
	19630	8.9	11.4	11.5	**-1%**	10.6	**8%**	11.5	**-8%**
	19440	13.4	13.4	13.4	**0%**	13.2	**2%**	13.4	**-2%**
	19240	11.9	11.9	11.9	**0%**	11.9	**0%**	11.9	**0%**
	19050	10.5	13.3	13.4	**-1%**	13.2	**1%**	13.4	**-1%**
	18830	14.6	14.6	14.8	**-2%**	13.4	**10%**	14.8	**-11%**
	18650	15.0	15.0	15.2	**-1%**	14.2	**7%**	15.2	**-7%**
	18475	16.9	16.9	16.9	**0%**	16.4	**3%**	16.9	**-3%**
	18290	16.9	16.9	17.0	**0%**	16.5	**3%**	17.0	**-3%**
	18025	18.5	18.5	18.6	**0%**	18.2	**2%**	18.6	**-2%**
	17785	20.2	20.2	20.3	**0%**	19.9	**2%**	20.3	**-2%**
SRD3	17510	19.2	19.2	19.5	**-1%**	19.1	**2%**	19.5	**-2%**
	17360	15.9	15.9	16.0	**0%**	16.0	**0%**	16.0	**0%**
	17110	15.2	17.5	17.1	**2%**	17.0	**1%**	17.1	**-1%**
	16970	13.6	16.1	15.9	**1%**	15.8	**1%**	15.9	**-1%**
	16720	9.2	11.9	11.9	**0%**	11.9	**0%**	11.9	**0%**
	16515	10.4	11.9	11.9	**0%**	11.8	**1%**	11.9	**-1%**
	16305	14.6	14.6	14.5	**0%**	14.3	**2%**	14.5	**-2%**
	16130	12.3	12.3	12.2	**1%**	12.3	**0%**	12.2	**0%**
	15960	11.0	12.6	12.6	**0%**	12.0	**5%**	12.1	**-1%**
	15745	13.3	13.3	13.3	**0%**	11.7	**12%**	12.6	**-8%**
	15540	13.7	13.7	13.7	**0%**	12.9	**6%**	13.2	**-2%**
	15335	12.1	12.1	12.1	**0%**	11.8	**2%**	11.9	**-1%**
SRE1	15125	11.6	12.3	12.3	**0%**	11.9	**3%**	12.0	**0%**
	14900	9.8	11.2	11.2	**0%**	11.1	**0%**	11.2	**0%**
	14720	9.8	11.0	11.3	**-3%**	11.2	**1%**	11.3	**-1%**
	14480	8.9	10.3	10.3	**0%**	10.1	**1%**	10.2	**-1%**
	14315	9.9	10.0	10.1	**-1%**	9.9	**2%**	9.9	**0%**
	14090	8.5	8.7	8.7	**0%**	8.7	**0%**	8.7	**0%**
	13850	9.7	9.7	9.1	**6%**	9.2	**-1%**	9.1	**0%**
	13635	10.3	10.3	10.0	**3%**	9.9	**0%**	10.0	**0%**
	13425	7.8	9.2	9.2	**0%**	9.3	**0%**	9.2	**0%**
	13190	9.5	9.5	9.3	**2%**	9.1	**3%**	9.3	**-3%**
SRE2	13030	9.6	9.6	9.9	**-3%**	9.6	**3%**	9.9	**-3%**
	12835	10.1	10.1	10.3	**-2%**	9.9	**5%**	10.4	**-5%**
	12615	10.9	10.9	11.0	**-2%**	10.7	**3%**	11.1	**-4%**
	12395	11.5	11.5	11.7	**-2%**	11.3	**4%**	11.7	**-4%**
	12195	12.5	12.5	12.6	**-1%**	12.3	**2%**	12.7	**-3%**
	11995	13.6	13.6	13.9	**-2%**	13.6	**2%**	14.0	**-3%**
	11780	14.4	14.4	14.7	**-2%**	14.5	**1%**	14.8	**-2%**
	11605	13.8	13.8	14.5	**-5%**	14.2	**2%**	14.6	**-3%**
	11405	15.1	15.1	15.4	**-2%**	15.1	**2%**	15.5	**-3%**
	11180	13.9	13.9	14.5	**-4%**	14.2	**2%**	14.7	**-3%**
SRE3	11015	13.3	13.3	13.4	**-1%**	13.2	**1%**	13.4	**-1%**
	10835	10.9	12.7	12.8	**-1%**	12.8	**0%**	12.8	**0%**
	10575	7.5	10.2	10.2	**0%**	10.2	**0%**	10.2	**0%**
	10390	8.8	11.0	11.8	**-6%**	11.6	**1%**	11.8	**-1%**
	10225	9.5	10.7	10.7	**0%**	10.7	**0%**	10.7	**0%**
	10000	11.1	11.1	11.1	**0%**	11.2	**0%**	11.1	**0%**
	9820	10.0	11.3	11.4	**0%**	11.3	**1%**	11.4	**-1%**
	9595	10.3	10.3	10.4	**0%**	10.3	**1%**	10.4	**-1%**
	9385	9.5	10.2	10.1	**1%**	10.0	**0%**	10.1	**0%**
	9220	8.9	9.8	9.8	**0%**	9.8	**0%**	9.8	**0%**
	9025	8.9	9.6	9.4	**2%**	9.4	**0%**	9.4	**0%**

Table A4.4B2 Santa Clara River Proposed Condition HEC-RAS to HEC-2 Conversion n=0.025									
		HEC-RAS Mixed	HEC-RAS Subcritical	Fluvial HEC-RAS Subcritical	Δ (%)	Fluvial HEC2	Δ (%)	Fluvial HEC2 IMPORT Subcritical	Δ (%)
	HEC-RAS Station	Vel Chnl (ft/s)	Vel Chnl (ft/s)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)
SRA1	46195	21.7	20.1	19.7	**2%**	19.6	**0%**	19.7	**0%**
	46020	24.1	19.1	19.1	**0%**	19.3	**-1%**	19.1	**1%**
	45545	20.3	20.3	20.3	**0%**	20.4	**0%**	20.3	**0%**
	45030	26.1	17.8	17.8	**0%**	18.1	**-2%**	17.8	**1%**
	44585	19.2	19.2	19.2	**0%**	19.1	**0%**	19.1	**0%**
	44210	26.2	14.8	14.8	**0%**	15.3	**-4%**	14.8	**3%**
SRA2	43820	19.9	19.9	19.9	**0%**	19.9	**0%**	19.9	**0%**
	43610	26.7	19.8	19.7	**0%**	19.7	**0%**	19.7	**0%**
	43410	28.8	19.2	18.1	**6%**	18.1	**0%**	18.1	**0%**
	43200	26.1	18.0	17.2	**4%**	17.2	**0%**	17.2	**0%**
	42975	26.6	16.7	16.3	**2%**	16.5	**-1%**	16.3	**1%**
	42815	23.9	15.7	15.4	**2%**	15.5	**-1%**	15.4	**1%**
	42590	22.4	15.3	15.1	**2%**	15.2	**-1%**	15.1	**1%**
	42430	19.6	15.6	15.6	**0%**	15.6	**0%**	15.6	**0%**
	42215	18.5	12.9	12.7	**1%**	13.5	**-6%**	12.7	**6%**
	41940	11.6	11.6	11.6	**0%**	12.0	**-3%**	11.6	**3%**
	41730	11.8	11.8	11.8	**0%**	12.4	**-5%**	11.8	**5%**
	41460	11.6	11.6	11.7	**-1%**	12.1	**-4%**	11.7	**3%**
SRA3	41280	16.4	16.4	16.4	**0%**	16.6	**-1%**	16.4	**1%**
	41080	19.9	16.5	16.0	**3%**	16.2	**-1%**	16.0	**1%**
	40825	18.0	15.3	15.0	**2%**	15.0	**0%**	15.0	**0%**
	40585	17.0	15.3	14.9	**3%**	15.0	**-1%**	14.8	**1%**
	40335	10.5	10.5	10.7	**-1%**	11.0	**-3%**	10.7	**3%**
	40130	11.3	11.3	11.1	**2%**	11.5	**-4%**	11.1	**4%**
	39945	11.0	11.0	10.7	**3%**	11.1	**-4%**	10.7	**3%**
	39755	16.5	16.5	16.1	**2%**	16.2	**-1%**	16.1	**1%**
	39605	19.7	16.6	16.2	**2%**	16.3	**-1%**	16.2	**1%**
	39310	16.5	16.5	15.9	**4%**	15.9	**0%**	15.9	**0%**
	39100	20.9	14.2	14.2	**0%**	16.0	**-12%**	14.2	**11%**
	38925	12.8	12.8	12.9	**0%**	13.6	**-6%**	12.9	**5%**
SRA4	38710	12.0	12.0	12.1	**0%**	12.5	**-3%**	12.1	**3%**
	38475	17.9	17.9	17.8	**0%**	17.8	**0%**	17.8	**0%**
	38300	22.5	17.7	17.7	**0%**	17.7	**0%**	17.7	**0%**
	38065	14.5	14.5	14.5	**0%**	15.0	**-3%**	14.5	**3%**
	37810	18.2	18.2	18.2	**0%**	18.2	**0%**	18.2	**0%**
	37655	20.9	17.4	17.4	**0%**	17.4	**0%**	17.4	**0%**
	37390	23.7	14.2	14.2	**0%**	14.5	**-3%**	14.2	**3%**
	37135	16.6	16.6	16.6	**0%**	16.6	**0%**	16.6	**0%**
	36930	19.8	16.3	15.6	**4%**	15.7	**-1%**	15.7	**0%**
	36735	16.1	16.1	16.1	**0%**	16.1	**0%**	16.1	**1%**
	36515	12.9	12.9	12.8	**0%**	13.7	**-7%**	13.3	**3%**
	36265	12.3	12.3	12.3	**0%**	12.8	**-3%**	12.5	**2%**
SRB1	36080	14.7	14.7	14.7	**0%**	14.8	**-1%**	14.6	**1%**
	35845	11.0	11.0	11.7	**-7%**	12.0	**-2%**	11.7	**2%**
	35725	15.0	15.0	14.1	**6%**	14.3	**-1%**	14.1	**1%**
	35515	17.1	15.2	14.0	**8%**	13.4	**4%**	13.6	**-1%**
	35245	17.3	14.5	13.7	**6%**	13.9	**-1%**	13.7	**1%**
	35040	19.6	15.6	13.9	**11%**	13.5	**3%**	13.6	**0%**
	34860	18.4	14.1	14.1	**0%**	14.2	**-1%**	14.1	**1%**
	34720	18.4	13.9	13.9	**0%**	14.0	**-1%**	13.9	**1%**
	34495	17.4	14.0	14.0	**0%**	14.1	**-1%**	14.0	**1%**
	34310	16.8	15.0	14.3	**5%**	14.0	**2%**	14.1	**-1%**
	34090	17.0	14.2	14.2	**0%**	14.3	**-1%**	14.2	**1%**
SRB2	33880	16.6	14.1	14.1	**0%**	14.2	**-1%**	14.1	**0%**
	33710	15.4	14.0	14.0	**0%**	14.0	**0%**	14.0	**0%**
	33500	16.2	14.3	13.1	**8%**	13.0	**0%**	13.1	**0%**
	33310	15.8	12.9	12.9	**0%**	12.8	**1%**	12.8	**0%**
	33115	10.4	10.4	10.4	**0%**	10.3	**0%**	10.2	**1%**
	32795	13.0	13.0	13.0	**0%**	12.2	**6%**	12.1	**1%**
	32605	14.4	13.1	13.1	**0%**	13.1	**0%**	13.1	**0%**
SRC1	32265	15.9	13.4	13.4	**0%**	13.7	**-2%**	13.4	**2%**
	31875	12.4	12.4	12.4	**0%**	12.6	**-2%**	12.4	**2%**
	31585	10.9	10.9	12.1	**-11%**	12.3	**-1%**	12.1	**1%**
	31360	10.3	10.3	11.5	**-12%**	13.9	**-20%**	11.5	**17%**
	31060	8.2	8.2	9.0	**-10%**	9.6	**-6%**	9.0	**6%**
	30720	6.7	6.7	7.3	**-9%**	7.5	**-3%**	7.3	**3%**
	30445	6.3	6.3	6.8	**-8%**	6.9	**-3%**	6.7	**3%**
	30095	6.7	6.7	7.0	**-3%**	7.1	**-3%**	7.0	**3%**
	29815	7.7	7.7	7.9	**-2%**	8.1	**-3%**	7.9	**2%**
	29565	7.4	7.4	7.7	**-5%**	7.9	**-2%**	7.7	**2%**
	29385	8.3	8.3	8.6	**-4%**	8.8	**-2%**	8.6	**2%**
SRC2	29140	9.2	9.2	10.2	**-11%**	10.4	**-3%**	10.2	**2%**
	28895	18.8	18.8	16.8	**11%**	17.1	**-2%**	16.8	**2%**
	28695	28.9	12.4	13.3	**-7%**	13.6	**-2%**	13.3	**2%**
	28500	22.4	17.7	16.7	**6%**	16.7	**0%**	16.6	**1%**
	28280	29.6	13.0	11.9	**8%**	12.5	**-5%**	11.9	**5%**
	28080	11.3	11.3	10.9	**3%**	11.2	**-3%**	10.9	**3%**
	27925	13.1	13.1	12.4	**5%**	12.8	**-3%**	12.4	**3%**
	27725	19.0	19.0	18.0	**6%**	18.1	**-1%**	18.0	**1%**
	27545	22.9	19.7	19.1	**3%**	19.2	**-1%**	19.1	**1%**
	27335	24.6	18.3	17.4	**5%**	17.5	**-1%**	17.4	**1%**
	27155	19.1	18.4	17.2	**6%**	17.4	**-1%**	17.2	**1%**
SRC3	26990	22.6	16.9	16.7	**1%**	16.8	**-1%**	16.7	**1%**
	26780	23.1	16.9	16.3	**4%**	16.4	**-1%**	16.3	**1%**
	26575	20.7	13.9	14.7	**-6%**	14.8	**-1%**	14.8	**0%**
	26355	15.9	15.9	15.4	**3%**	15.5	**-1%**	15.4	**1%**
	26170	17.0	16.5	15.3	**7%**	15.3	**0%**	15.3	**0%**
	25965	18.2	16.3	15.2	**7%**	15.4	**-1%**	15.2	**1%**
	25785	18.9	16.5	14.4	**13%**	14.6	**-2%**	14.4	**1%**
	25600	18.5	17.0	15.0	**12%**	15.7	**-4%**	15.0	**4%**
	25425	18.3	14.6	14.6	**0%**	15.1	**-3%**	14.6	**3%**
	25215	14.3	14.3	14.2	**0%**	15.3	**-8%**	14.2	**7%**
	25000	13.2	13.2	13.1	**0%**	13.4	**-2%**	13.1	**2%**

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A4.4B2 HEC-RAS to HEC-2 Conversion SCR Proposed n=0.025 continued									
		HEC-RAS Mixed	HEC-RAS Subcritical	Fluvial HEC-RAS Subcritical	Δ (%)	Fluvial HEC2	Δ (%)	Fluvial HEC2 IMPORT Subcritical	Δ (%)
Subreach	HEC-RAS Station	Vel Chnl (ft/s)	Vel Chnl (ft/s)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)	Vel Chnl (ft/s)	Vel Chnl (ft/s %)
SRC4	24795	14.1	14.1	14.0	**0%**	14.3	**-2%**	14.0	**2%**
	24550	15.1	15.1	15.0	**1%**	15.4	**-3%**	15.0	**3%**
	24335	18.2	18.2	18.1	**1%**	18.2	**-1%**	18.1	**1%**
	24115	20.0	18.3	18.2	**0%**	18.3	**0%**	18.2	**0%**
	23975	20.8	18.0	18.0	**0%**	17.9	**0%**	18.0	**0%**
	23755	18.1	18.0	17.8	**1%**	17.8	**-1%**	17.8	**1%**
	23565	20.2	17.6	17.4	**1%**	17.5	**-1%**	17.4	**1%**
	23365	18.4	17.6	16.9	**4%**	17.1	**-1%**	16.9	**1%**
	23180	21.9	18.5	16.0	**13%**	17.0	**-6%**	17.0	**0%**
	23000	22.0	15.4	15.3	**0%**	16.2	**-5%**	15.8	**2%**
	22790	17.9	17.9	18.0	**0%**	17.9	**0%**	17.8	**1%**
	22600	19.8	17.4	16.6	**5%**	16.6	**0%**	16.6	**0%**
	22415	21.3	16.8	16.3	**3%**	16.4	**-1%**	16.3	**1%**
SRD1	22195	13.6	13.6	14.2	**-4%**	14.5	**-2%**	14.2	**2%**
	22010	16.1	16.1	15.4	**5%**	15.6	**-1%**	15.4	**1%**
	21790	19.7	15.9	14.7	**8%**	14.9	**-1%**	14.7	**1%**
	21615	21.3	15.6	14.8	**5%**	14.9	**-1%**	14.8	**1%**
	21440	17.5	16.1	15.0	**6%**	15.1	**-1%**	15.0	**1%**
	21225	18.1	15.2	14.3	**6%**	14.3	**0%**	14.4	**-1%**
	21020	20.3	14.9	12.3	**17%**	12.6	**-2%**	12.3	**2%**
	20845	15.1	15.1	14.3	**5%**	14.5	**-1%**	14.4	**1%**
	20595	12.4	12.4	11.1	**10%**	11.5	**-3%**	11.1	**3%**
	20435	12.1	12.1	10.8	**11%**	11.1	**-3%**	10.8	**3%**
	20280	15.6	15.6	14.5	**7%**	14.5	**0%**	14.5	**0%**
	20070	19.3	15.4	14.4	**6%**	14.4	**0%**	14.5	**0%**
SRD2	19855	20.6	15.2	14.3	**6%**	14.3	**0%**	14.2	**1%**
	19630	20.6	14.8	14.4	**3%**	15.9	**-11%**	14.4	**10%**
	19440	13.1	13.1	12.9	**2%**	13.2	**-2%**	12.9	**2%**
	19240	15.9	15.9	15.6	**2%**	15.6	**0%**	15.6	**0%**
	19050	18.8	12.7	12.2	**4%**	12.5	**-2%**	12.2	**2%**
	18830	13.3	13.3	12.1	**9%**	14.8	**-22%**	12.1	**18%**
	18650	12.1	12.1	10.8	**11%**	12.3	**-14%**	10.8	**12%**
	18475	8.9	8.9	8.8	**1%**	9.2	**-5%**	8.8	**5%**
	18290	9.8	9.8	9.4	**4%**	10.0	**-6%**	9.4	**6%**
	18025	7.9	7.9	7.8	**2%**	8.0	**-3%**	7.8	**3%**
	17785	8.5	8.5	8.4	**1%**	8.6	**-3%**	8.4	**3%**
SRD3	17510	11.0	11.0	10.1	**8%**	10.5	**-4%**	10.1	**4%**
	17360	17.1	17.1	16.9	**1%**	16.9	**0%**	16.9	**0%**
	17110	22.3	16.6	15.7	**6%**	15.9	**-1%**	15.7	**1%**
	16970	23.1	16.4	15.7	**4%**	16.0	**-2%**	15.7	**2%**
	16720	24.4	16.0	15.9	**0%**	15.9	**0%**	15.9	**0%**
	16515	19.4	15.4	15.4	**0%**	15.5	**-1%**	15.4	**1%**
	16305	11.6	11.6	11.1	**4%**	11.4	**-3%**	11.1	**3%**
	16130	15.7	15.7	15.2	**3%**	15.1	**0%**	15.2	**0%**
	15960	17.7	13.8	13.7	**1%**	14.8	**-9%**	14.7	**1%**
	15745	12.3	12.3	12.3	**0%**	15.1	**-23%**	13.4	**11%**
	15540	10.6	10.6	10.5	**0%**	11.5	**-9%**	11.2	**3%**
	15335	16.2	16.2	16.2	**0%**	16.2	**0%**	16.0	**1%**
SRE1	15125	17.9	16.6	16.6	**0%**	16.5	**1%**	16.4	**1%**
	14900	19.3	15.6	16.3	**-4%**	16.4	**-1%**	16.3	**1%**
	14720	18.1	15.1	15.9	**-5%**	16.1	**-1%**	15.9	**1%**
	14480	19.0	14.7	14.5	**1%**	14.6	**0%**	14.5	**1%**
	14315	14.0	13.8	14.0	**-2%**	13.8	**2%**	13.8	**0%**
	14090	14.3	13.8	13.7	**0%**	13.8	**-1%**	13.7	**1%**
	13850	12.6	12.6	13.9	**-10%**	13.7	**1%**	13.8	**0%**
	13635	15.5	15.5	14.0	**10%**	14.0	**-1%**	14.0	**1%**
	13425	18.0	13.5	13.5	**0%**	13.4	**0%**	13.5	**0%**
	13190	12.2	12.2	12.3	**-1%**	12.9	**-4%**	12.3	**4%**
SRE2	13030	14.2	14.2	12.0	**16%**	12.5	**-5%**	11.9	**5%**
	12835	13.3	13.3	11.8	**12%**	12.6	**-7%**	11.7	**7%**
	12615	12.5	12.5	11.0	**12%**	11.5	**-4%**	11.0	**5%**
	12395	12.3	12.3	10.9	**12%**	11.4	**-5%**	10.8	**5%**
	12195	10.6	10.6	10.0	**6%**	10.2	**-3%**	9.9	**3%**
	11995	12.8	12.8	11.1	**13%**	11.4	**-3%**	11.0	**4%**
	11780	12.6	12.6	10.4	**17%**	10.7	**-2%**	10.4	**3%**
	11605	13.9	13.9	11.6	**17%**	11.9	**-3%**	11.4	**4%**
	11405	13.2	13.2	12.1	**8%**	12.4	**-3%**	11.9	**4%**
	11180	16.6	16.6	15.2	**8%**	15.6	**-3%**	14.9	**4%**
SRE3	11015	19.1	19.1	18.9	**1%**	19.1	**-1%**	18.9	**1%**
	10835	21.9	17.9	17.7	**1%**	17.8	**0%**	17.7	**0%**
	10575	24.1	16.0	16.0	**0%**	16.0	**0%**	16.0	**0%**
	10390	22.7	16.3	12.7	**22%**	13.0	**-2%**	12.7	**2%**
	10225	17.8	15.0	14.7	**2%**	14.8	**-1%**	14.7	**1%**
	10000	14.9	14.9	14.6	**2%**	14.4	**1%**	14.6	**-1%**
	9820	18.6	15.0	14.9	**0%**	15.1	**-1%**	14.9	**1%**
	9595	14.6	14.6	14.5	**0%**	14.7	**-1%**	14.5	**1%**
	9385	15.8	14.0	13.8	**2%**	13.9	**-1%**	13.8	**1%**
	9220	16.4	13.7	13.7	**1%**	13.8	**-1%**	13.7	**1%**
	9025	15.9	14.3	13.8	**3%**	13.8	**0%**	13.8	**0%**

Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.5

Existing & Proposed Conditions Hydraulic Subreach Analysis

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A4.5A1: Santa Clara River Existing Conditions Hec-Ras Output and Parameter Correlation: Reach A

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRA1	**46195**	115111	1035.0	1054.3	1054.3	1060.3	0.004	19.7	5847.5	483.4	1.00			
	46020	115111	1032.0	1052.4	1052.4	1058.1	0.004	19.1	6013.5	531.5	1.00	0.017		
	45545	115111	1030.0	1049.2	1049.2	1055.7	0.004	20.3	5664.1	446.8	1.01	0.004	0.008	
	45030	115111	1025.0	1045.6	1044.6	1050.5	0.003	17.8	6472.9	521.5	0.89	0.010	0.007	0.009
	44585	115111	1022.0	1043.1	1043.1	1048.8	0.004	19.2	6003.6	531.9	1.01	0.007	0.008	0.007
	44210	115111	1020.0	1041.6	1038.7	1045.0	0.002	14.8	7793.1	585.9	0.71	0.005	0.006	0.007
SRA2	**43820**	115111	1018.0	1037.5	1037.5	1043.6	0.004	19.9	5785.5	476.5	1.01	0.005	0.005	0.006
	43610	115111	1017.0	1034.1	1034.1	1040.1	0.004	19.7	5832.2	483.7	1.00	0.005	0.005	0.005
	43410	115111	1016.0	1030.7	1030.7	1035.9	0.004	18.2	6338.3	623.3	1.00	0.005	0.005	0.005
	43200	115111	1014.0	1029.3	1029.3	1033.9	0.004	17.3	6660.7	737.2	1.00	0.010	0.007	0.006
	42975	115111	1012.0	1026.1	1026.1	1030.3	0.005	16.3	7050.2	860.4	1.01	0.009	0.009	0.008
	42815	115111	1011.0	1024.3	1024.3	1027.9	0.005	15.3	7548.6	1051.0	1.00	0.006	0.008	0.008
	42590	115111	1010.0	1021.3	1021.3	1024.8	0.005	15.0	7695.7	1112.9	1.00	0.004	0.005	0.007
	42430	115111	1008.0	1019.6	1019.6	1023.3	0.005	15.5	7449.5	1001.0	1.00	0.013	0.008	0.007
	42215	115111	1006.0	1020.4	1017.7	1022.0	0.002	10.2	11269.5	1312.6	0.61	0.009	0.011	0.008
	41940	115111	1005.0	1019.5	1017.7	1021.5	0.002	11.2	10258.2	1332.5	0.71	0.004	0.006	0.008
	41730	115111	1004.0	1018.9	1016.5	1021.0	0.002	11.4	10078.8	1249.1	0.71	0.005	0.004	0.006
	41460	115111	1002.0	1018.3	1015.2	1020.3	0.002	11.3	10198.6	1335.2	0.72	0.007	0.006	0.005
SRA3	**41280**	115111	1001.0	1015.3	1015.3	1019.5	0.005	16.4	7014.3	851.9	1.01	0.006	0.007	0.006
	41080	115111	1000.0	1013.6	1013.6	1017.6	0.005	16.1	7149.5	899.0	1.01	0.005	0.005	0.006
	40825	115111	999.5	1012.2	1012.2	1015.6	0.005	14.8	7757.4	1146.8	1.01	0.002	0.003	0.004
	40585	115111	998.0	1010.6	1010.6	1014.0	0.005	14.8	7785.2	1161.4	1.01	0.006	0.004	0.004
	40335	115111	996.0	1010.4	1008.9	1012.2	0.003	11.0	10452.1	1494.5	0.73	0.008	0.007	0.005
	40130	115111	995.0	1010.0	1008.4	1011.7	0.002	10.4	11087.0	1631.3	0.70	0.005	0.007	0.006
	39945	115111	994.0	1009.8	1007.6	1011.2	0.002	9.5	12146.7	1639.3	0.61	0.005	0.005	0.006
	39755	115111	994.0	1007.3	1007.3	1010.5	0.005	14.4	7974.8	1238.0	1.00	0.000	0.003	0.003
	39605	115111	993.0	1005.7	1005.7	1009.0	0.005	14.7	7830.6	1171.1	1.00	0.007	0.003	0.004
	39310	115111	992.0	1004.1	1004.1	1007.5	0.005	14.7	7842.0	1184.1	1.01	0.003	0.004	0.003
	39100	115111	990.0	1004.2	1002.0	1006.1	0.002	11.2	10276.1	1302.0	0.70	0.010	0.006	0.006
	38925	115111	989.5	1003.9	1001.3	1005.8	0.002	10.9	10519.7	1177.1	0.65	0.003	0.006	0.005
SRA4	**38710**	115111	988.0	1003.7	1000.0	1005.4	0.001	10.4	11078.5	1039.0	0.56	0.007	0.005	0.007
	38475	115111	986.0	1000.2	1000.2	1004.6	0.005	16.7	6875.8	795.5	1.00	0.009	0.008	0.006
	38300	115111	985.5	998.1	997.5	1002.3	0.004	16.5	6965.9	701.8	0.92	0.003	0.006	0.006
	38065	115111	984.0	998.2	995.7	1001.3	0.002	14.1	8168.8	678.4	0.72	0.006	0.005	0.006
	37810	115111	983.0	995.2	995.2	1000.4	0.004	18.2	6319.8	622.1	1.01	0.004	0.005	0.005
	37655	115111	982.0	994.2	994.2	998.5	0.004	16.8	6851.1	789.4	1.01	0.006	0.005	0.005
	37390	115111	981.0	989.9	989.9	993.7	0.004	15.7	7414.9	986.7	0.98	0.004	0.005	0.004
	37135	115111	980.0	988.6	988.6	992.1	0.005	15.1	7645.5	1091.6	1.00	0.004	0.004	0.004
	36930	115111	978.0	987.7	986.9	990.5	0.003	13.3	8648.1	1125.5	0.85	0.010	0.007	0.006
	36735	115111	977.0	986.4	986.4	989.7	0.004	14.6	7881.5	1194.2	1.00	0.005	0.008	0.006
	36515	115111	975.0	986.3	985.3	988.6	0.003	12.1	9521.5	1325.6	0.79	0.009	0.007	0.008
	36265	115111	974.0	985.2	984.8	987.8	0.003	13.1	8807.0	1373.1	0.91	0.004	0.006	0.006

corr(x,v)=	0.486087
corr(x,a)=	-0.393283
corr(x,b)=	**-0.5195**
corr(x,m1)=	0.287884
corr(x,m2)=	0.270636
corr(x,m3)=	0.366906

Figure A4.5A1: Santa Clara River Existing Conditions HEC-RAS Reach A - Station vs Top Width

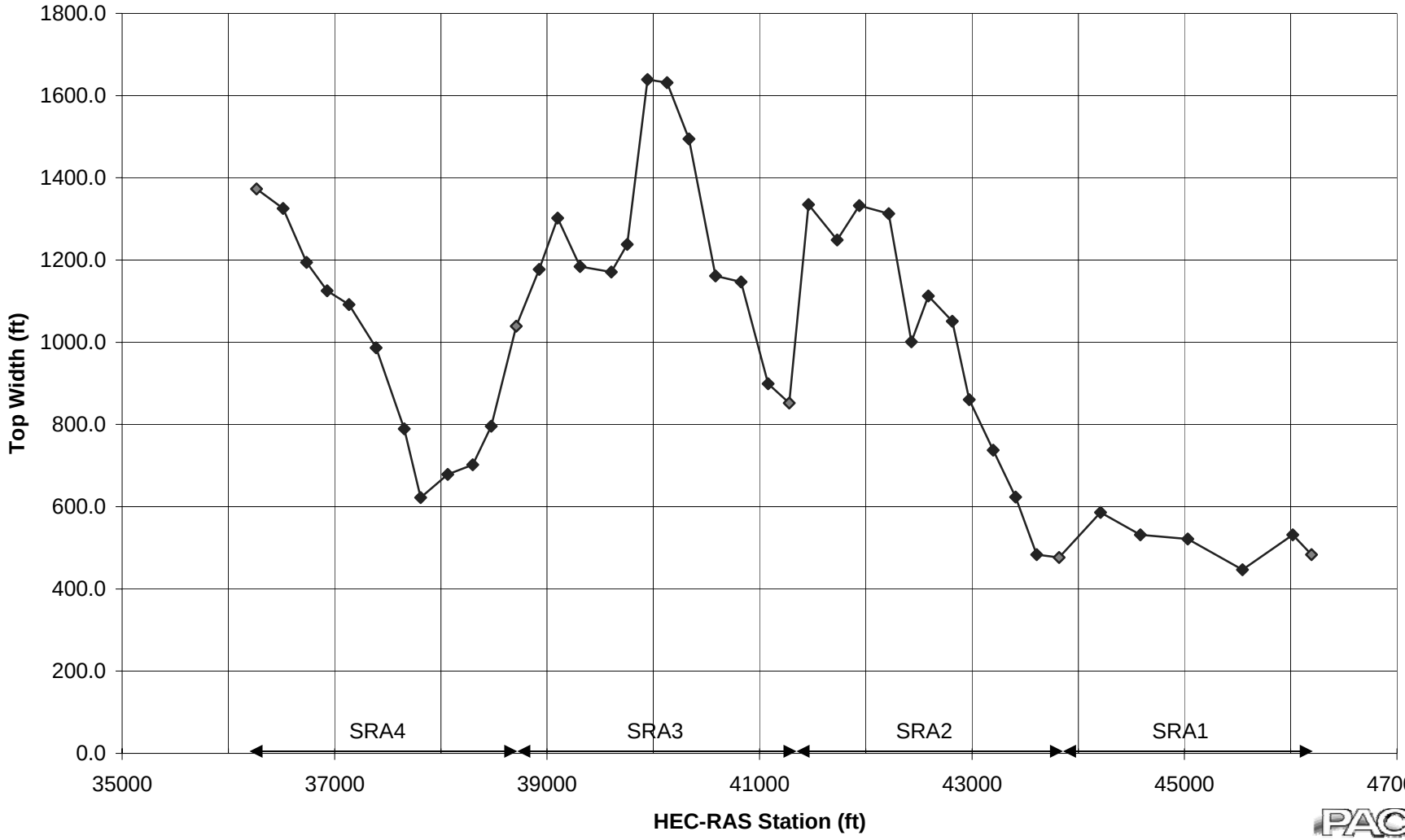


Table A4.5A2: Santa Clara River Existing Conditions Hec-Ras Output and Parameter Correlation: Reach B

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRB1	**36080**	116236	973.0	984.1	984.1	987.0	0.005	13.7	8492.5	1450.4	1.00			
	35845	116236	971.0	983.9	982.8	986.0	0.002	11.6	10013.5	1478.1	0.79	0.009		
	35725	116236	970.0	982.6	982.6	985.5	0.004	13.8	8438.9	1427.9	1.00	0.008	0.008	
	35515	116236	969.0	981.3	981.3	984.4	0.004	14.0	8309.5	1362.8	1.00	0.005	0.006	0.007
	35245	116236	968.0	980.1	980.1	983.1	0.005	13.8	8434.2	1553.4	0.99	0.004	0.004	0.005
	35040	116236	967.0	978.4	978.3	981.4	0.005	13.8	8428.2	1401.8	0.98	0.005	0.004	0.004
	34860	116236	966.0	977.4	977.4	980.5	0.005	14.0	8307.5	1363.0	1.00	0.006	0.005	0.005
	34720	116236	965.5	976.2	976.2	979.2	0.005	13.9	8382.5	1419.6	1.01	0.004	0.005	0.005
	34495	116236	964.0	974.3	974.3	977.3	0.004	14.0	8313.9	1380.4	1.00	0.007	0.005	0.006
	34310	116236	963.0	972.7	972.7	975.8	0.004	14.3	8114.6	1297.7	1.01	0.005	0.006	0.005
	34090	116236	962.0	971.6	971.6	974.8	0.004	14.3	8123.9	1281.0	1.00	0.005	0.005	0.006
SRB2	**33880**	116236	960.0	970.5	970.5	973.6	0.004	14.2	8188.0	1320.1	1.00	0.010	0.007	0.007
	33710	116236	959.0	969.3	969.3	972.4	0.004	14.1	8238.1	1363.2	1.01	0.006	0.008	0.007
	33500	116236	958.0	968.2	968.2	970.8	0.004	13.1	8872.2	1690.4	1.01	0.005	0.005	0.007
	33310	116236	957.0	967.0	967.0	969.6	0.004	12.9	8986.4	1751.5	1.01	0.005	0.005	0.005
	33115	116236	956.0	966.4	965.6	968.3	0.004	11.3	10261.8	1811.5	0.84	0.005	0.005	0.005
	32795	116236	954.0	965.0	964.6	967.3	0.003	12.2	9528.8	1732.9	0.92	0.006	0.006	0.006
	32605	116236	952.0	963.5	963.5	966.5	0.004	14.1	8272.7	1344.6	1.00	0.011	0.008	0.007

corr(x,v)=	0.186906
corr(x,a)=	-0.18573
corr(x,b)=	**-0.37919**
corr(x,m1)=	-0.14733
corr(x,m2)=	-0.13339
corr(x,m3)=	-0.33786

Figure A4.5A2: Santa Clara River Existing Conditions HEC-RAS Reach B - Station vs Top Width

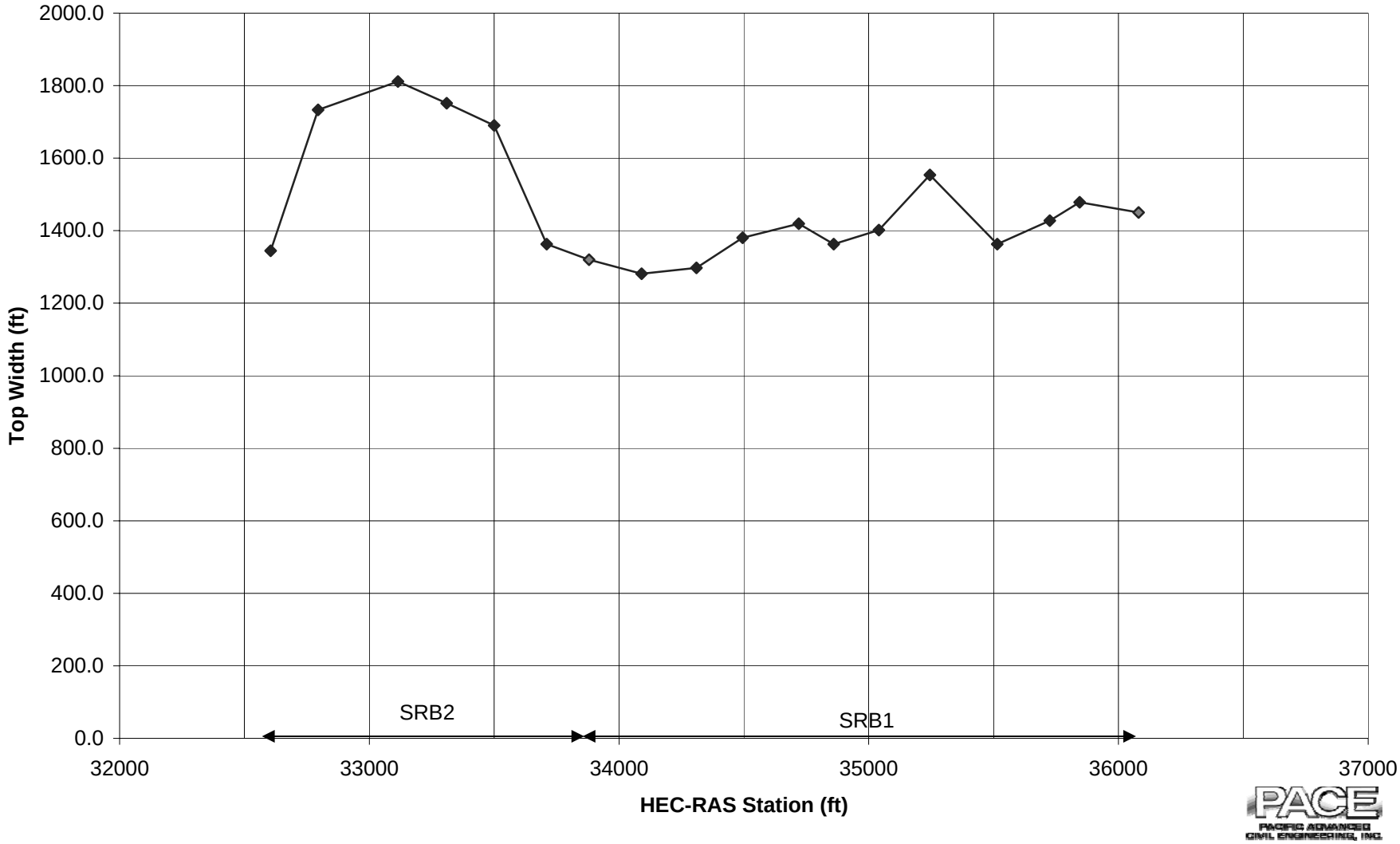


Table A4.5A3: Santa Clara River Existing Conditions Hec-Ras Output and Parameter Correlation: Reach C

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRC1	**32265**	140776	950.0	961.4	961.4	964.1	0.004	13.3	10579.2	1944.9	1.01			
	31875	140776	949.0	960.0	960.0	961.9	0.004	10.9	12908.1	2482.2	0.84	0.003		
	31585	140776	946.0	957.7	957.0	959.6	0.004	11.3	12511.1	2181.1	0.83	0.010	0.006	
	31360	140776	944.0	957.2	955.4	958.9	0.002	10.5	13391.5	1875.2	0.69	0.009	0.010	0.007
	31060	140776	942.0	957.2	953.3	958.3	0.001	8.4	16729.5	1706.2	0.47	0.007	0.008	0.009
	30720	140776	940.0	957.3	951.3	958.0	0.001	6.8	20683.4	1886.9	0.36	0.006	0.006	0.007
	30445	140776	938.0	957.2	949.6	957.8	0.000	6.4	22074.1	1777.6	0.32	0.007	0.007	0.007
	30095	140776	936.0	957.0	947.9	957.7	0.000	6.8	20641.0	1666.4	0.34	0.006	0.006	0.006
	29815	140776	935.0	956.6	948.1	957.5	0.001	7.7	18373.0	1573.0	0.40	0.004	0.005	0.006
	29565	140776	934.0	956.5	947.3	957.3	0.001	7.5	18750.2	1613.5	0.39	0.004	0.004	0.005
	29385	140776	933.0	956.1	949.0	957.2	0.001	8.5	16517.2	1577.6	0.46	0.006	0.005	0.004
SRC2	**29140**	140776	932.0	954.7	951.0	956.8	0.002	11.5	12276.2	1324.5	0.66	0.004	0.005	0.004
	28895	140776	930.0	951.6	951.6	956.0	0.003	16.8	8402.3	965.7	1.00	0.008	0.006	0.006
	28695	140776	928.0	947.9	947.9	953.3	0.004	18.8	7507.5	701.1	1.01	0.010	0.009	0.007
	28500	140776	927.5	945.1	945.1	951.2	0.004	19.8	7160.2	654.2	0.99	0.003	0.006	0.007
	28280	140776	926.0	941.7	941.7	947.9	0.004	20.1	7009.5	562.7	1.00	0.007	0.005	0.007
	28080	140776	925.0	942.3	940.1	946.6	0.002	16.7	8442.0	682.9	0.80	0.005	0.006	0.005
	27925	140776	924.0	940.4	939.5	946.0	0.003	19.1	7355.4	549.8	0.92	0.006	0.006	0.006
	27725	140776	923.0	939.3	939.3	945.4	0.003	19.8	7106.6	586.7	1.00	0.005	0.006	0.005
	27545	140776	922.0	937.7	937.7	943.3	0.003	19.0	7395.6	656.5	1.00	0.006	0.005	0.006
	27335	140776	921.0	936.2	936.2	940.8	0.003	17.3	8160.9	887.0	1.00	0.005	0.005	0.005
	27155	140776	920.5	935.4	935.4	939.6	0.003	16.4	8571.6	1033.5	1.01	0.003	0.004	0.004
SRC3	**26990**	140776	920.0	933.7	933.7	937.6	0.004	15.8	8895.8	1147.6	1.00	0.003	0.003	0.004
	26780	140776	918.0	931.4	931.4	935.1	0.004	15.5	9080.7	1213.5	1.00	0.010	0.007	0.005
	26575	140776	917.0	930.6	930.0	933.7	0.004	14.2	9923.8	1259.9	0.89	0.005	0.007	0.006
	26355	140776	916.0	929.2	929.2	932.8	0.005	15.2	9247.2	1278.4	1.00	0.005	0.005	0.006
	26170	140776	915.0	928.9	928.1	931.7	0.003	13.5	10408.5	1352.5	0.86	0.005	0.005	0.005
	25965	140776	914.0	927.2	927.2	930.8	0.005	15.2	9254.7	1290.2	1.00	0.005	0.005	0.005
	25785	140776	913.5	926.1	926.1	929.5	0.005	15.0	9402.3	1344.9	1.00	0.003	0.004	0.004
	25600	140776	912.5	924.9	924.9	927.9	0.005	13.9	10151.1	1661.6	0.99	0.005	0.004	0.004
	25425	140776	911.0	925.4	923.8	927.0	0.002	10.3	13664.5	2021.6	0.69	0.009	0.007	0.006
	25215	140776	910.0	923.3	923.3	926.3	0.005	13.8	10181.3	1732.2	1.01	0.005	0.006	0.006
	25000	140776	909.0	922.1	922.1	924.6	0.004	12.6	11135.5	2284.2	1.01	0.005	0.005	0.006
SRC4	**24795**	140776	908.0	920.4	920.4	922.8	0.004	12.6	11204.7	2315.5	1.01	0.005	0.005	0.005
	24550	140776	906.0	919.5	918.0	921.0	0.002	9.7	14446.3	2238.3	0.68	0.008	0.007	0.006
	24335	140776	905.0	917.6	917.6	920.3	0.004	13.0	10833.4	2087.5	1.01	0.005	0.007	0.006
	24115	140776	904.0	915.9	915.9	918.6	0.005	13.1	10751.3	2018.8	1.00	0.005	0.005	0.006
	23975	140776	903.5	914.6	914.6	917.4	0.005	13.3	10577.2	1919.3	1.00	0.004	0.004	0.004
	23755	140776	902.0	913.3	913.2	916.0	0.005	13.3	10567.8	1938.0	1.01	0.007	0.006	0.005
	23565	140776	900.0	912.4	912.4	915.1	0.005	13.2	10692.0	2036.3	1.01	0.011	0.009	0.007
	23365	140776	900.0	911.1	911.1	914.0	0.005	13.6	10329.9	1783.9	1.00	0.000	0.005	0.006
	23180	140776	899.0	911.0	909.4	912.5	0.002	10.1	14012.5	2086.5	0.68	0.005	0.003	0.005
	23000	140776	898.0	910.9	908.4	912.1	0.001	9.0	15727.7	2065.4	0.57	0.006	0.005	0.004
	22790	140776	897.5	910.4	908.2	911.8	0.001	9.5	14833.4	1946.2	0.61	0.002	0.004	0.004
	22600	140776	896.0	910.1	907.6	911.6	0.001	9.5	14788.1	1866.4	0.60	0.008	0.005	0.005
	22415	140776	895.5	909.7	906.9	911.3	0.002	10.1	13933.7	1712.9	0.62	0.003	0.005	0.004

corr(x,v)=	-0.05991
corr(x,a)=	0.2074
corr(x,b)=	-0.22352
corr(x,m1)=	0.195674
corr(x,m2)=	0.31057
corr(x,m3)=	**0.398648**

Figure A4.5A3: Santa Clara River Existing Conditions HEC-RAS Reach C - Station vs Bedslope 3

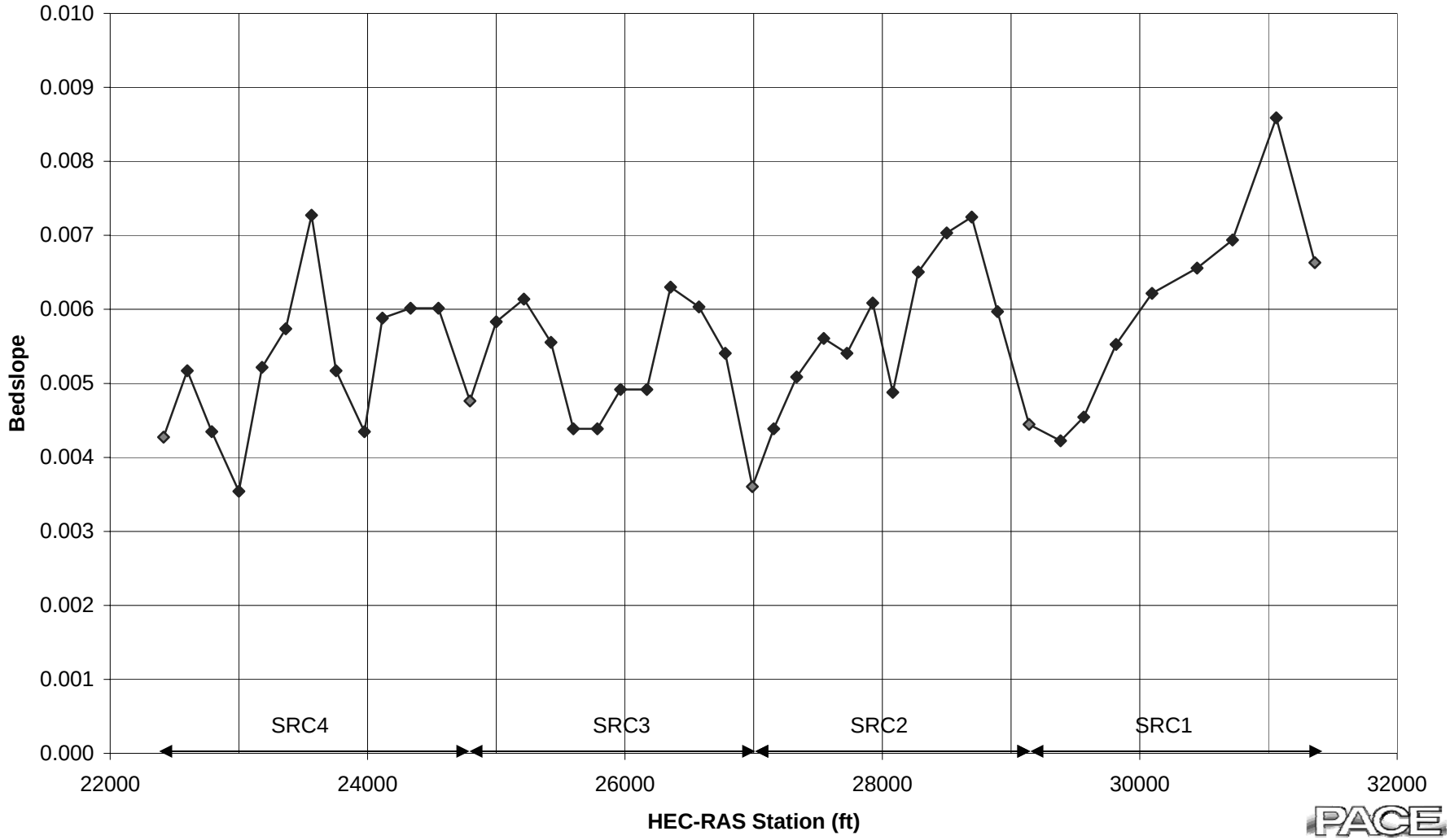


Table A4.5A4: Santa Clara River Existing Conditions Hec-Ras Output and Parameter Correlation: Reach D

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRD1	**22195**	141426	894.0	906.9	906.9	910.5	0.004	15.4	9204.5	1262.7	1.00			
	22010	141426	892.0	906.2	906.2	909.7	0.003	15.1	9380.5	1322.1	1.00	0.011		
	21790	141426	891.5	904.9	904.9	908.1	0.003	14.4	9826.5	1586.7	1.00	0.002	0.006	
	21615	141426	892.0	903.1	903.1	906.0	0.003	13.7	10342.2	1845.7	1.00	-0.003	0.000	0.003
	21440	141426	890.0	901.2	901.2	904.5	0.004	14.6	9680.3	1773.5	1.00	0.011	0.004	0.004
	21225	141426	888.0	899.8	899.8	902.3	0.004	12.6	11221.5	2263.5	1.00	0.009	0.010	0.006
	21020	141426	887.0	897.4	897.4	900.4	0.004	13.8	10350.8	1908.4	0.99	0.005	0.007	0.008
	20845	141426	886.0	897.0	897.0	899.4	0.004	12.5	11348.1	2407.3	1.01	0.006	0.005	0.007
	20595	141426	885.0	896.4	895.9	898.3	0.003	11.0	12863.1	2527.3	0.86	0.004	0.005	0.005
	20435	141426	884.0	896.2	895.3	897.8	0.002	10.3	13709.7	2581.1	0.79	0.006	0.005	0.005
	20280	141426	883.7	895.0	895.0	897.3	0.004	12.1	11653.2	2572.8	1.00	0.002	0.004	0.004
	20070	141426	882.0	892.7	892.7	895.1	0.004	12.4	11394.6	2436.1	1.01	0.008	0.005	0.006
SRD2	**19855**	141426	880.5	891.1	891.1	893.8	0.004	13.1	10778.8	2072.9	1.01	0.007	0.008	0.006
	19630	141426	880.0	889.8	889.7	892.5	0.004	13.2	10735.2	1915.0	0.98	0.002	0.005	0.006
	19440	141426	878.0	889.9	888.7	891.7	0.002	10.8	13151.5	2083.7	0.75	0.011	0.006	0.006
	19240	141426	877.5	888.9	888.5	891.1	0.003	12.1	11650.5	2090.1	0.91	0.003	0.006	0.005
	19050	141426	876.0	889.0	887.2	890.5	0.002	9.6	14759.7	2167.4	0.64	0.008	0.005	0.007
	18830	141426	874.0	888.7	886.5	890.1	0.001	9.3	15134.9	2098.9	0.61	0.009	0.009	0.007
	18650	141426	873.5	888.7	885.4	889.8	0.001	8.5	16644.3	2025.1	0.52	0.003	0.006	0.007
	18475	141426	872.0	888.7	884.6	889.6	0.001	7.7	18373.6	1945.0	0.44	0.009	0.006	0.007
	18290	141426	871.5	888.4	884.4	889.4	0.001	8.1	17448.5	1844.7	0.46	0.003	0.006	0.005
	18025	141426	870.0	888.3	882.8	889.2	0.001	7.6	18674.7	1611.8	0.39	0.006	0.004	0.006
	17785	141426	868.0	887.9	882.8	889.0	0.001	8.5	16558.7	1418.6	0.44	0.008	0.007	0.006
SRD3	**17510**	141426	867.5	886.2	883.7	888.6	0.002	12.3	11457.1	1289.7	0.73	0.002	0.005	0.005
	17360	141426	866.5	883.4	883.4	887.9	0.004	16.9	8357.4	937.1	1.00	0.007	0.004	0.005
	17110	141426	864.0	881.1	881.1	884.6	0.005	15.0	9425.5	1362.5	1.01	0.010	0.009	0.006
	16970	141426	863.7	879.7	879.7	883.0	0.005	14.4	9799.5	1514.8	1.00	0.002	0.007	0.007
	16720	141426	863.5	875.3	875.3	878.4	0.005	14.2	9981.9	1621.0	1.01	0.001	0.001	0.005
	16515	141426	862.0	873.5	873.5	876.3	0.005	13.4	10549.7	1886.9	1.00	0.007	0.004	0.003
	16305	141426	860.0	871.6	871.2	874.0	0.004	12.6	11236.9	1898.6	0.91	0.010	0.008	0.006
	16130	141426	860.0	870.5	870.5	873.2	0.004	13.3	10641.4	1965.0	1.01	0.000	0.005	0.006
	15960	141426	859.0	869.2	869.2	871.8	0.005	12.8	11034.6	2193.0	1.01	0.006	0.003	0.005
	15745	141426	858.0	868.6	867.8	870.4	0.003	10.9	12927.8	2278.9	0.81	0.005	0.005	0.004
	15540	141426	857.5	868.1	867.1	869.8	0.003	10.4	13602.2	2324.4	0.76	0.002	0.004	0.004
	15335	141426	856.0	866.5	866.5	869.0	0.005	12.6	11254.1	2302.4	1.00	0.007	0.005	0.005
corr(x,v)=	**0.170227**													
corr(x,a)=	-0.15893													
corr(x,b)=	0.035906													
corr(x,m1)=	0.087873													
corr(x,m2)=	0.094747													
corr(x,m3)=	0.162424													

Figure A4.5A4: Santa Clara River Existing Conditions HEC-RAS Reach D - Station vs Channel Velocity

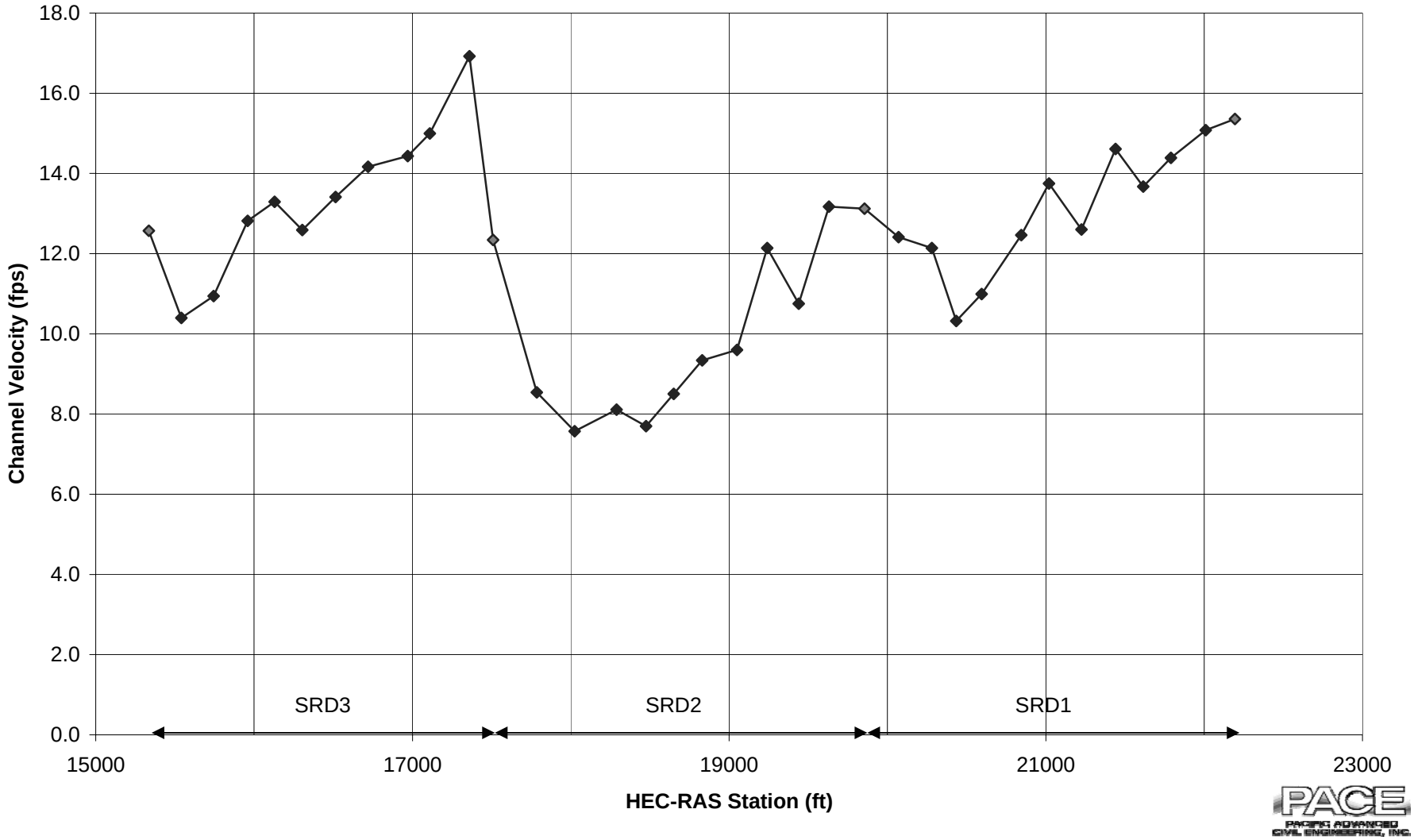


Table A4.5A5: Santa Clara River Existing Conditions Hec-Ras Output and Parameter Correlation: Reach E

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRE1	**15125**	142475	854.0	864.5	864.5	867.5	0.004	13.7	10371.5	1769.0	1.00			
	14900	142475	853.0	863.3	863.3	866.3	0.005	14.0	10205.6	1697.8	1.00	0.004		
	14720	142475	852.0	862.1	862.1	865.0	0.005	13.7	10381.9	1810.0	1.01	0.006	0.005	
	14480	142475	850.5	860.5	860.5	863.5	0.004	13.7	10409.0	1796.5	1.00	0.006	0.006	0.005
	14315	142475	850.0	859.9	859.8	862.7	0.005	13.5	10576.7	1874.0	1.00	0.003	0.005	0.005
	14090	142475	849.7	858.7	858.7	861.6	0.005	13.7	10387.9	1766.9	1.00	0.001	0.002	0.004
	13850	142475	848.0	857.1	857.1	860.1	0.005	13.8	10293.9	1731.4	1.00	0.007	0.004	0.004
	13635	142475	846.0	856.0	856.0	859.0	0.005	14.0	10182.3	1687.5	1.00	0.009	0.008	0.006
	13425	142475	845.0	854.6	854.6	857.4	0.004	13.4	10627.8	1893.5	1.00	0.005	0.007	0.007
	13190	142475	844.0	853.1	852.8	855.6	0.004	12.7	11213.3	1844.9	0.91	0.004	0.004	0.006
SRE2	**13030**	142475	843.0	852.7	852.0	855.0	0.003	12.3	11565.9	1764.2	0.85	0.006	0.005	0.005
	12835	142475	842.0	852.1	851.0	854.4	0.003	12.1	11770.0	1607.6	0.79	0.005	0.006	0.005
	12615	142475	841.0	851.8	849.8	853.8	0.002	11.3	12646.0	1470.5	0.68	0.005	0.005	0.005
	12395	142475	840.0	851.5	849.2	853.4	0.002	11.1	12874.2	1438.1	0.65	0.005	0.005	0.005
	12195	142475	839.0	851.4	848.1	853.0	0.001	10.1	14130.7	1388.8	0.56	0.005	0.005	0.005
	11995	142475	837.0	850.7	848.1	852.7	0.002	11.3	12590.6	1281.4	0.64	0.010	0.008	0.006
	11780	142475	836.0	850.5	847.7	852.3	0.001	10.7	13373.2	1402.9	0.61	0.005	0.007	0.007
	11605	142475	835.5	849.7	847.2	852.0	0.002	12.0	11833.0	1304.2	0.70	0.003	0.004	0.006
	11405	142475	834.0	849.4	846.2	851.7	0.001	12.0	11855.1	1132.2	0.65	0.008	0.005	0.005
	11180	142475	833.0	847.6	845.6	851.1	0.003	15.0	9504.9	868.5	0.80	0.004	0.006	0.005
SRE3	**11015**	142475	831.5	844.8	844.8	850.4	0.004	18.9	7530.6	680.3	1.00	0.009	0.006	0.007
	10835	142475	831.0	843.8	843.8	848.6	0.004	17.7	8059.6	834.5	1.00	0.003	0.006	0.005
	10575	142475	830.0	840.2	840.2	844.1	0.004	16.0	8918.2	1127.5	1.00	0.004	0.003	0.005
	10390	142475	828.0	839.5	838.6	842.2	0.003	13.2	10811.2	1390.1	0.83	0.011	0.007	0.006
	10225	142475	827.5	838.2	838.2	841.6	0.004	14.7	9676.6	1447.2	1.00	0.003	0.007	0.006
	10000	142475	826.0	837.1	837.1	840.4	0.004	14.6	9744.8	1487.1	1.01	0.007	0.005	0.007
	9820	142475	824.0	835.4	835.4	838.8	0.004	15.0	9530.3	1373.2	1.00	0.011	0.009	0.007
	9595	142475	823.8	834.1	834.1	837.4	0.005	14.6	9769.1	1619.4	1.00	0.001	0.005	0.006
	9385	142475	823.0	833.1	833.1	836.0	0.005	13.7	10378.5	1773.7	1.00	0.004	0.002	0.005
	9220	142475	822.0	831.8	831.8	834.7	0.005	13.7	10412.7	1813.7	1.01	0.006	0.005	0.003
	9025	142475	821.0	830.4	830.4	833.4	0.004	13.8	10348.0	1751.7	1.00	0.005	0.006	0.005

corr(x,v)=	-0.248811
corr(x,a)=	0.216874
corr(x,b)=	**0.4079725**
corr(x,m1)=	-0.076918
corr(x,m2)=	-0.084312
corr(x,m3)=	-0.104576

Figure A4.5A5: Santa Clara River Existing Conditions HEC-RAS Reach E - Station vs Top Width

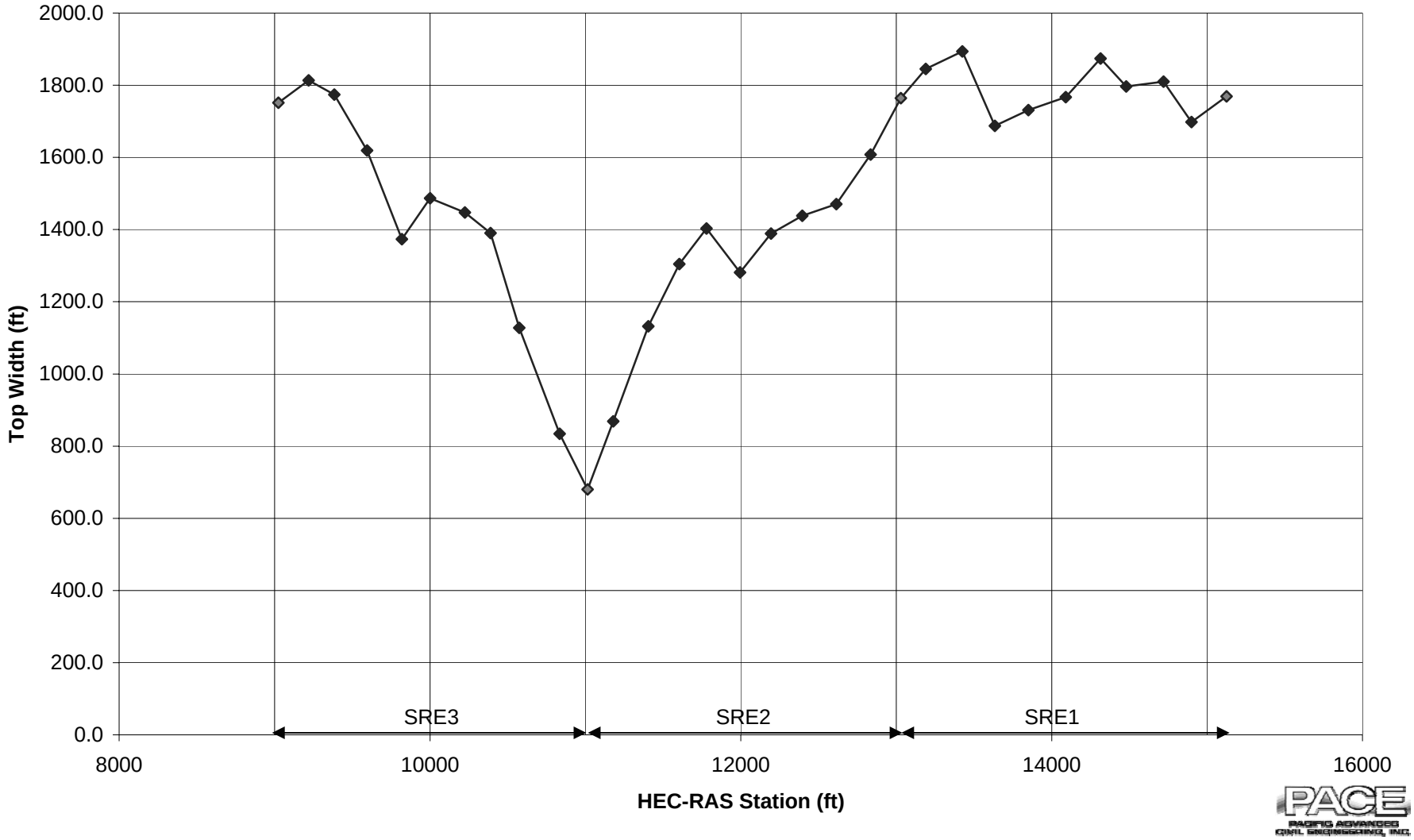


Table A4.5B1: Santa Clara River Proposed Conditions Hec-Ras Output and Parameter Correlation: Reach A

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRA1	**46195**	115111	1035.0	1054.3	1054.3	1060.3	0.004	19.7	5847.5	483.4	1.00			
	46020	115111	1032.0	1052.4	1052.4	1058.1	0.004	19.1	6013.5	531.5	1.00	0.017		
	45545	115111	1030.0	1049.2	1049.2	1055.7	0.004	20.3	5664.2	446.8	1.01	0.004	0.008	
	45030	115111	1025.0	1045.6	1044.6	1050.5	0.003	17.8	6472.4	521.5	0.89	0.010	0.007	0.009
	44585	115111	1022.0	1043.1	1043.1	1048.8	0.004	19.2	6004.2	531.9	1.01	0.007	0.008	0.007
	44210	115111	1020.0	1041.6	1038.7	1045.0	0.002	14.8	7793.3	585.9	0.71	0.005	0.006	0.007
SRA2	**43820**	115111	1018.0	1037.5	1037.5	1043.6	0.004	19.9	5785.1	476.5	1.01	0.005	0.005	0.006
	43610	115111	1017.0	1034.1	1034.1	1040.1	0.004	19.7	5832.0	483.7	1.00	0.005	0.005	0.005
	43410	115111	1016.0	1030.7	1030.7	1035.9	0.004	18.1	6344.4	623.6	1.00	0.005	0.005	0.005
	43200	115111	1014.0	1029.3	1029.3	1033.9	0.004	17.2	6697.3	738.0	1.01	0.010	0.007	0.006
	42975	115111	1012.0	1026.1	1026.1	1030.3	0.005	16.3	7064.9	860.6	1.00	0.009	0.009	0.008
	42815	115111	1011.0	1024.4	1024.4	1028.0	0.005	15.4	7497.0	1037.2	1.01	0.006	0.008	0.008
	42590	115111	1010.0	1021.5	1021.5	1025.0	0.005	15.1	7649.4	1098.8	1.01	0.004	0.005	0.007
	42430	115111	1008.0	1020.3	1020.3	1024.0	0.005	15.6	7396.5	1011.9	1.00	0.013	0.008	0.007
	42215	115111	1006.0	1019.7	1018.7	1022.3	0.003	12.7	9040.3	1182.7	0.81	0.009	0.011	0.008
	41940	115111	1005.0	1019.3	1017.7	1021.4	0.002	11.6	9945.3	1284.3	0.73	0.004	0.006	0.008
	41730	115111	1004.0	1018.7	1016.5	1020.8	0.002	11.8	9727.4	1189.1	0.73	0.005	0.004	0.006
	41460	115111	1002.0	1018.1	1015.2	1020.2	0.002	11.7	9876.9	1057.3	0.67	0.007	0.006	0.005
SRA3	**41280**	115111	1001.0	1015.3	1015.3	1019.5	0.005	16.4	7032.5	852.2	1.00	0.006	0.007	0.006
	41080	115111	1000.0	1013.6	1013.6	1017.6	0.005	16.0	7175.8	899.5	1.00	0.005	0.005	0.006
	40825	115111	999.5	1012.1	1012.1	1015.6	0.005	15.0	7673.9	1123.0	1.01	0.002	0.003	0.004
	40585	115111	998.0	1010.6	1010.6	1014.0	0.005	14.9	7741.1	1139.8	1.01	0.006	0.004	0.004
	40335	115111	996.0	1011.0	1008.7	1012.7	0.002	10.7	10771.0	1248.8	0.64	0.008	0.007	0.005
	40130	115111	995.0	1010.4	1008.3	1012.3	0.002	11.1	10380.2	1195.0	0.66	0.005	0.007	0.006
	39945	115111	994.0	1010.2	1007.6	1011.9	0.002	10.7	10785.0	1172.5	0.62	0.005	0.005	0.006
	39755	115111	994.0	1007.2	1007.2	1011.2	0.005	16.1	7140.7	893.3	1.00	0.000	0.003	0.003
	39605	115111	993.0	1005.8	1005.8	1009.9	0.005	16.2	7091.8	873.2	1.00	0.007	0.003	0.004
	39310	115111	992.0	1004.4	1004.4	1008.3	0.005	15.9	7232.2	929.3	1.01	0.003	0.004	0.003
	39100	115111	990.0	1003.7	1002.1	1006.9	0.003	14.2	8088.1	788.3	0.78	0.010	0.006	0.006
	38925	115111	989.5	1003.7	1001.5	1006.3	0.002	12.9	8958.4	873.3	0.71	0.003	0.006	0.005
SRA4	**38710**	115111	988.0	1003.6	1000.3	1005.8	0.002	12.1	9534.8	820.2	0.62	0.007	0.005	0.007
	38475	115111	986.0	1000.0	1000.0	1005.0	0.004	17.8	6455.5	659.8	1.00	0.009	0.008	0.006
	38300	115111	985.5	997.9	997.9	1002.7	0.004	17.7	6520.8	677.2	1.00	0.003	0.006	0.006
	38065	115111	984.0	998.0	995.7	1001.3	0.002	14.5	7917.9	658.4	0.74	0.006	0.005	0.006
	37810	115111	983.0	995.2	995.2	1000.4	0.004	18.2	6321.3	618.2	1.00	0.004	0.005	0.005
	37655	115111	982.0	994.1	994.1	998.8	0.004	17.4	6619.8	713.6	1.01	0.006	0.005	0.005
	37390	115111	981.0	991.5	990.1	994.6	0.003	14.2	8124.7	840.6	0.80	0.004	0.005	0.004
	37135	115111	980.0	989.3	989.3	993.6	0.005	16.6	6941.6	821.4	1.01	0.004	0.004	0.004
	36930	115111	978.0	987.9	987.5	991.7	0.004	15.6	7364.7	834.7	0.93	0.010	0.007	0.006
	36735	115111	977.0	986.9	986.9	990.9	0.005	16.1	7167.6	897.0	1.00	0.005	0.008	0.006
	36515	115111	975.0	987.0	985.4	989.6	0.002	12.8	8997.4	994.8	0.75	0.009	0.007	0.008
	36265	115111	974.0	986.5	985.2	988.8	0.003	12.3	9335.4	1176.0	0.77	0.004	0.006	0.006

corr(x,v)=	**0.420839**
corr(x,a)=	-0.34894
corr(x,b)=	-0.35235
corr(x,m1)=	0.287884
corr(x,m2)=	0.270636
corr(x,m3)=	0.366906

Figure A4.5B1: Santa Clara River Proposed Conditions HEC-RAS Reach A - Station vs Channel Velocity

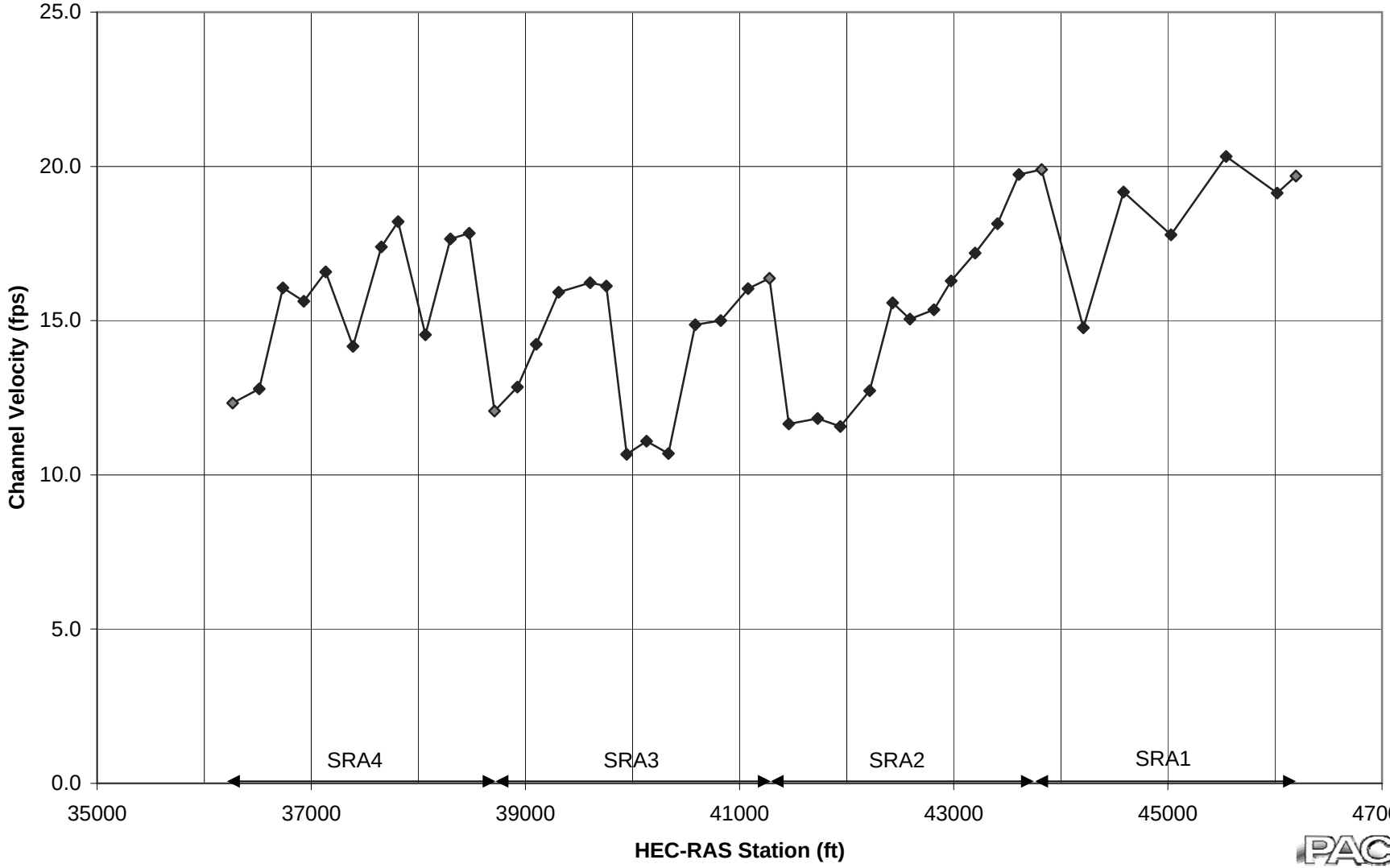


Table A4.5B2: Santa Clara River Proposed Conditions Hec-Ras Output and Parameter Correlation: Reach B

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRB1	**36080**	116236	973.0	984.6	984.6	988.0	0.006	14.7	7914.1	1176.0	1.00			
	35845	116236	971.0	984.1	982.9	986.2	0.003	11.7	9897.1	1385.2	0.76	0.009		
	35725	116236	970.0	982.6	982.6	985.7	0.005	14.1	8236.8	1374.9	1.00	0.008	0.008	
	35515	116236	969.0	981.3	981.3	984.4	0.004	14.0	8305.4	1363.6	1.00	0.005	0.006	0.007
	35245	116236	968.0	980.2	980.2	983.1	0.005	13.7	8476.1	1553.7	1.00	0.004	0.004	0.005
	35040	116236	967.0	978.3	978.3	981.4	0.005	13.9	8335.5	1400.5	1.01	0.005	0.004	0.004
	34860	116236	966.0	977.4	977.4	980.5	0.004	14.1	8261.7	1362.4	1.01	0.006	0.005	0.005
	34720	116236	965.5	976.2	976.2	979.2	0.004	13.9	8382.6	1419.6	1.01	0.004	0.005	0.005
	34495	116236	964.0	974.3	974.3	977.3	0.004	14.0	8314.1	1380.4	1.00	0.007	0.005	0.006
	34310	116236	963.0	972.6	972.6	975.8	0.005	14.3	8141.1	1311.4	1.01	0.005	0.006	0.005
	34090	116236	962.0	971.6	971.6	974.7	0.004	14.2	8178.3	1312.6	1.00	0.005	0.005	0.006
SRB2	**33880**	116236	960.0	970.3	970.3	973.3	0.004	14.1	8232.7	1343.5	1.01	0.010	0.007	0.007
	33710	116236	959.0	969.3	969.3	972.3	0.004	14.0	8301.6	1377.9	1.01	0.006	0.008	0.007
	33500	116236	958.0	968.1	968.1	970.7	0.005	13.1	8884.5	1720.7	1.01	0.005	0.005	0.007
	33310	116236	957.0	967.0	967.0	969.5	0.004	12.9	9026.4	1780.3	1.01	0.005	0.005	0.005
	33115	116236	956.0	966.6	965.3	968.3	0.003	10.4	11217.6	1847.3	0.74	0.005	0.005	0.005
	32795	116236	954.0	964.6	964.6	967.2	0.004	13.0	8949.4	1735.6	1.01	0.006	0.006	0.006
	32605	116236	952.0	963.6	963.6	966.3	0.004	13.1	8889.4	1766.1	1.00	0.011	0.008	0.007

corr(x,v)=	0.387052
corr(x,a)=	-0.3601
corr(x,b)=	**-0.74378**
corr(x,m1)=	-0.14733
corr(x,m2)=	-0.13339
corr(x,m3)=	-0.33786

Figure A4.5B2: Santa Clara River Proposed Conditions HEC-RAS Reach B - Station vs Top Width

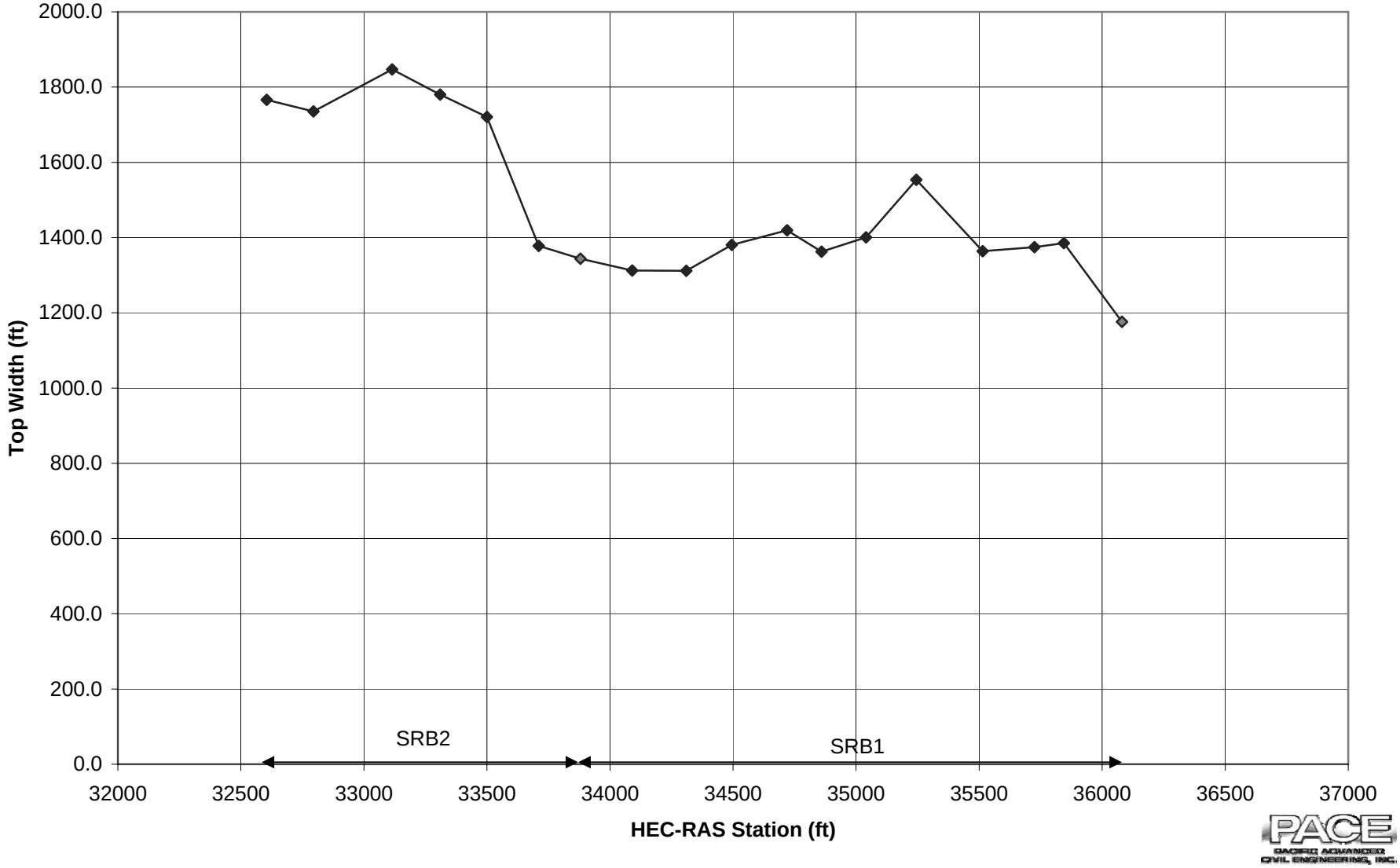


Table A4.5B3: Santa Clara River Proposed Conditions Hec-Ras Output and Parameter Correlation: Reach C

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRC1	**32265**	140776	950.0	961.3	961.3	964.1	0.004	13.4	10505.6	1941.1	1.02	0.006	0.008	0.007
	31875	140776	949.0	959.4	959.4	961.8	0.006	12.4	11368.1	2409.1	1.00	0.003	0.004	0.005
	31585	140776	946.0	957.3	957.0	959.5	0.004	12.1	11630.6	2178.5	0.92	0.010	0.006	0.006
	31360	140776	944.0	956.6	955.4	958.6	0.003	11.5	12197.9	1866.2	0.80			
	31060	140776	942.0	956.6	953.3	957.9	0.001	9.0	15628.5	1701.3	0.52	0.007		
	30720	140776	940.0	956.6	951.3	957.4	0.001	7.3	19427.4	1882.3	0.40	0.006	0.006	
	30445	140776	938.0	956.5	949.6	957.2	0.000	6.8	20869.5	1771.8	0.35	0.007	0.007	0.007
	30095	140776	936.0	956.3	947.9	957.1	0.000	7.0	20255.2	1619.5	0.35	0.006	0.006	0.006
	29815	140776	935.0	955.9	948.1	956.9	0.001	7.9	17894.8	1430.1	0.39	0.004	0.005	0.006
	29565	140776	934.0	955.8	947.3	956.7	0.001	7.7	18197.7	1320.3	0.37	0.004	0.004	0.005
	29385	140776	933.0	955.5	949.4	956.6	0.001	8.6	16378.8	1233.0	0.42	0.006	0.005	0.004
SRC2	**29140**	140776	932.0	954.8	950.0	956.4	0.001	10.2	13831.1	1082.5	0.50	0.004	0.005	0.004
	28895	140776	930.0	951.3	951.3	955.7	0.004	16.8	8407.0	966.7	1.00	0.008	0.006	0.006
	28695	140776	928.0	948.3	945.7	951.0	0.002	13.3	10604.2	929.9	0.69	0.010	0.009	0.007
	28500	140776	927.5	946.0	946.0	950.3	0.005	16.7	8456.7	998.2	1.01	0.003	0.006	0.007
	28280	140776	926.0	943.4	939.9	945.6	0.001	11.9	11789.8	976.2	0.61	0.007	0.005	0.007
	28080	140776	925.0	943.4	938.2	945.2	0.001	10.9	12937.5	923.4	0.51	0.005	0.006	0.005
	27925	140776	924.0	942.6	938.7	945.0	0.001	12.4	11348.0	864.0	0.60	0.006	0.006	0.006
	27725	140776	923.0	939.3	939.3	944.3	0.004	18.0	7836.7	784.8	1.00	0.005	0.006	0.005
	27545	140776	922.0	937.6	937.6	943.3	0.004	19.1	7378.1	656.3	1.00	0.006	0.005	0.006
	27335	140776	921.0	936.2	936.2	940.9	0.004	17.4	8079.1	865.4	1.00	0.005	0.005	0.005
	27155	140776	920.5	935.3	935.3	939.9	0.004	17.2	8170.8	888.2	1.00	0.003	0.004	0.004
SRC3	**26990**	140776	920.0	933.7	933.7	938.1	0.005	16.7	8413.9	976.9	1.00	0.003	0.003	0.004
	26780	140776	918.0	931.3	931.3	935.4	0.005	16.3	8650.6	1062.3	1.00	0.010	0.007	0.005
	26575	140776	917.0	930.4	930.0	933.8	0.004	14.7	9560.9	1203.7	0.92	0.005	0.007	0.006
	26355	140776	916.0	929.1	929.1	932.8	0.005	15.4	9144.2	1256.8	1.01	0.005	0.005	0.006
	26170	140776	915.0	928.2	928.2	931.8	0.005	15.3	9212.4	1267.9	1.00	0.005	0.005	0.005
	25965	140776	914.0	927.3	927.2	930.8	0.005	15.2	9292.6	1281.8	0.99	0.005	0.005	0.005
	25785	140776	913.5	926.8	926.2	930.0	0.004	14.4	9809.4	1224.0	0.89	0.003	0.004	0.004
	25600	140776	912.5	925.8	925.2	929.3	0.004	15.0	9384.8	1112.9	0.91	0.005	0.004	0.004
	25425	140776	911.0	925.3	924.4	928.6	0.003	14.6	9667.5	1090.1	0.86	0.009	0.007	0.006
	25215	140776	910.0	924.7	923.7	927.9	0.003	14.2	9894.1	1097.3	0.84	0.005	0.006	0.006
	25000	140776	909.0	924.5	922.5	927.2	0.002	13.1	10725.5	1062.4	0.73	0.005	0.005	0.006
SRC4	**24795**	140776	908.0	923.6	921.8	926.6	0.002	14.0	10061.5	957.4	0.76	0.005	0.005	0.005
	24550	140776	906.0	922.5	920.9	926.0	0.003	15.0	9403.5	856.1	0.80	0.008	0.007	0.006
	24335	140776	905.0	920.0	920.0	925.1	0.004	18.1	7779.4	765.0	1.00	0.005	0.007	0.006
	24115	140776	904.0	918.7	918.7	923.8	0.004	18.2	7736.8	757.9	1.00	0.005	0.005	0.006
	23975	140776	903.5	917.7	917.7	922.7	0.004	18.0	7837.6	789.5	1.00	0.004	0.004	0.004
	23755	140776	902.0	916.8	916.8	921.7	0.004	17.8	7930.3	816.5	1.00	0.007	0.006	0.005
	23565	140776	900.0	915.6	915.6	920.3	0.004	17.4	8100.0	867.0	1.00	0.011	0.009	0.007
	23365	140776	900.0	914.4	914.4	918.9	0.004	16.9	8320.3	939.5	1.00	0.000	0.005	0.006
	23180	140776	899.0	913.2	912.6	917.2	0.004	16.0	8806.1	926.0	0.91	0.005	0.003	0.005
	23000	140776	898.0	912.8	911.1	916.5	0.003	15.3	9178.0	784.0	0.79	0.006	0.005	0.004
	22790	140776	897.5	910.5	910.5	915.5	0.005	18.0	7838.5	784.0	1.00	0.002	0.004	0.004
	22600	140776	896.0	909.6	909.6	913.9	0.005	16.6	8469.8	1007.6	1.01	0.008	0.005	0.005
	22415	140776	895.5	908.0	908.0	912.1	0.005	16.3	8630.1	1052.8	1.00	0.003	0.005	0.004

corr(x,v)=	-0.71507
corr(x,a)=	**0.711145**
corr(x,b)=	0.655976
corr(x,m1)=	0.131527
corr(x,m2)=	0.154975
corr(x,m3)=	0.224278

Figure A4.5B3: Santa Clara River Proposed Conditions HEC-RAS Reach C - Station vs Flow Area

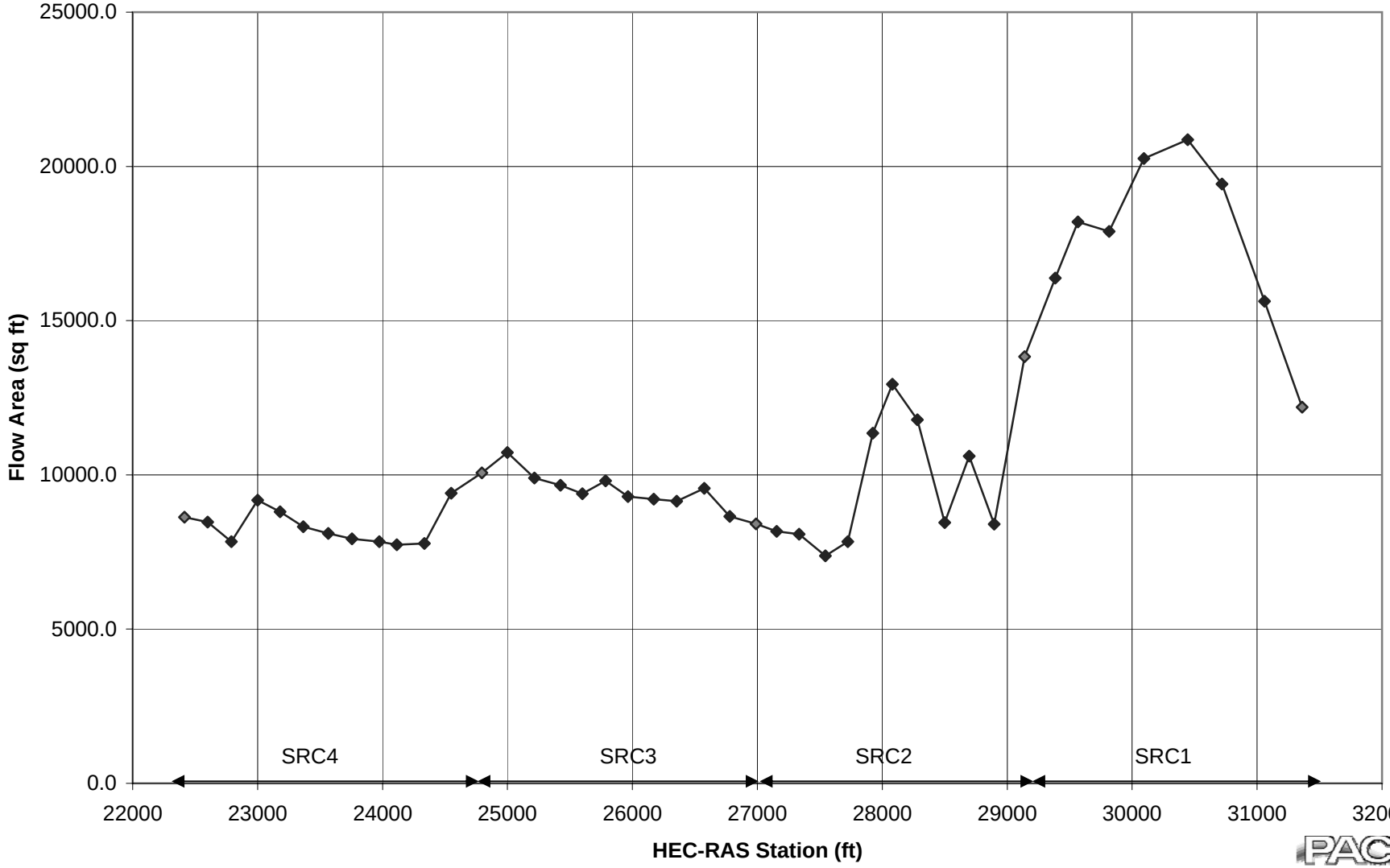


Table A4.5B4: Santa Clara River Proposed Conditions Hec-Ras Output and Parameter Correlation: Reach D

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRD1	**22195**	141426	894.0	907.5	906.9	910.6	0.004	14.2	9951.4	1281.6	0.90			
	22010	141426	892.0	906.1	906.1	909.8	0.005	15.4	9195.9	1252.3	1.00	0.011		
	21790	141426	891.5	904.8	904.8	908.1	0.005	14.7	9642.9	1507.8	1.00	0.002	0.006	
	21615	141426	892.0	902.8	902.8	906.2	0.005	14.8	9557.4	1401.1	1.00	-0.003	0.000	0.003
	21440	141426	890.0	901.6	901.6	905.1	0.005	15.0	9424.5	1342.6	1.00	0.011	0.004	0.004
	21225	141426	888.0	900.5	900.5	903.7	0.005	14.3	9886.6	1563.9	1.00	0.009	0.010	0.006
	21020	141426	887.0	900.0	898.9	902.3	0.003	12.3	11464.6	1568.5	0.80	0.005	0.007	0.008
	20845	141426	886.0	898.4	898.4	901.6	0.005	14.3	9883.4	1561.0	1.00	0.006	0.005	0.007
	20595	141426	885.0	898.3	896.5	900.3	0.002	11.1	12704.0	1548.1	0.68	0.004	0.005	0.005
	20435	141426	884.0	898.1	895.8	899.9	0.002	10.8	13124.4	1524.8	0.65	0.006	0.005	0.005
	20280	141426	883.7	896.0	896.0	899.3	0.005	14.5	9735.6	1527.4	1.01	0.002	0.004	0.004
	20070	141426	882.0	894.3	894.3	897.5	0.005	14.4	9793.6	1537.7	1.01	0.008	0.005	0.006
SRD2	**19855**	141426	880.5	892.7	892.7	895.8	0.005	14.3	9916.9	1593.1	1.01	0.007	0.008	0.006
	19630	141426	880.0	891.5	890.5	894.7	0.003	14.4	9854.6	1098.6	0.84	0.002	0.005	0.006
	19440	141426	878.0	891.4	889.7	894.0	0.002	12.9	10950.1	1194.6	0.75	0.011	0.006	0.006
	19240	141426	877.5	889.4	889.4	893.2	0.005	15.6	9068.4	1219.4	1.01	0.003	0.006	0.005
	19050	141426	876.0	889.4	887.9	891.7	0.003	12.2	11580.6	1442.6	0.76	0.008	0.005	0.007
	18830	141426	874.0	888.8	887.5	891.1	0.003	12.1	11667.4	1538.2	0.78	0.009	0.009	0.007
	18650	141426	873.5	888.7	886.7	890.5	0.002	10.8	13119.6	1607.3	0.66	0.003	0.006	0.007
	18475	141426	872.0	888.9	885.0	890.1	0.001	8.8	16151.2	1621.7	0.49	0.009	0.006	0.007
	18290	141426	871.5	888.5	885.1	889.9	0.001	9.4	15041.5	1594.7	0.54	0.003	0.006	0.005
	18025	141426	870.0	888.6	882.9	889.5	0.001	7.8	18154.4	1520.5	0.40	0.006	0.004	0.006
	17785	141426	868.0	888.3	882.8	889.3	0.001	8.4	16871.0	1398.4	0.43	0.008	0.007	0.006
SRD3	**17510**	141426	868.0	887.5	883.4	889.0	0.001	10.1	14045.6	1353.6	0.55	0.000	0.004	0.004
	17360	141426	868.0	884.0	884.0	888.4	0.004	16.9	8365.0	944.5	1.00	0.000	0.000	0.003
	17110	141426	864.0	881.1	881.1	884.9	0.005	15.7	9039.2	1191.9	1.00	0.016	0.010	0.006
	16970	141426	863.7	879.6	879.6	883.4	0.005	15.7	8997.0	1180.2	1.00	0.002	0.011	0.008
	16720	141426	863.5	875.4	875.4	879.4	0.005	15.9	8873.6	1146.5	1.01	0.001	0.001	0.007
	16515	141426	862.0	873.9	873.9	877.5	0.005	15.4	9209.6	1260.0	1.00	0.007	0.004	0.003
	16305	141426	860.0	874.5	872.0	876.4	0.002	11.1	12765.9	1360.4	0.64	0.010	0.008	0.006
	16130	141426	860.0	872.2	872.2	875.8	0.005	15.2	9332.9	1326.0	1.01	0.000	0.005	0.006
	15960	141426	859.0	871.6	871.0	874.5	0.004	13.7	10347.3	1395.6	0.88	0.006	0.003	0.005
	15745	141426	858.0	871.3	869.8	873.7	0.003	12.3	11500.9	1363.9	0.75	0.005	0.005	0.004
	15540	141426	857.5	871.2	868.5	873.0	0.002	10.5	13415.3	1427.0	0.61	0.002	0.004	0.004
	15335	141426	856.0	868.1	868.1	872.2	0.006	16.2	8723.3	1064.1	1.00	0.007	0.005	0.005

corr(x,v)=	0.100396
corr(x,a)=	-0.14163
corr(x,b)=	**0.358193**
corr(x,m1)=	0.081919
corr(x,m2)=	0.060966
corr(x,m3)=	0.113964

Figure A4.5B4: Santa Clara River Proposed Conditions HEC-RAS Reach D - Station vs Top Width

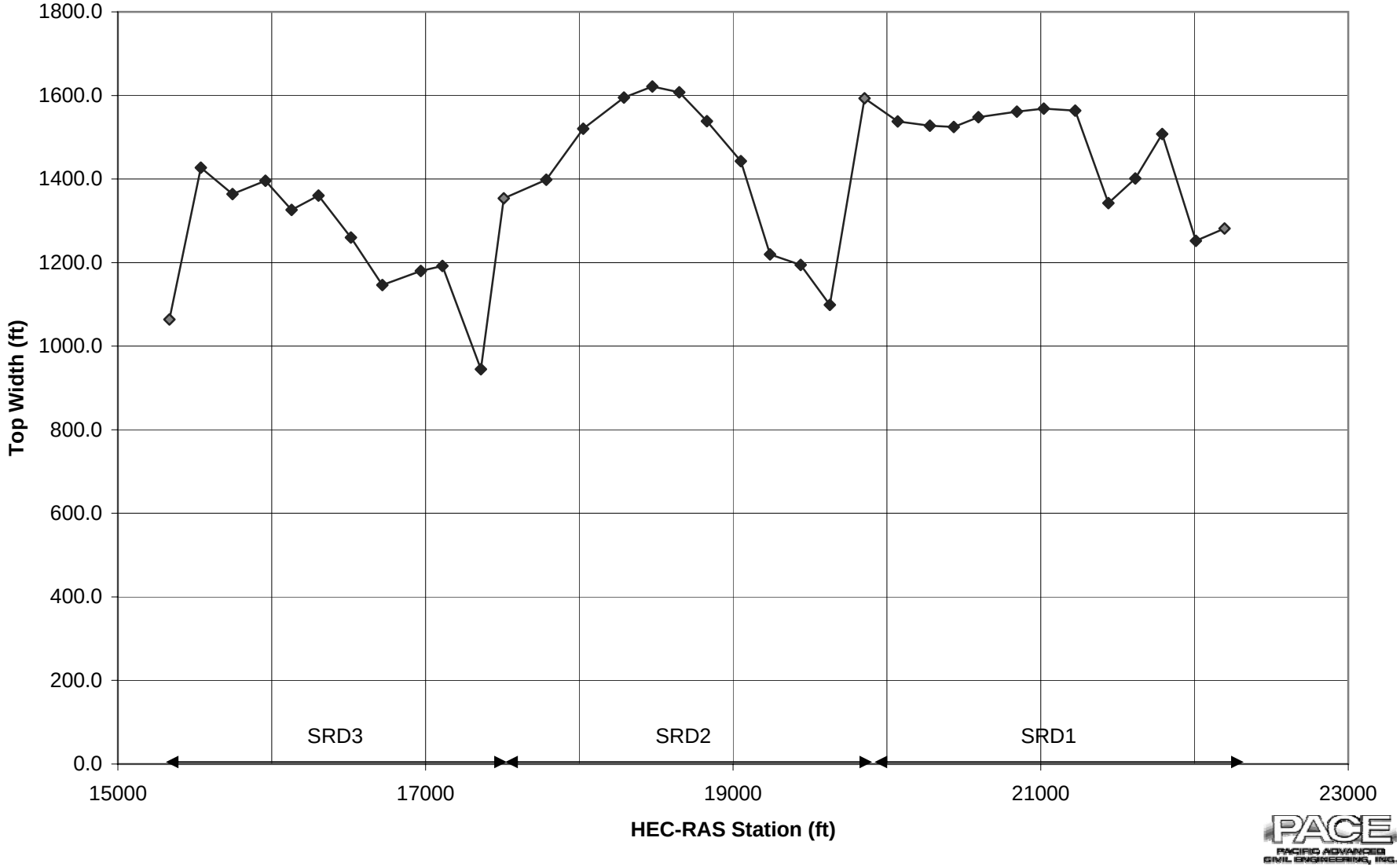
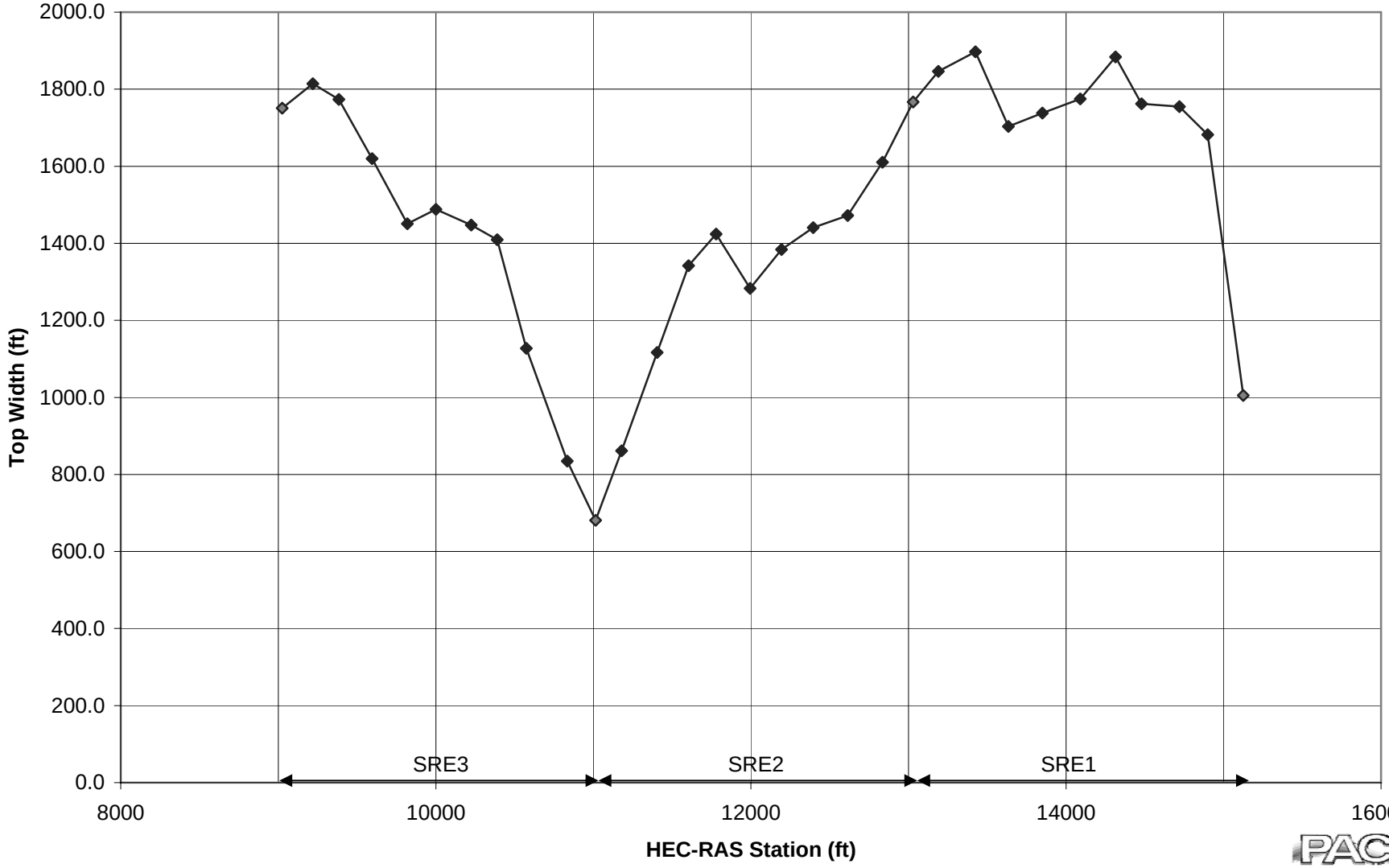


Table A4.5B5: Santa Clara River Proposed Conditions Hec-Ras Output and Parameter Correlation: Reach E

Subreach	River Sta	Q Total	Min Ch El ft	W.S. Elev ft	Crit W.S. ft	E.G. Elev ft	E.G. Slope	Vel Chnl fps	Flow Area sq ft	Top Width ft	Froude #	bedslope 1	bedslope 2	bedslope 3
SRE1	**15125**	142475	854.0	866.3	866.3	870.5	0.006	16.6	8594.5	1005.2	1.00			
	14900	142475	853.0	864.2	864.2	868.3	0.005	16.3	8744.6	1682.0	1.00	0.004		
	14720	142475	852.0	863.3	863.3	867.2	0.005	15.9	8988.3	1754.8	1.00	0.006	0.005	
	14480	142475	850.5	860.8	860.8	864.0	0.005	14.5	9824.9	1761.9	0.99	0.006	0.006	0.005
	14315	142475	850.0	860.1	860.1	863.2	0.005	14.0	10171.0	1883.6	1.00	0.003	0.005	0.005
	14090	142475	850.0	858.7	858.7	861.6	0.005	13.7	10369.2	1774.7	1.00	0.000	0.001	0.003
	13850	142475	848.0	857.1	857.1	860.1	0.005	13.9	10284.5	1738.4	1.00	0.008	0.004	0.004
	13635	142475	846.0	856.0	856.0	859.0	0.005	14.0	10211.8	1703.1	1.00	0.009	0.009	0.006
	13425	142475	845.0	854.2	854.2	857.1	0.005	13.5	10578.2	1897.2	1.01	0.005	0.007	0.008
	13190	142475	844.0	853.3	852.7	855.7	0.004	12.3	11549.9	1846.1	0.87	0.004	0.004	0.006
SRE2	**13030**	142475	843.0	852.9	852.0	855.1	0.003	12.0	11909.3	1766.8	0.81	0.006	0.005	0.005
	12835	142475	842.0	852.3	851.0	854.5	0.003	11.8	12100.7	1610.1	0.76	0.005	0.006	0.005
	12615	142475	841.0	852.0	849.8	853.9	0.002	11.0	12926.1	1472.3	0.66	0.005	0.005	0.005
	12395	142475	840.0	851.7	849.2	853.5	0.002	10.9	13135.4	1440.7	0.63	0.005	0.005	0.005
	12195	142475	839.0	851.6	848.1	853.1	0.001	10.0	14313.4	1384.2	0.55	0.005	0.005	0.005
	11995	142475	837.0	850.9	848.0	852.8	0.002	11.1	12823.3	1283.1	0.62	0.010	0.008	0.006
	11780	142475	836.0	850.7	847.7	852.4	0.002	10.4	13642.5	1424.2	0.59	0.005	0.007	0.007
	11605	142475	835.5	850.0	847.3	852.1	0.002	11.6	12285.5	1341.9	0.68	0.003	0.004	0.006
	11405	142475	834.0	849.4	846.2	851.7	0.002	12.1	11766.0	1116.4	0.66	0.008	0.005	0.005
	11180	142475	833.0	847.5	845.6	851.1	0.002	15.2	9359.0	861.1	0.81	0.004	0.006	0.005
SRE3	**11015**	142475	831.5	844.9	844.9	850.4	0.004	18.9	7546.8	680.7	1.00	0.009	0.006	0.007
	10835	142475	831.0	843.8	843.8	848.6	0.004	17.7	8059.5	834.5	1.00	0.003	0.006	0.005
	10575	142475	830.0	840.2	840.2	844.1	0.004	16.0	8907.8	1127.5	1.00	0.004	0.003	0.005
	10390	142475	828.0	839.8	838.5	842.3	0.003	12.7	11218.3	1409.0	0.79	0.011	0.007	0.006
	10225	142475	827.5	838.2	838.2	841.6	0.005	14.7	9676.6	1447.2	1.00	0.003	0.007	0.006
	10000	142475	826.0	837.1	837.1	840.4	0.004	14.6	9788.3	1488.1	1.00	0.007	0.005	0.007
	9820	142475	824.0	835.4	835.4	838.8	0.004	14.9	9537.7	1450.9	1.00	0.011	0.009	0.007
	9595	142475	823.8	834.2	834.2	837.4	0.005	14.5	9808.5	1620.1	1.00	0.001	0.005	0.006
	9385	142475	823.0	833.1	833.1	836.0	0.005	13.8	10337.7	1773.6	1.01	0.004	0.002	0.005
	9220	142475	822.0	831.8	831.8	834.7	0.005	13.7	10430.0	1814.1	1.00	0.006	0.005	0.003
	9025	142475	821.0	830.4	830.4	833.4	0.004	13.8	10307.8	1751.0	1.00	0.005	0.006	0.005

corr(x,v)=	-0.0153
corr(x,a)=	0.022217
corr(x,b)=	**0.248521**
corr(x,m1)=	-0.07691
corr(x,m2)=	-0.08554
corr(x,m3)=	-0.10549

Figure A4.5B5: Santa Clara River Proposed Conditions HEC-RAS Reach E - Station vs Top Width



Santa Clara River Fluvial Study

APPENDIX CHAPTER 4.6

Existing & Proposed Conditions SAM.AID Transport Equation Summary

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A4.6A: Santa Clara River Existing Conditions SAM Transport Potential Summary												
Subreach	US Sta	DS Sta	Width (ft)	Yang	Ackers-White	MPM	Brownlie, d50	Laursen-Copeland	Laursen-Madden	Yang, d50	Ackers-White, d50	MPM, d50
SRA1	46195	44210	525.6	11,578,207		403,938	10,213,413		10,288,930		2,616,358	428,254
SRA2	43820	41460	977.0	7,019,537		330,678	5,396,854		7,428,092		1,828,759	
SRA3	41280	38925	1,242.2	8,423,927		401,167	5,999,501		8,661,182		2,114,228	
SRA4	38710	36265	952.0	7,472,957		343,735	5,760,137		7,762,680		1,917,288	
SRB1	36080	34090	1,389.0	10,501,440		483,359	7,166,304		10,291,797		2,506,537	
SRB2	33880	32605	1,650.3	9,981,533		488,063	6,529,088		10,032,043		2,427,273	
SRC1	32265	29385	1,965.8	549,651		101,035		3,776,574		445,251		
SRC2	29140	27155	780.8	6,114,881	103,813,640	470,866	5,607,809	59,236,428		3,144,927		
SRC3	26990	25000	1,492.1	6,112,071	72,451,720	558,797	4,709,391	56,391,164		3,062,371		
SRC4	24795	22415	2,008.5	4,354,715	38,238,164	468,697	3,139,686	37,428,088		2,332,338		
SRD1	22195	20070	2,009.0	6,555,626	68,813,664	675,434	4,673,919	60,892,464		3,226,039		
SRD2	19855	17785	1,936.3	1,702,374		241,344		12,902,746		1,141,649		
SRD3	17510	15335	1,812.5	6,123,644	66,058,544	623,943	4,496,810	56,559,088		3,077,924		
SRE1	15125	13190	1,878.9	9,343,788		796,646	6,294,619		9,559,064		1,623,079	
SRE2	13030	11180	1,372.4	2,942,931		307,423	2,244,769	23,642,152	3,819,590	1,718,088	681,086	
SRE3	11015	9025	1,390.6	7,526,579		624,904	5,541,755		7,915,211		1,347,439	

Table A4.6B: Santa Clara River Proposed Conditions SAM Transport Potential Summary												
Subreach	US Sta	DS Sta	Width (ft)	Yang	Ackers-White	MPM	Brownlie, d50	Laursen-Copeland	Laursen-Madden	Yang, d50	Ackers-White, d50	MPM, d50
SRA1	46195	44210	525.6	11,578,207		403,938	10,213,413		10,288,930		2,616,358	428,254
SRA2	43820	41460	958.6	7,946,985		359,566	6,086,816		8,125,280		2,006,747	
SRA3	41280	38925	1,022.2	8,573,228		385,857	6,421,179		8,636,340		2,127,909	
SRA4	38710	36265	797.6	8,853,698		370,217	7,072,628		8,670,224		2,163,247	
SRB1	36080	34090	1,376.0	12,125,351		534,683	8,220,035		11,438,973		2,793,897	
SRB2	33880	32605	1,709.1	10,043,264		494,553	6,502,022		10,096,604		2,439,216	
SRC1	32265	29385	1,859.8	949,043		147,697		6,770,803		699,695		
SRC2	29140	27155	899.2	4,534,666		389,467		41,054,972		2,493,064		
SRC3	26990	25000	1,159.3	7,868,941	119,958,744	633,550	6,462,984	77,554,248		3,741,335		
SRC4	24795	22415	860.1	8,184,735		603,656		83,418,544		3,895,934		
SRD1	22195	20070	1,511.4	7,052,652	89,557,384	661,922	5,428,181	67,565,112		3,449,140		
SRD2	19855	17785	1,431.8	2,755,468		319,200		22,530,518		1,691,165		
SRD3	17510	15335	1,274.3	6,885,280	95,199,624	620,768	5,553,703	66,390,272		3,411,958		
SRE1	15125	13190	1,588.9	8,848,421	138,177,216	731,941	6,244,320	84,638,576		3,866,203		
SRE2	13030	11180	1,375.5	2,726,007		291,031		21,732,192		1,620,062		
SRE3	11015	9025	1,399.4	7,687,321	121,551,024	635,705	5,646,198	72,173,344		3,516,310		

Santa Clara River Fluvial Study

APPENDIX CHAPTER 5.1

Historical Topographic Maps

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Figure B1 – Mesa Area 1929-1931 USGS Surveys, 1940 Editions of Castaic and Saugus 6' Quads

Figure B2 – Mesas Area – 1947 USGS Survey, 1969 Edition of Val Verde and Newhall 7.5 Quads

Figure B3 – 11/63 and 1/64 Horizon Survey from 8/15/90, Mapsheets by Sikand

Figure B4 – Digital Topography by Psomas Engineering, from Data Generated @1999

Figure B5 – Digital Topography by McElhanney, from Data Generated @2004

Figure B6 – Digital Topography by McElhanney, from Data Generated @2005

Santa Clara River Fluvial Study

APPENDIX CHAPTER 5.2

Historical Thalweg Analysis

Previous drafts of this report calculated long-term trends based on an analysis of historic thalweg data. Analysis of long-term data based on cross-sections has been found to more clearly portray the historic trends of the creek bed. The historic analysis is included here for completeness.

The thalwegs and an additional alignment were digitized from the historic topography shown in Chapter 5, and these alignments were overlain in every digitized data set. That is, the 1930 thalweg was overlain in the 1930, 1947, 1963, 1999, 2004 and 2005 topographies. This was repeated for the other thalwegs as well. Thalwegs were chosen because they served as a reference and generally represent the lowest portion of the riverbed cross-section for a given year. The additional alignment was positioned so that an even distribution of alignments was achieved over the width of the channel for the study reach. The alignments are shown in Figure A5.3.1. The bed elevations along all alignments for all years were determined and compared, and a historic mean bed elevation was determined. Calculations of the minimum and mean bed elevation for all stations for all years examined is presented in Table A5.3.1. The historic bed elevation data, as well as historic mean bed elevation, is presented in Figure 5.2A-B. The figure illustrates variation in bed elevations throughout the period of record.

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Table A5.2 Santa Clara River Thalweg Analysis Caluclation of Long Term Aggradation/Degradation Based on Historical Bed Analysis (ft)

Subreach	HEC-RAS Station	1930 Topo Mean	1930 Topo Min	1947 Topo Mean	1947 Topo Min	1963 Topo Mean	1963 Topo Min	1999 Topo Mean	1999 Topo Min	2004 Topo Mean	2004 Topo Min	2005 Topo Mean	2005 Topo Min	(1)MINIMUM OF ALL MINIMUMS	(1)MEAN OF ALL MEANS	99 MEAN-ALL MEAN
	48025	1053.7	1053.5					1050.5	1049.1					**1049.1**	**1050.5**	**0.0**
	47850	1052.1	1051.8					1048.7	1046.0					**1046.0**	**1048.7**	**0.0**
	47670	1051.1	1050.3					1048.8	1044.4					**1044.4**	**1048.8**	**0.0**
	47510	1049.1	1049.1					1045.7	1044.0					**1044.0**	**1045.7**	**0.0**
	47440	1048.5	1048.5					1045.4	1044.0					**1044.0**	**1045.4**	**0.0**
	47180	1046.6	1045.9			1049.9	1049.6	1046.5	1042.0					**1042.0**	**1048.2**	**-1.7**
	47015	1046.9	1045.0			1048.9	1047.7	1046.7	1040.4					**1040.4**	**1047.8**	**-1.1**
	46890	1049.2	1043.5			1047.3	1046.5	1045.6	1040.0					**1040.0**	**1046.4**	**-0.8**
	46800	1047.0	1042.1			1046.3	1045.5	1042.0	1038.5					**1038.5**	**1044.1**	**-2.1**
	46760	1045.2	1041.5			1045.8	1045.1	1041.6	1039.4					**1039.4**	**1043.7**	**-2.1**
	46695	1043.7	1040.9			1045.3	1044.7	1040.9	1038.7					**1038.7**	**1043.1**	**-2.2**
	46550	1040.8	1038.9			1043.6	1043.3	1038.2	1037.1					**1037.1**	**1040.9**	**-2.7**
	46370	1042.8	1034.8			1043.1	1042.0	1036.9	1036.2	1039.6	1039.5			**1036.2**	**1039.9**	**-2.9**
SRA1	46195	1041.5	1032.2			1042.4	1041.6	1036.3	1034.6	1037.4	1032.3			**1032.3**	**1038.7**	**-2.4**
	46020	1029.4	1023.3			1040.1	1040.0	1032.9	1032.0	1031.7	1029.9	1034.6	1033.8	**1029.9**	**1034.8**	**-1.9**
	45545	1031.9	1017.5			1045.0	1040.0	1032.4	1030.0	1034.1	1027.6	1033.9	1030.7	**1027.6**	**1036.4**	**-3.9**
	45030	1038.7	1015.0			1034.0	1030.2	1028.8	1026.0	1028.6	1025.8	1027.2	1026.5	**1025.8**	**1029.7**	**-0.8**
	44585	1043.6	1015.0			1039.6	1030.0	1038.1	1022.0	1033.9	1019.2	1031.4	1023.0	**1019.2**	**1035.8**	**2.4**
	44210	1037.5	1015.0			1033.7	1026.7	1029.3	1020.0	1028.7	1017.3	1026.9	1020.9	**1017.3**	**1029.7**	**-0.3**
SRA2	43820	1017.8	1010.2			1023.0	1020.0	1018.4	1018.0	1017.2	1015.9	1017.5	1016.5	**1015.9**	**1019.0**	**-0.6**
	43610	1014.8	1010.0			1021.9	1020.0	1019.5	1016.7	1016.4	1014.4	1017.7	1016.1	**1014.4**	**1018.9**	**0.6**
	43410	1014.4	1010.0	1019.9	1019.9	1023.2	1020.0	1019.2	1015.7	1017.8	1013.5	1020.8	1014.8	**1013.5**	**1020.2**	**-1.0**
	43200	1018.2	1010.0	1023.3	1018.1	1025.2	1020.0	1021.4	1014.0	1020.2	1012.3	1024.4	1013.5	**1012.3**	**1022.9**	**-1.5**
	42975	1021.4	1010.0	1025.3	1016.9	1025.6	1020.0	1018.9	1012.0	1022.1	1011.0	1023.3	1013.0	**1011.0**	**1023.0**	**-4.1**
	42815	1019.9	1009.0	1026.8	1015.0	1024.7	1020.0	1017.5	1012.0	1021.4	1009.5	1024.2	1011.7	**1009.5**	**1022.9**	**-5.4**
	42590	1015.0	1006.5	1024.9	1015.0	1023.0	1017.9	1013.8	1010.0	1016.2	1008.8	1023.2	1009.3	**1008.8**	**1020.3**	**-6.4**
	42430	1012.5	1005.0	1023.1	1013.6	1020.1	1013.9	1012.3	1010.0	1012.9	1007.4	1013.3	1008.5	**1007.4**	**1016.3**	**-4.1**
	42215	1014.0	1005.0	1022.2	1012.1	1017.1	1010.0	1011.8	1008.0	1010.4	1006.6	1011.3	1007.5	**1006.6**	**1014.6**	**-2.7**
	41940	1008.8	1005.0	1020.0	1009.5	1013.5	1010.0	1010.4	1006.0	1006.2	1005.1	1008.6	1006.0	**1005.1**	**1011.7**	**-1.3**
	41730	1008.8	1002.6	1013.0	1008.0	1012.2	1010.0	1009.0	1004.0	1007.8	1003.5	1006.6	1003.5	**1003.5**	**1009.7**	**-0.7**
	41460	1010.1	999.5	1009.8	1006.7	1011.0	1009.7	1007.5	1002.0	1005.5	1000.9	1004.2	1002.5	**1000.9**	**1007.6**	**-0.1**
SRA3	41280	1010.0	998.2	1006.5	1004.0	1008.5	1006.7	1007.5	1002.0	1002.6	1000.4	1002.3	1000.6	**1000.4**	**1005.5**	**2.0**
	41080	1009.5	996.8	1004.1	1002.3	1004.6	1003.2	1003.7	1001.3	1000.5	999.1	999.8	998.8	**998.8**	**1002.5**	**1.1**
	40825	1005.0	995.0	1005.9	1000.0	1004.4	1000.0	1003.0	1000.0	1000.7	996.0	998.9	997.4	**996.0**	**1002.6**	**0.4**
	40585	1002.7	995.0	1003.3	1000.0	1003.5	1000.0	1003.3	998.0	999.7	995.5	996.9	995.6	**995.5**	**1001.3**	**2.0**
	40335	1005.4	995.0	1000.0	995.1	1002.3	1000.0	1001.2	996.0	997.4	992.7	994.8	994.2	**992.7**	**999.1**	**2.0**
	40130	1006.5	993.7	1001.2	992.5	1002.8	1000.0	999.8	996.0	997.0	992.1	994.0	993.2	**992.1**	**999.0**	**0.8**
	39945	1003.5	990.0	1000.0	991.3	1002.5	999.9	997.3	994.0	995.6	991.0	993.5	991.7	**991.0**	**997.8**	**-0.5**
	39755	999.2	990.0	993.5	988.6	1000.2	997.3	996.2	994.0	994.3	990.1	993.3	990.9	**988.6**	**995.5**	**0.7**
	39605	995.8	989.9	990.9	987.7	997.9	995.6	996.9	994.0	994.7	989.4	991.7	989.4	**987.7**	**994.4**	**2.5**
	39310	993.5	985.0	987.9	985.9	991.5	990.0	995.6	992.0	992.6	988.1	990.6	987.6	**985.9**	**991.6**	**3.9**
	39100	992.9	985.0	986.7	982.9	992.0	990.0	993.0	990.0	991.0	987.4	988.7	985.5	**982.9**	**990.3**	**2.8**
	38925	991.3	983.3	986.8	980.8	992.0	990.0	993.0	990.0	990.6	987.4	987.6	984.8	**980.8**	**990.0**	**3.0**
SRA4	38710	990.0	980.3	983.7	980.0	990.6	990.0	991.3	988.0	988.7	985.5	986.0	984.5	**980.0**	**988.1**	**3.3**
	38475	988.8	980.0	983.0	980.0	991.0	990.0	989.7	986.3	988.2	984.0	984.1	982.5	**980.0**	**987.2**	**2.5**
	38300	988.0	979.2	982.1	979.8	990.4	990.0	988.2	986.0	987.6	983.1	982.8	982.0	**979.8**	**986.2**	**2.0**
	38065	987.8	977.5	979.6	978.1	990.0	990.0	984.3	984.0	983.7	982.0	981.6	980.8	**978.1**	**983.8**	**0.5**
	37810	986.3	975.5	979.8	976.4	985.6	984.8	984.1	983.2	983.8	980.3	981.0	979.5	**976.4**	**982.9**	**1.2**
	37655	984.7	975.0	978.9	975.7	984.0	982.3	983.5	982.0	982.7	979.7	980.8	978.7	**975.7**	**982.0**	**1.5**
	37390	983.0	975.0	978.6	975.0	981.6	980.0	982.1	981.1	981.7	978.1	978.4	976.6	**975.0**	**980.5**	**1.6**
	37135	982.3	975.0	979.4	975.0	981.3	980.0	980.4	979.5	979.9	975.8	979.1	975.9	**975.0**	**980.0**	**0.4**
	36930	981.3	974.5	979.6	975.0	981.3	980.0	978.7	978.0	978.3	975.4	977.4	975.0	**975.0**	**979.1**	**-0.4**
	36735	980.8	973.1	977.3	974.9	980.6	980.0	977.7	976.3	977.4	974.6	976.0	973.7	**973.7**	**977.8**	**-0.1**
	36515	979.2	972.5	975.2	973.3	980.1	980.0	976.9	976.0	976.4	973.0	975.4	972.8	**972.8**	**976.8**	**0.1**
	36265	977.4	971.2	973.2	971.4	980.2	980.0	976.1	974.0	975.5	972.7	974.5	972.0	**971.4**	**975.9**	**0.2**
SRB1	36080	973.9	969.8	972.1	970.0	980.3	980.0	976.9	973.2	974.1	971.8	972.1	970.2	**970.0**	**975.1**	**1.8**
	35845	971.7	968.9	971.0	970.0	979.0	977.6	977.9	972.0	972.9	970.3	970.1	968.7	**968.7**	**974.2**	**3.7**
	35725	970.4	968.5	970.3	970.0	978.0	977.0	978.3	970.0	972.0	969.6	969.4	968.7	**968.7**	**973.6**	**4.7**
	35515	969.3	967.7	970.4	970.0	976.0	975.6	976.8	970.0	972.1	969.3	968.8	968.2	**968.2**	**972.8**	**4.0**
	35245	968.7	966.5	969.9	967.8	973.6	972.7	974.6	968.0	971.8	968.4	968.6	966.4	**966.4**	**971.7**	**2.9**
	35040	968.2	965.8	968.7	966.4	972.4	971.2	973.4	968.0	971.2	966.1	967.6	965.9	**965.9**	**970.7**	**2.8**
	34860	967.5	965.0	967.5	965.0	971.5	970.0	972.6	966.0	969.7	965.1	966.6	965.3	**965.0**	**969.6**	**3.1**
	34720	966.7	965.0	966.8	964.9	970.6	970.0	971.0	966.0	968.8	964.8	965.2	964.0	**964.0**	**968.5**	**2.5**
	34495	966.8	965.0	965.4	963.5	970.0	970.0	967.9	964.0	967.2	963.7	964.4	962.0	**962.0**	**967.0**	**0.9**
	34310	967.0	963.8	964.4	962.5	968.7	967.9	966.4	963.2	965.4	962.4	963.9	960.7	**960.7**	**965.8**	**0.7**
	34090	965.9	962.0	963.1	961.6	967.3	965.2	965.9	962.0	963.7	960.8	961.6	959.3	**959.3**	**964.3**	**1.6**
SRB2	33880	964.7	961.3	962.7	960.1	965.2	962.3	964.6	960.0	961.6	958.9	960.6	958.1	**958.1**	**962.9**	**1.6**
	33710	963.1	960.0	962.5	960.0	963.4	960.0	963.9	960.0	960.1	957.8	959.2	957.6	**957.6**	**961.8**	**2.1**
	33500	962.5	960.0	962.3	960.3	961.2	960.0	961.4	958.0	959.3	957.7	957.7	956.1	**956.1**	**960.4**	**1.0**
	33310	961.5	960.0	960.9	959.0	959.9	959.4	961.1	956.2	959.7	955.3	957.2	954.9	**954.9**	**959.8**	**1.3**
	33115	960.8	960.0	960.5	957.3	959.8	957.3	961.0	956.0	958.1	954.8	957.0	954.1	**954.1**	**959.3**	**1.7**
	32795	961.4	958.8	960.5	956.8	959.0	954.8	958.2	954.0	955.5	947.7	955.2	951.9	**947.7**	**957.7**	**0.5**
	32605	960.4	957.8	958.7	955.0	957.6	952.9	956.7	952.5	954.6	950.9	954.1	950.6	**950.6**	**956.3**	**0.4**
SRC1	32265	957.7	956.3	952.4	951.8	954.3	950.0	954.8	951.4	953.1	949.6	951.2	949.1	**949.1**	**953.2**	**1.6**
	31875	960.1	955.0	951.3	948.2	950.0	950.0	952.8	949.5	949.4	944.0	950.1	944.0	**944.0**	**950.7**	**2.1**
	31585	960.7	952.8	950.2	945.0	950.0	950.0	948.4	946.0	947.0	943.9	945.8	943.4	**943.4**	**948.3**	**0.1**
	31360	959.1	951.1	946.8	945.0	949.3	948.5	948.0	945.1	946.0	943.3	945.5	942.5	**942.5**	**947.1**	**0.9**
	31060	955.9	950.0	947.3	945.0	948.2	945.9	944.8	944.0	942.2	939.1	942.3	939.8	**939.1**	**945.0**	**-0.2**
	30720	950.7	945.0	946.8	942.2	946.1	942.7	943.0	940.0	939.8	936.2	940.9	938.7	**936.2**	**943.3**	**-0.4**
	30445	946.7	942.0	945.2	940.0	945.9	940.4	941.0	938.0	938.2	935.1	939.5	937.4	**935.1**	**942.0**	**-0.9**
	30095	946.1	944.1	940.4	937.3	943.6	940.0	939.1	936.8	935.8	933.4	935.0	931.6	**931.6**	**938.8**	**0.3**
	29815	942.0	936.7	939.3	935.9	940.5	940.0	937.0	936.0	933.8	931.0	933.6	933.0	**931.0**	**936.8**	**0.2**
	29565	938.9	934.3	939.1	933.9	940.0	940.0	935.1	934.0	933.2	930.0	931.9	930.5	**930.0**	**935.9**	**-0.8**
	29385	937.3	931.1	936.8	932.7	941.2	940.0	933.8	932.7	932.3	929.6	931.5	930.1	**929.6**	**935.1**	**-1.3**
SRC2	29140	936.9	930.4	933.4	931.2	940.0	940.0	933.5	932.0	929.0	926.8	928.9	927.6	**926.8**	**933.0**	**0.5**
	28895	925.0	924.4	930.4	930.0	937.9	937.6	931.6	930.0	927.7	926.1	928.4	926.9	**926.1**	**931.2**	**0.4**
	28695	923.9	923.7	930.4	929.5	934.5	932.7	932.1	928.0	929.8	925.0	930.4	925.7	**925.0**	**931.4**	**0.7**
	28500	922.9	922.5	928.6	927.0	932.3	930.3	929.9	928.0	926.2	924.0	928.0	924.6	**924.0**	**929.0**	**1.0**
	28280	922.0	921.6	926.7	925.0	931.7	930.0	929.9	926.0	927.2	922.7	926.1	923.2	**922.7**	**928.3**	**1.6**
	28080	921.6	920.5	927.0	925.0	931.0	930.0	928.5	926.0	926.2	921.8	925.0	923.2	**921.8**	**927.5**	**0.9**
	27925	920.0	920.0	925.5	925.0	930.2	930.0	927.1	924.7	924.2	921.9	923.4	922.1	**921.9**	**926.1**	**1.0**
	27725	919.5	919.4	924.2	923.8	928.6	928.3	924.0	924.0	920.8	920.4	921.9	920.5	**920.4**	**923.9**	**0.1**
	27545	919.3	919.1	923.1	922.8	927.9	927.3	923.2	922.5	920.0	919.3	920.6	919.4	**919.3**	**923.0**	**0.3**
	27335	919.0	918.6	922.0	921.4	926.6	925.9	922.0	922.0	919.6	918.7	920.0	918.3	**918.3**	**922.0**	**0.0**
	27155	918.8	918.3	921.0	920.3	925.7	924.3	921.2	920.5	919.5	918.0	919.1	918.0	**918.0**	**921.3**	**-0.1**
SRC3	26990	918.4	917.7	920.2	919.4	924.1	922.9	920.6	920.0	919.4	917.9	917.2	916.2	**916.2**	**920.3**	**0.3**
	26780	918.0	917.2	919.6	918.5	922.7	921.2	919.4	918.0	917.6	916.8	916.3	914.3	**914.3**	**919.1**	**0.2**
	26575	917.5	916.8	919.2	917.6	921.4	920.0	918.3	918.0	916.5	915.5	915.6	913.7	**913.7**	**918.2**	**0.1**
	26355	917.0	916.2	919.0	916.9	921.0	920.0	917.9	916.0	916.1	914.6	914.9	913.4	**913.4**	**917.8**	**0.2**
	26170	916.9	915.7	919.1	915.9	921.0	919.8	916.6	916.0	914.3	912.5	914.2	912.9	**912.5**	**917.0**	**-0.5**
	25965	917.1	915.3	918.3	915.0	919.2	918.1	916.4	914.1	915.1	912.3	913.8	911.6	**911.6**	**916.6**	**-0.2**
	25785	917.2	914.5	917.4	913.9	917.5	916.5	915.7	914.0	914.0	911.5	912.3	911.1	**911.1**	**915.4**	**0.3**
	25600	917.2	914.1	916.7	912.9	916.1	915.0	915.2	912.1	913.5	910.8	911.7	909.7	**909.7**	**914.6**	**0.6**
	25425	917.1	914.2	915.7	912.2	914.7	913.7	915.0	912.0	912.8	909.7	911.3	910.0	**909.7**	**913.9**	**1.1**
	25215	916.4	912.9	914.7	910.9	913.1	911.9	914.7	910.0	911.6	908.8	910.6	908.6	**908.6**	**912.9**	**1.8**
	25000	915.1	910.7	912.7	910.0	912.1	910.4	911.8	908.1	910.3	908.1	909.5	907.8	**907.8**	**911.3**	**0.5**
SRC4	24795	911.2	907.7	910.6	910.0	910.6	910.0	910.0	908.0	909.0	906.3	907.5	905.6	**905.6**	**909.5**	**0.5**
	24550	905.6	905.0	908.9	908.4	909.7	909.1	907.1	906.0	905.4	904.1	905.0	904.0	**904.0**	**907.2**	**-0.1**
	24335	904.6	902.2	908.7	906.3	908.3	907.9	906.5	906.0	904.7	903.5	904.2	903.2	**903.2**	**906.5**	**0.0**
	24115	904.2	899.1	905.7	904.7	907.0	906.7	905.1	904.0	903.2	902.6	902.8	901.8	**901.8**	**904.7**	**0.4**
	23975	903.8	897.5	904.8	904.2	906.1	905.8	903.9	903.5	903.2	901.6	901.7	901.2	**901.2**	**903.9**	**-0.1**
	23755	902.9	895.7	904.0	903.3	904.5	904.0	902.9	902.0	901.7	900.4	900.2	899.9	**899.9**	**902.7**	**0.2**
	23565	902.3	895.0	903.8	902.5	903.4	902.7	903.0	900.0	900.6	899.6	899.6	898.7	**898.7**	**902.1**	**0.9**
	23365	901.9	895.0	904.0	902.2	901.8	901.3	902.3	900.4	898.6	897.1	898.8	897.9	**897.1**	**901.1**	**1.2**
	23180	901.2	894.0	904.1	901.2	900.6	900.0	900.0	898.2	900.1	896.6	900.1	897.2	**896.6**	**901.0**	**-1.0**
	23000	900.5	892.7	902.8	900.3	900.2	900.0	898.0	898.0	898.4	896.1	896.7	896.0	**896.0**	**899.2**	**-1.2**
	22790	899.8	891.5	900.4	900.0	900.2	900.0	898.0	898.0	897.4	895.5	896.5	895.0	**895.0**	**898.5**	**-0.5**
	22600	898.8	890.0	899.4	898.9	899.1	898.4	899.8	896.0	898.3	894.8	896.7	894.5	**894.5**	**898.7**	**1.1**
	22415	897.3	890.0	898.2	897.5	897.5	896.7	898.2	894.8	897.0	894.1	896.5	893.3	**893.3**	**897.5**	**0.7**

(1) "All years" excludes 1930

Table A5.2 Santa Clara River Thalweg Analysis Caluclation of Long Term Aggradation/Degradation Based on Historical Bed Analysis (ft) (continued)

Subreach	HEC-RAS Station	1930		1947		1963		1999		2004		2005		(1)MINIMUM OF ALL MINIMUMS	(1)MEAN OF ALL MEANS	99 MEAN-ALL MEAN
		Topo Mean	Topo Min	Topo Mean	Topo Min	Topo Mean	Topo Min	Topo Mean	Topo Min	Topo Mean	Topo Min	Topo Mean	Topo Min			
SRD1	22195	895.9	888.8	896.9	896.1	895.3	894.7	896.2	894.0	895.7	893.6	895.3	892.1	**892.1**	**895.9**	**0.3**
	22010	894.9	887.4	895.6	894.5	894.3	893.8	894.3	892.3	894.3	892.5	893.4	891.5	**891.5**	**894.4**	**-0.1**
	21790	893.8	886.5	894.5	893.8	893.4	892.7	894.2	892.0	893.4	892.2	891.6	890.4	**890.4**	**893.5**	**0.8**
	21615	892.3	885.0	893.0	892.3	892.7	891.9	893.7	891.9	891.5	891.0	890.5	889.0	**889.0**	**892.3**	**1.4**
	21440	890.0	884.9	891.3	890.0	891.6	891.1	892.5	890.0	890.7	889.9	890.3	888.3	**888.3**	**891.3**	**1.2**
	21225	889.1	884.2	890.1	889.0	890.7	890.2	892.3	888.3	890.9	889.0	889.7	886.4	**886.4**	**890.7**	**1.5**
	21020	888.0	883.5	888.5	888.0	889.1	887.8	891.4	888.0	889.7	887.9	888.3	885.7	**885.7**	**889.4**	**2.0**
	20845	887.5	883.0	887.2	886.2	887.1	886.1	890.2	887.0	888.6	885.9	886.2	883.9	**883.9**	**887.9**	**2.3**
	20595	886.5	882.2	885.7	885.0	886.3	884.3	888.2	884.2	886.9	885.0	885.4	883.9	**883.9**	**886.5**	**1.7**
	20435	885.7	881.6	885.2	884.7	884.5	883.3	887.3	884.0	885.7	883.8	884.2	882.8	**882.8**	**885.4**	**1.9**
	20280	885.1	881.0	884.3	883.7	883.4	882.6	886.0	884.0	884.7	882.8	883.5	882.0	**882.0**	**884.4**	**1.6**
	20070	884.0	880.3	882.8	882.6	882.1	881.3	883.6	882.0	883.7	882.3	882.0	880.9	**880.9**	**882.9**	**0.8**
SRD2	19855	882.5	879.1	881.6	880.9	880.5	880.0	882.2	880.1	882.6	881.2	881.0	880.1	**880.0**	**881.6**	**0.6**
	19630	879.9	877.2	881.4	880.0	880.2	880.0	881.2	880.0	881.1	879.8	879.8	879.0	**879.0**	**880.7**	**0.5**
	19440	877.2	875.4	881.0	878.8	879.5	878.6	879.9	878.0	879.5	877.6	878.7	877.7	**877.6**	**879.7**	**0.1**
	19240	875.8	874.3	879.7	877.0	878.5	877.0	879.8	877.2	877.5	876.6	877.6	876.8	**876.6**	**878.6**	**1.2**
	19050	873.5	870.0	877.4	875.4	877.3	875.6	878.2	876.0	875.9	875.3	876.6	875.5	**875.3**	**877.1**	**1.1**
	18830	871.8	869.0	875.7	875.0	876.2	875.0	878.9	875.0	874.6	872.9	875.5	874.0	**872.9**	**876.2**	**2.7**
	18650	870.1	868.8	875.5	872.3	875.2	874.6	876.6	874.0	875.0	871.6	874.1	873.1	**871.6**	**875.3**	**1.3**
	18475	868.9	867.0	874.5	870.0	874.4	873.4	875.7	872.0	874.4	870.7	872.1	868.8	**868.8**	**874.2**	**1.5**
	18290	867.9	865.2	874.5	870.0	873.7	871.9	875.9	872.0	873.5	870.1	871.8	869.0	**869.0**	**873.9**	**2.0**
	18025	867.1	865.0	873.8	870.0	871.2	870.0	874.1	870.0	873.3	868.4	871.3	867.6	**867.6**	**872.7**	**1.3**
	17785	866.0	865.0	872.1	868.6	869.6	869.2	873.6	868.1	872.0	868.2	870.2	867.1	**867.1**	**871.5**	**2.1**
SRD3	17510	861.9	860.4	870.6	866.4	869.5	866.7	873.7	868.0	871.5	866.0	870.1	866.2	**866.0**	**871.1**	**2.6**
	17360	860.4	859.5	869.5	865.0	868.3	865.2	873.2	866.0	869.7	865.7	868.1	864.6	**864.6**	**869.8**	**3.4**
	17110	859.0	858.6	867.3	865.0	865.9	864.1	870.0	864.8	867.3	865.0	864.4	860.9	**860.9**	**867.0**	**3.0**
	16970	858.9	857.8	867.0	865.0	866.0	863.8	866.7	864.0	865.8	864.5	864.0	861.9	**861.9**	**865.9**	**0.8**
	16720	858.3	856.6	864.3	862.0	864.3	862.0	865.2	863.0	865.3	863.4	863.1	861.6	**861.6**	**864.5**	**0.8**
	16515	857.6	855.6	862.7	859.7	862.5	860.3	863.8	862.0	864.0	862.1	861.7	859.7	**859.7**	**862.9**	**0.8**
	16305	856.8	854.8	862.8	859.2	861.6	860.0	863.3	860.0	863.7	861.7	861.6	859.3	**859.2**	**862.6**	**0.7**
	16130	856.1	854.1	862.4	859.3	860.2	858.6	862.5	860.0	862.9	861.2	860.5	858.9	**858.6**	**861.7**	**0.8**
	15960	855.3	853.5	861.5	858.2	858.4	857.0	861.8	860.0	861.0	859.5	859.7	858.6	**857.0**	**860.5**	**1.3**
	15745	854.0	852.9	860.3	856.8	856.5	855.3	860.0	858.0	859.7	858.2	859.0	857.5	**855.3**	**859.1**	**0.9**
	15540	853.2	851.9	859.5	855.0	855.1	854.2	858.3	856.0	859.5	857.1	857.8	856.4	**854.2**	**858.0**	**0.3**
	15335	852.6	851.7	859.6	855.0	852.8	852.0	858.1	856.0	857.2	855.7	857.0	855.5	**852.0**	**857.0**	**1.1**
SRE1	15125	851.8	850.7	859.5	855.0	852.1	850.2	856.0	854.0	855.8	853.3	855.3	853.3	**850.2**	**855.7**	**0.2**
	14900	851.2	850.0	857.3	852.3	854.0	850.4	855.4	853.2	854.8	852.8	854.3	852.4	**850.4**	**855.2**	**0.2**
	14720	850.7	848.3	856.0	853.1	853.6	850.0	854.6	852.0	853.9	851.0	853.9	852.5	**850.0**	**854.4**	**0.2**
	14480	849.6	845.7	854.5	850.0	852.9	848.5	854.3	850.4	853.2	849.1	853.6	851.0	**848.5**	**853.7**	**0.6**
	14315	849.1	845.0	854.3	849.1	852.1	848.0	852.6	850.0	852.0	848.6	852.3	850.0	**848.0**	**852.7**	**-0.1**
	14090	848.3	844.2	852.0	845.0	851.3	847.2	851.6	848.6	850.6	847.8	850.7	848.5	**845.0**	**851.2**	**0.4**
	13850	845.8	839.9	850.7	845.0	850.2	846.4	850.8	848.0	849.2	846.4	849.5	848.1	**845.0**	**850.1**	**0.7**
	13635	843.4	837.9	849.4	844.3	847.7	845.0	850.0	846.0	848.0	845.2	848.8	847.6	**844.3**	**848.8**	**1.2**
	13425	843.5	836.4	847.7	842.5	846.2	843.2	848.1	846.0	847.2	844.5	847.6	845.9	**842.5**	**847.4**	**0.8**
	13190	841.7	835.0	845.7	840.4	844.6	841.7	846.4	844.0	845.8	843.3	846.1	845.0	**840.4**	**845.7**	**0.7**
SRE2	13030	840.1	834.7	844.0	840.0	842.5	840.0	846.1	843.3	844.8	842.4	845.3	844.2	**840.0**	**844.5**	**1.6**
	12835	838.0	833.7	841.8	840.0	841.1	838.5	844.4	842.0	843.7	841.0	844.0	842.9	**838.5**	**843.0**	**1.4**
	12615	836.5	832.5	840.4	837.1	839.8	837.0	843.6	841.5	842.3	840.1	842.5	841.6	**837.0**	**841.7**	**1.9**
	12395	835.8	831.7	839.2	835.0	838.7	835.9	841.9	840.0	841.7	839.5	841.4	840.0	**835.0**	**840.6**	**1.3**
	12195	834.7	830.7	839.2	835.0	836.4	834.0	841.1	839.0	840.0	838.9	840.1	838.7	**834.0**	**839.4**	**1.8**
	11995	833.4	830.0	839.2	834.6	836.3	832.6	839.6	838.0	838.7	837.2	839.1	838.1	**832.6**	**838.6**	**1.0**
	11780	831.8	830.0	837.7	832.6	834.8	831.2	837.7	836.0	837.2	835.5	837.7	836.1	**831.2**	**837.0**	**0.7**
	11605	831.1	830.0	836.5	831.3	833.5	830.1	837.1	836.0	836.5	834.8	836.6	834.2	**830.1**	**836.1**	**1.1**
	11405	830.2	830.0	834.5	830.0	831.8	829.7	834.8	834.0	835.5	833.7	835.0	832.8	**829.7**	**834.3**	**0.5**
	11180	829.1	828.4	832.5	828.4	828.9	828.3	833.4	832.5	833.5	831.8	833.6	832.4	**828.3**	**832.4**	**1.0**
SRE3	11015	827.8	827.1	831.3	826.6	828.4	827.3	832.1	832.0	832.8	831.0	832.3	830.5	**826.6**	**831.4**	**0.7**
	10835	826.4	825.7	829.9	825.0	827.6	825.7	832.3	830.0	832.2	830.2	831.5	829.4	**825.0**	**830.7**	**1.5**
	10575	825.4	825.0	827.6	825.0	826.2	825.0	831.3	830.0	831.0	828.3	830.1	828.4	**825.0**	**829.2**	**2.0**
	10390	824.1	823.7	826.1	825.0	824.6	823.5	829.7	828.0	830.2	827.5	829.0	828.1	**823.5**	**827.9**	**1.8**
	10225	823.3	822.6	825.2	822.6	823.5	822.4	828.7	828.0	828.6	827.3	827.9	827.4	**822.4**	**826.8**	**2.0**
	10000	823.9	820.9	822.2	820.0	821.5	821.0	827.3	826.0	828.0	826.4	825.4	824.3	**820.0**	**824.9**	**2.5**
	9820	823.0	820.0	821.2	820.0	820.9	820.0	826.3	824.0	827.6	826.0	825.4	823.7	**820.0**	**824.3**	**2.1**
	9595	822.9	818.5	820.3	819.3	819.9	819.1	825.8	824.0	826.5	824.8	824.3	822.3	**819.1**	**823.4**	**2.4**
	9385	822.5	815.0	819.4	816.7	818.9	818.3	825.5	824.0	825.2	823.7	823.7	821.3	**816.7**	**822.5**	**3.0**
	9220	821.6	815.0	818.0	815.0	818.0	816.9	824.2	822.0					**815.0**	**820.0**	**4.1**
	9025	820.0	815.0	816.1	815.0	816.5	815.8							**815.0**	**816.3**	

(1) "All years" excludes 1930

Figure A5.2.2A Santa Clara River Historical Minimum Bed Elevation

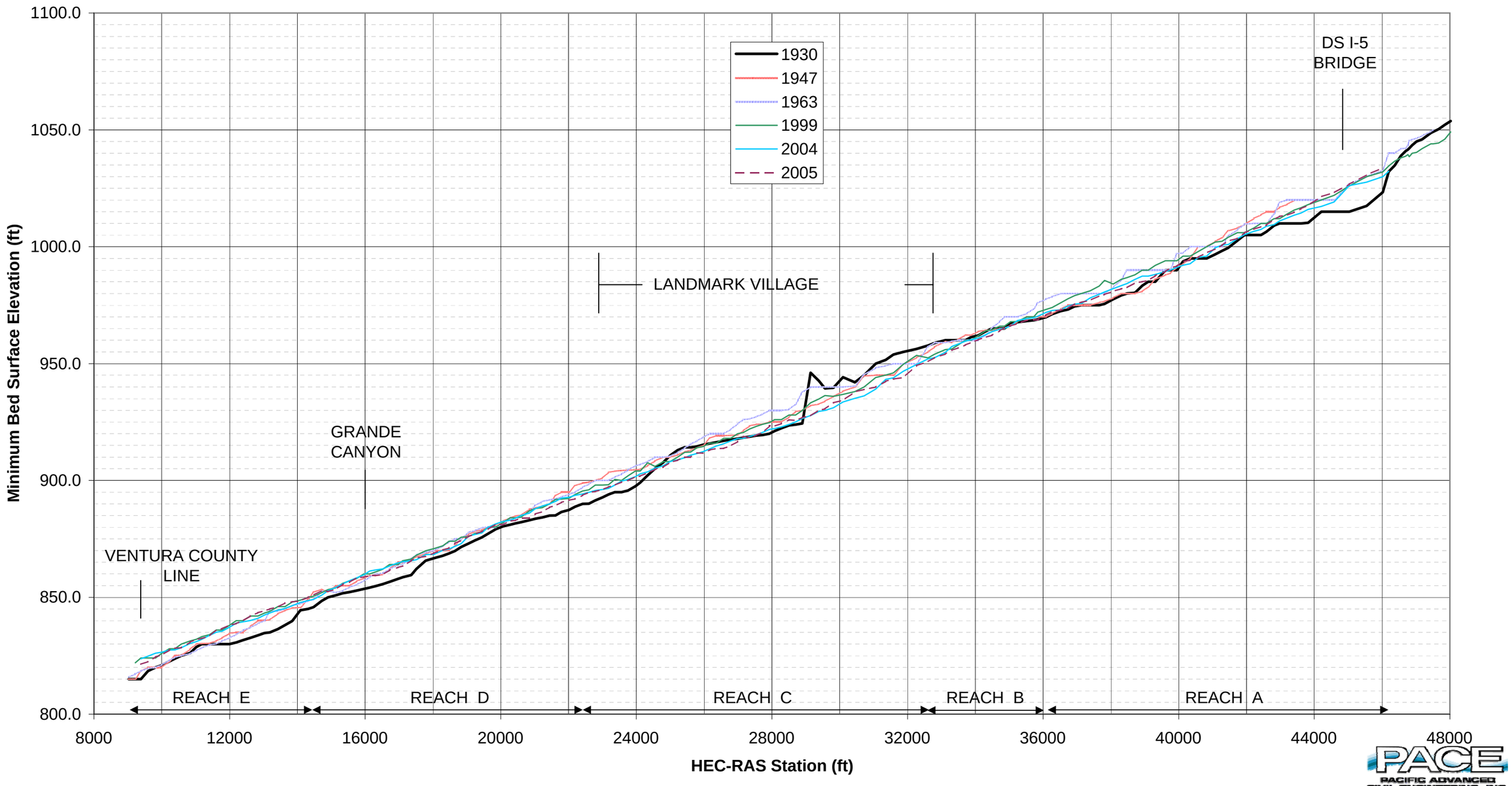
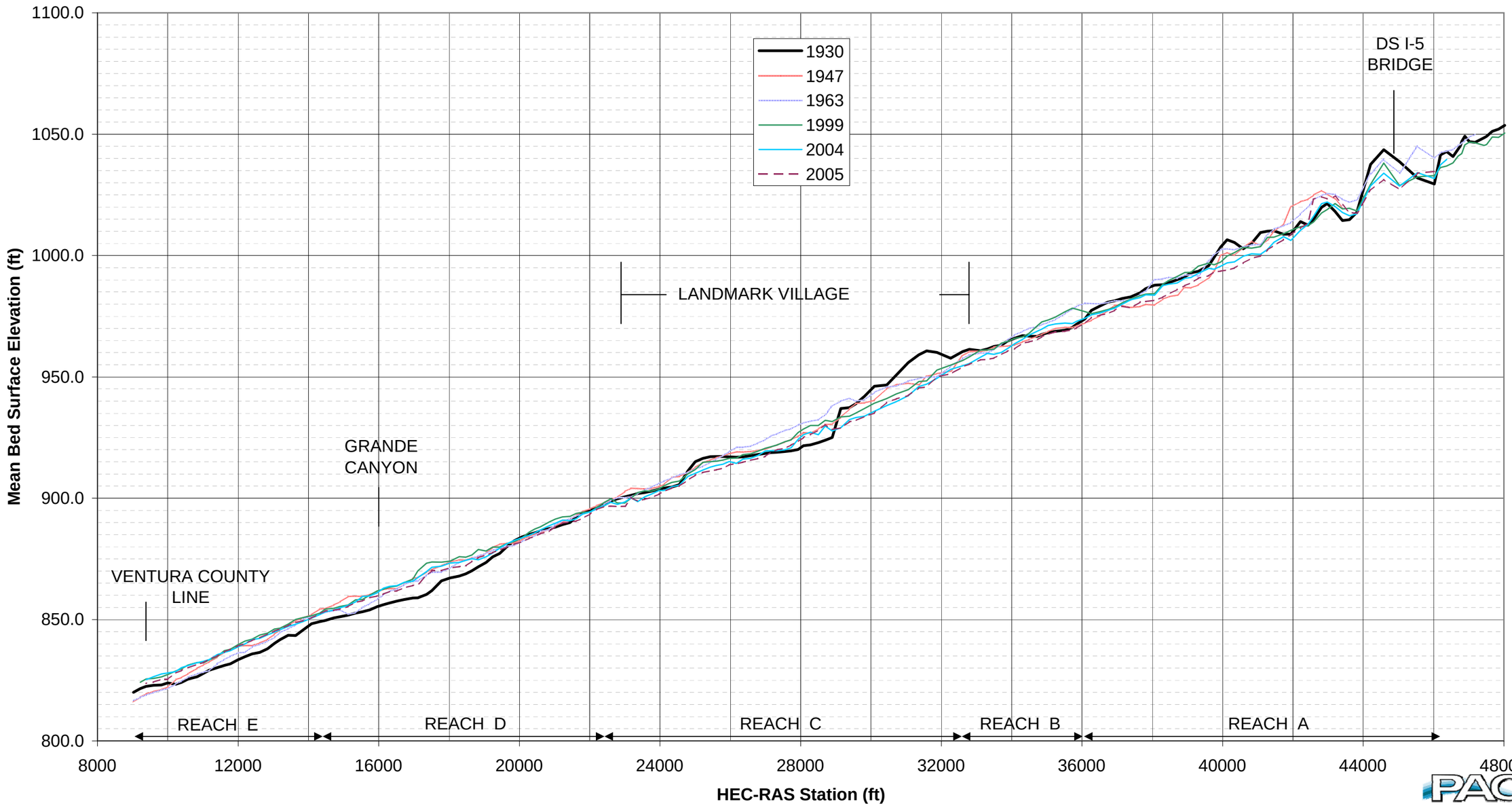


Figure A5.2.2B Santa Clara River Historical Mean Bed Elevation



PACIFIC ADVANCED CIVIL ENGINEERING, INC.

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

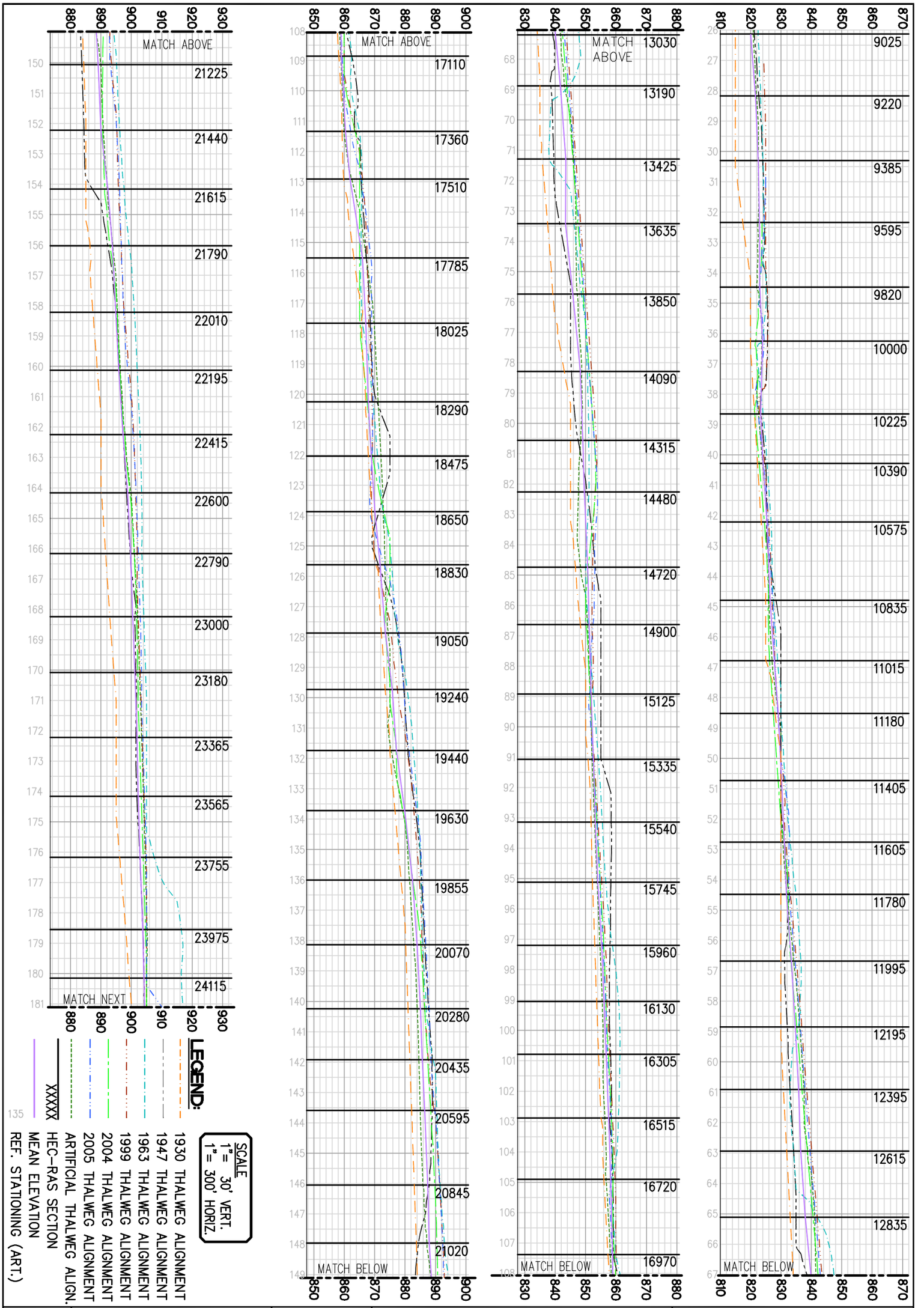


FIGURE A5.3.1A

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1930 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: A By: ddrahn on Mar. 14, 2006 at 05:05 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

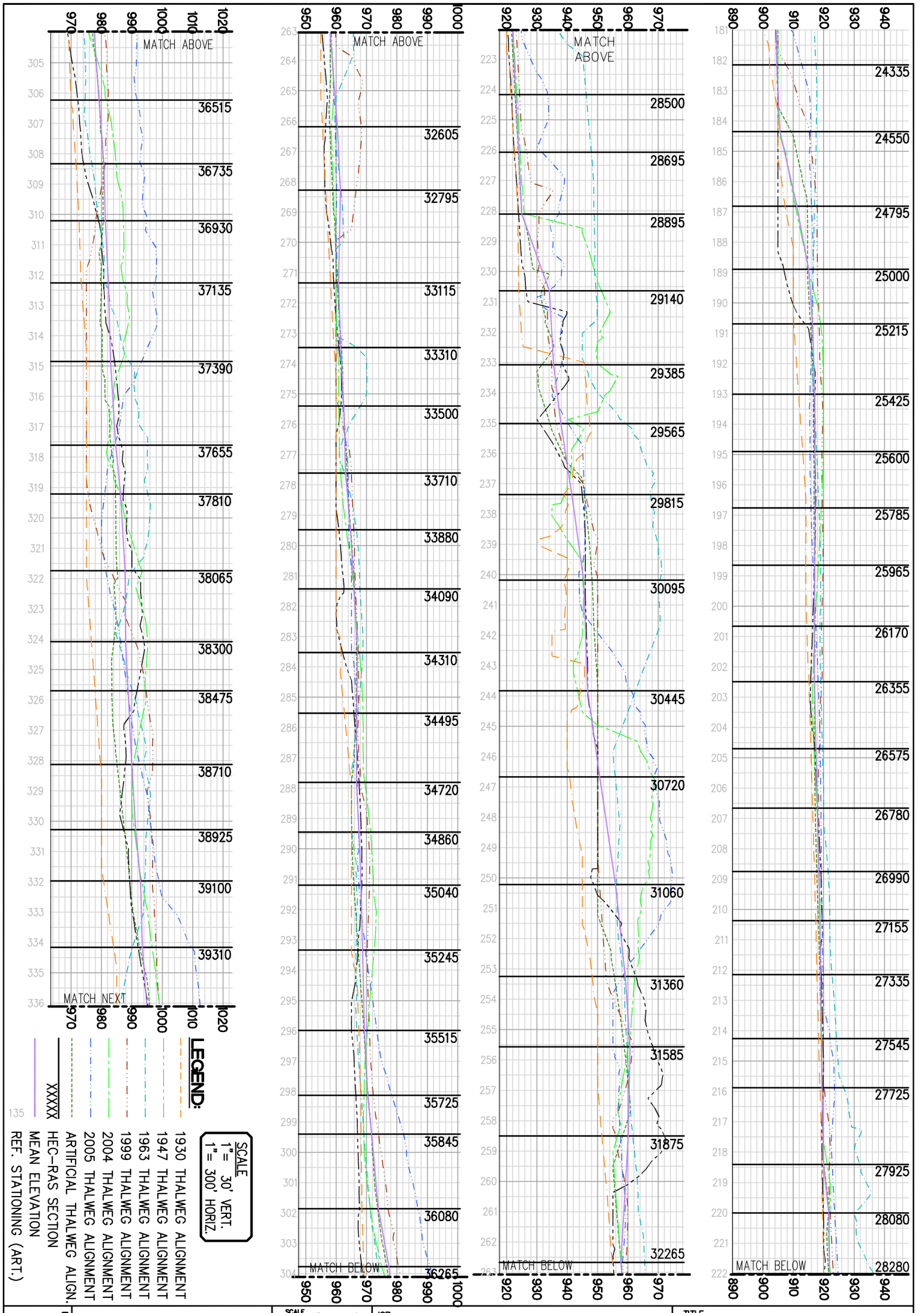


FIGURE A5.8.1B

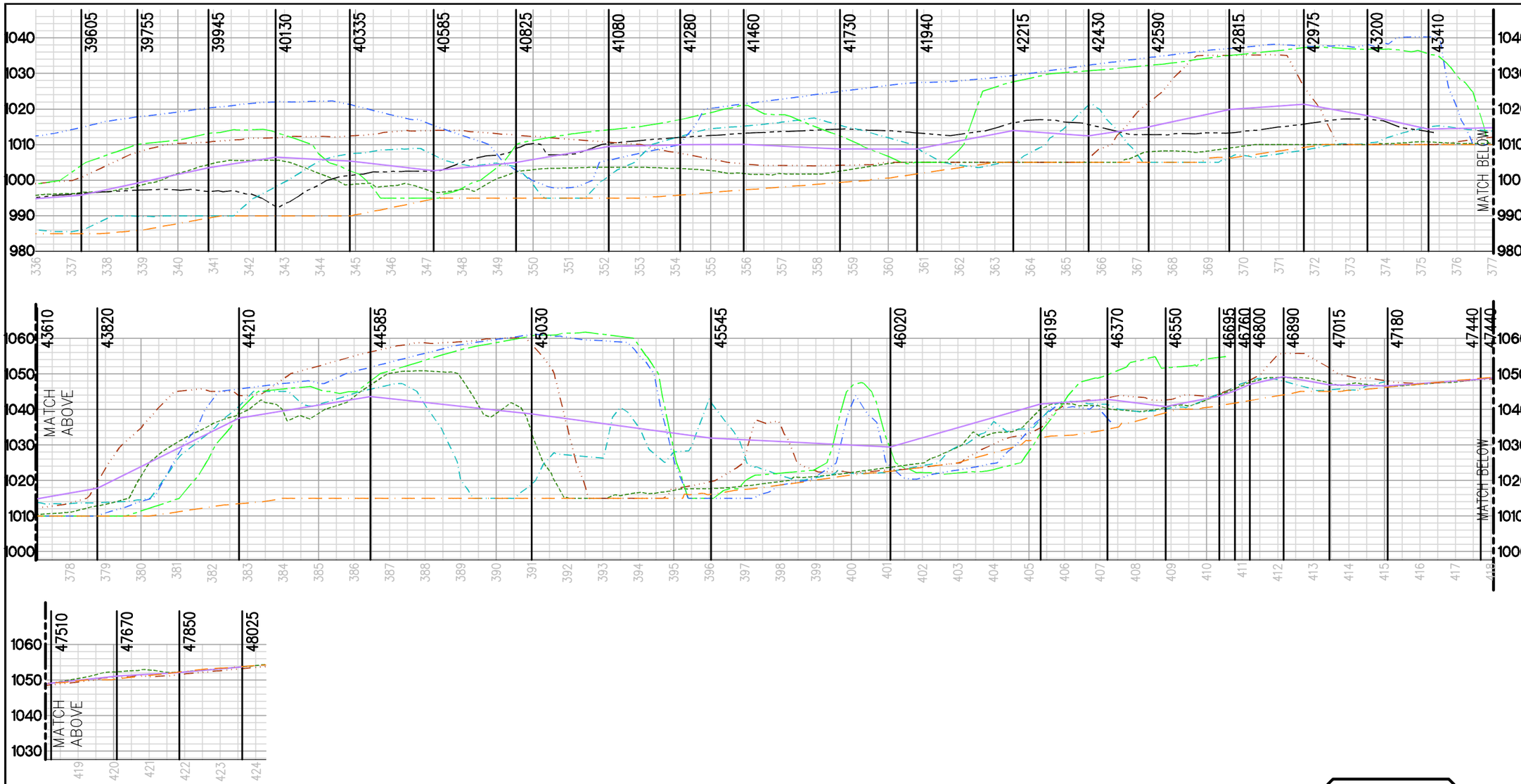
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1930 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: B By: ddrahn on Mar. 14, 2006 at 05:05 pm



LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

SCALE
1"= 30' VERT.
1"= 300' HORIZ.

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (1930 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE 1"= 300'
DESIGNED DAJ
DRAWN DAD
CHECKED MEK
DATE 09/13/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.1C

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: C By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

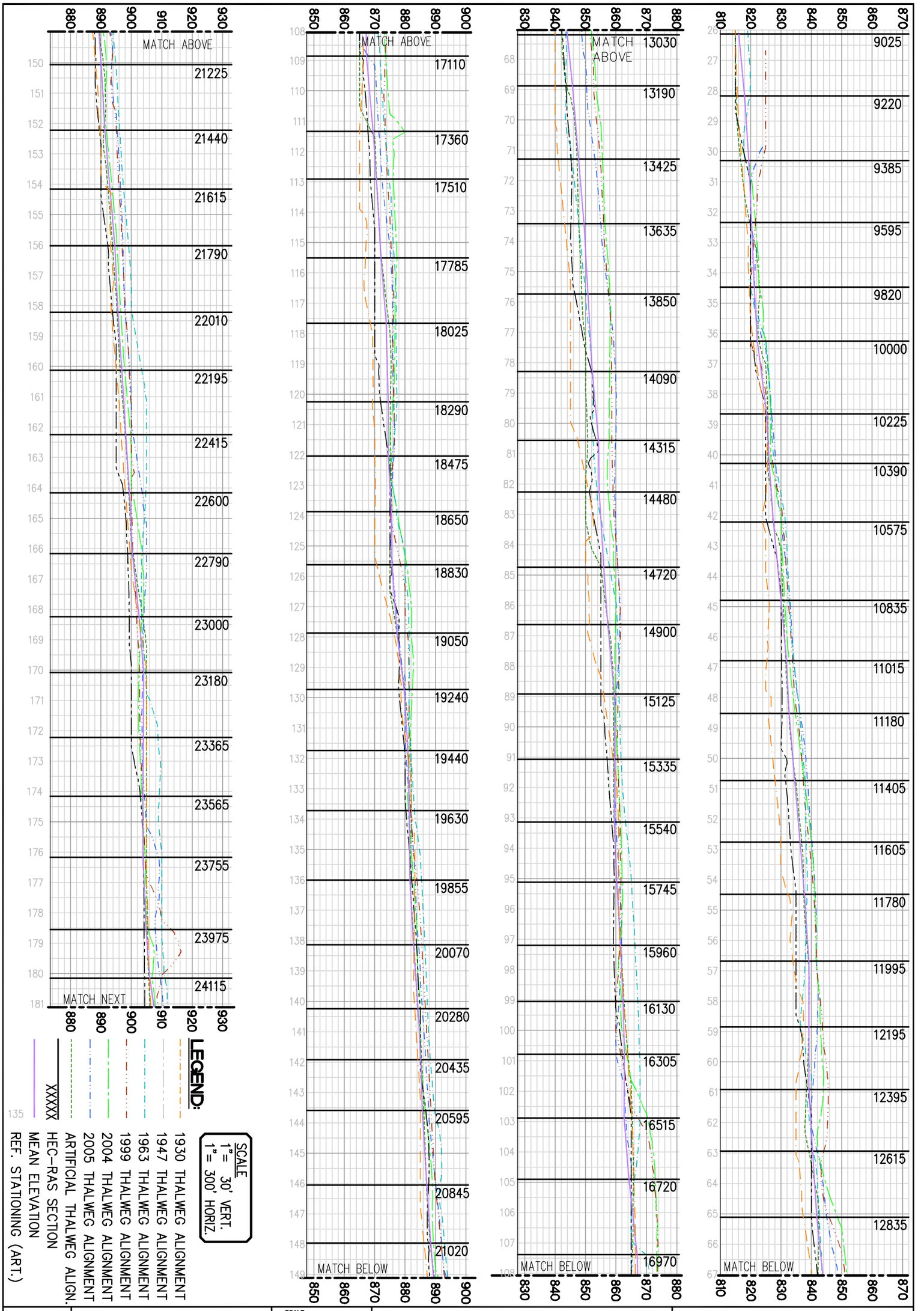


FIGURE A5.3.1D

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1947 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: D By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

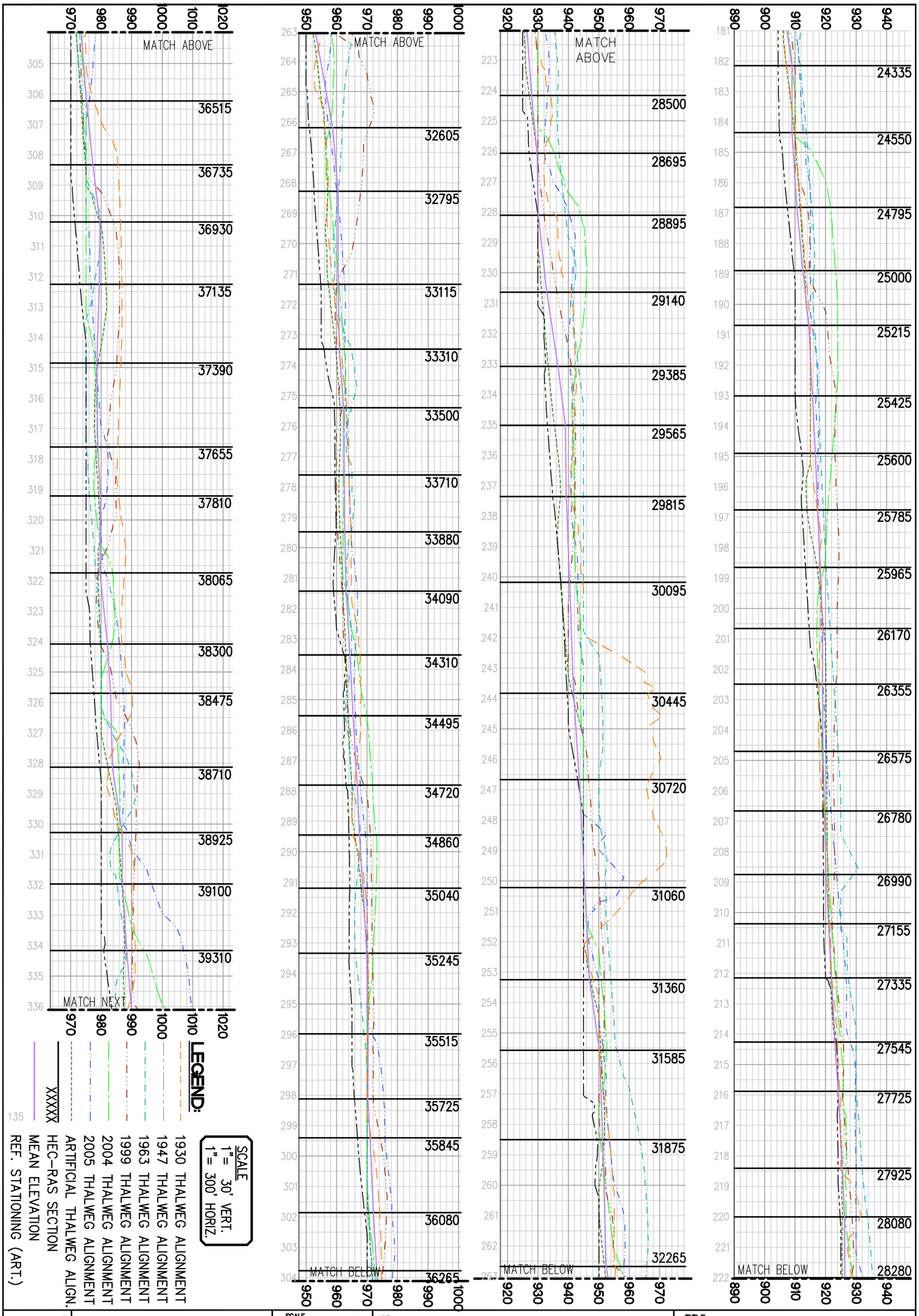


FIGURE A5.8.1E

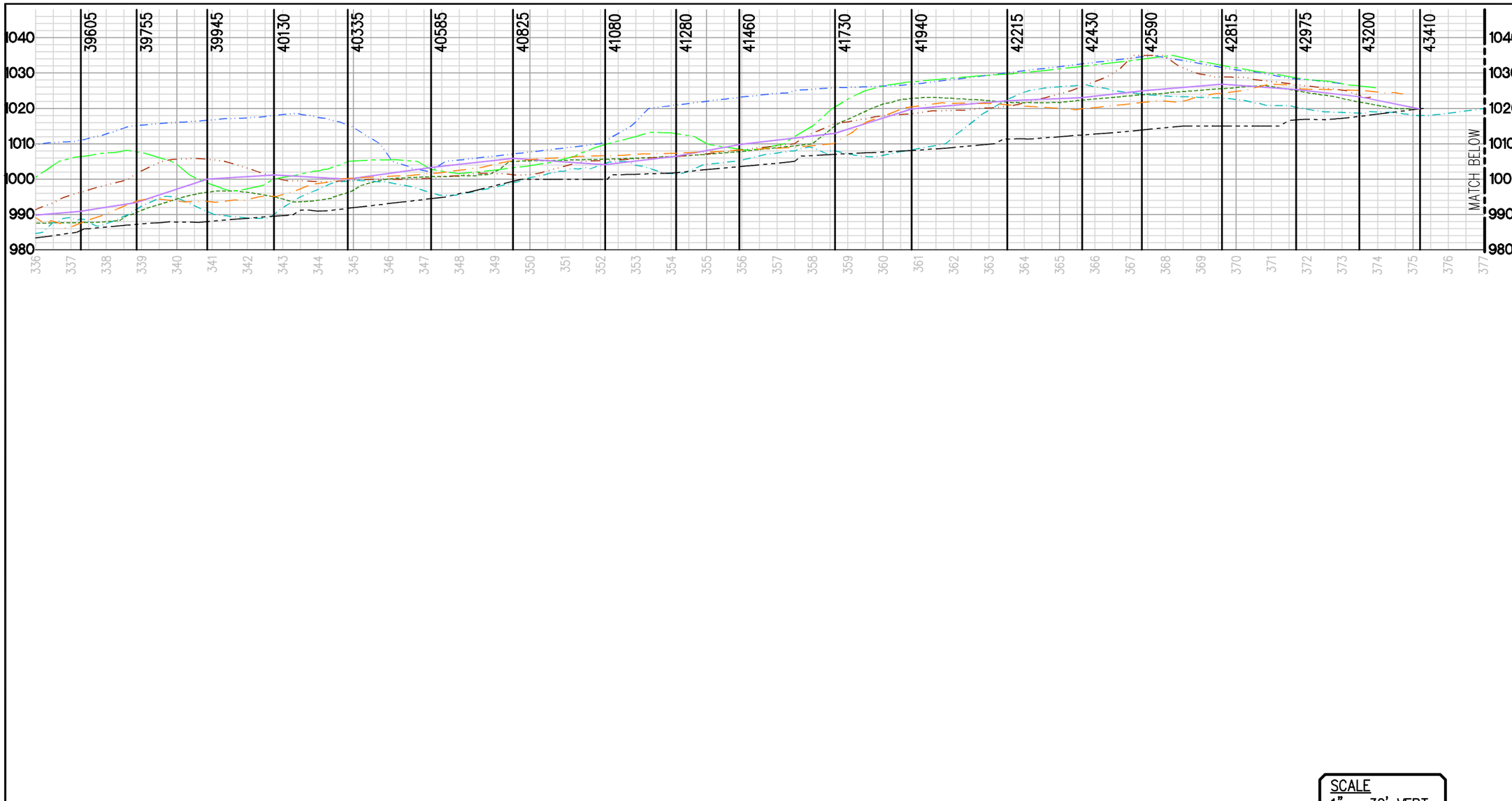
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1947 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: E By: ddrahn on Mar. 14, 2006 at 05:04 pm



SCALE
1"= 30' VERT.
1"= 300' HORIZ.

LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (1947 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.1F

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: F By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

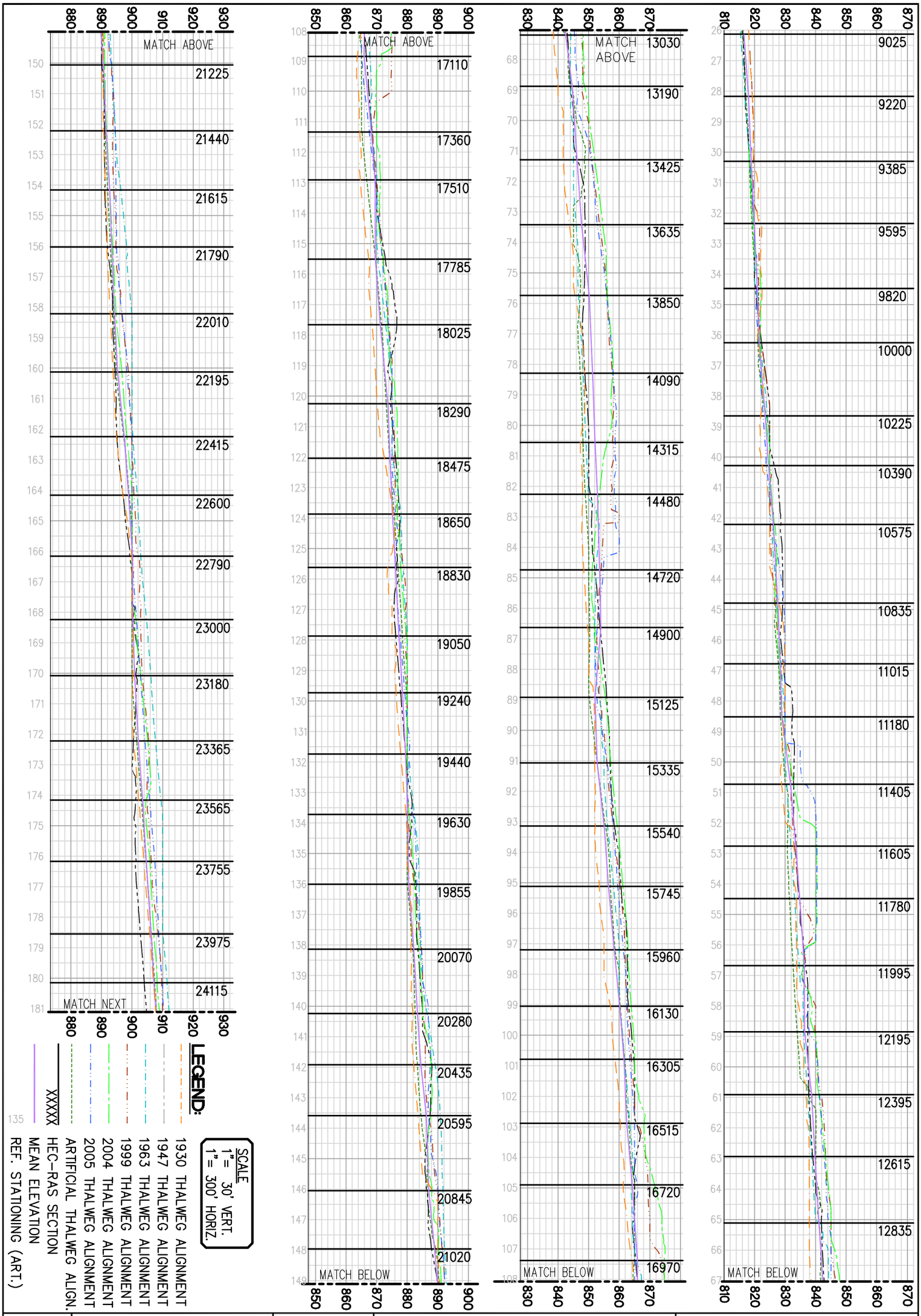


FIGURE A5.3.1G

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1963 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: G By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

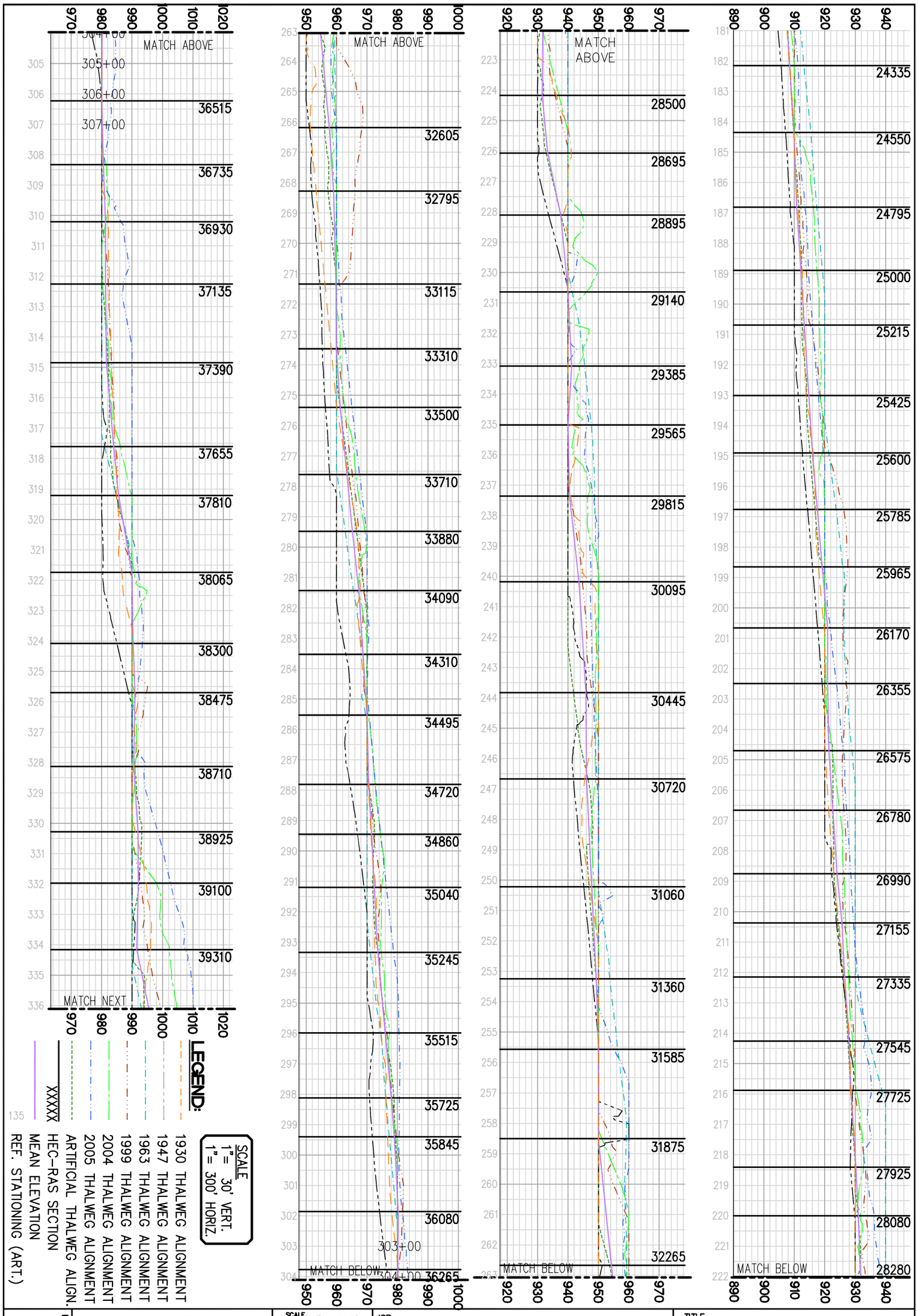


FIGURE A5.8.1H

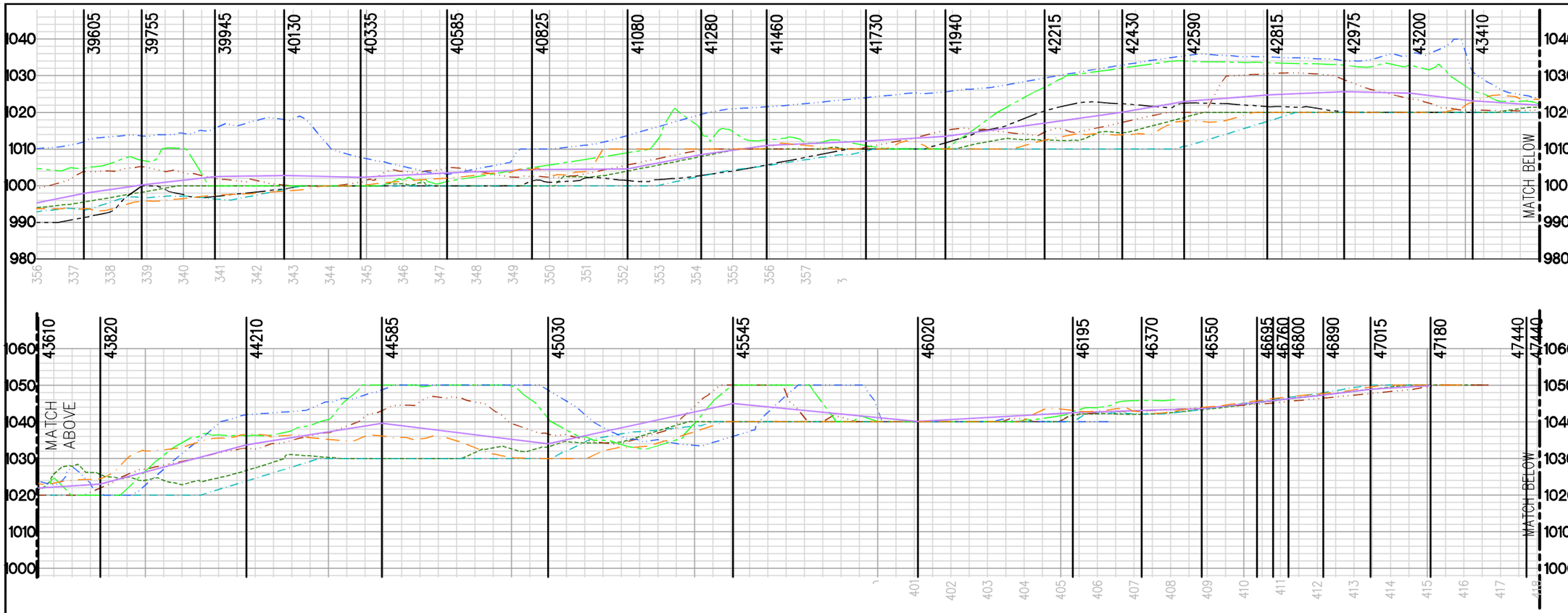
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1963 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: H By: ddrahn on Mar. 14, 2006 at 05:04 pm



SCALE
1"= 30' VERT.
1"= 300' HORIZ.

LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (1963 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE 1"= 300'
DESIGNED DAJ
DRAWN DAD
CHECKED MEK
DATE 09/13/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.11

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: I By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

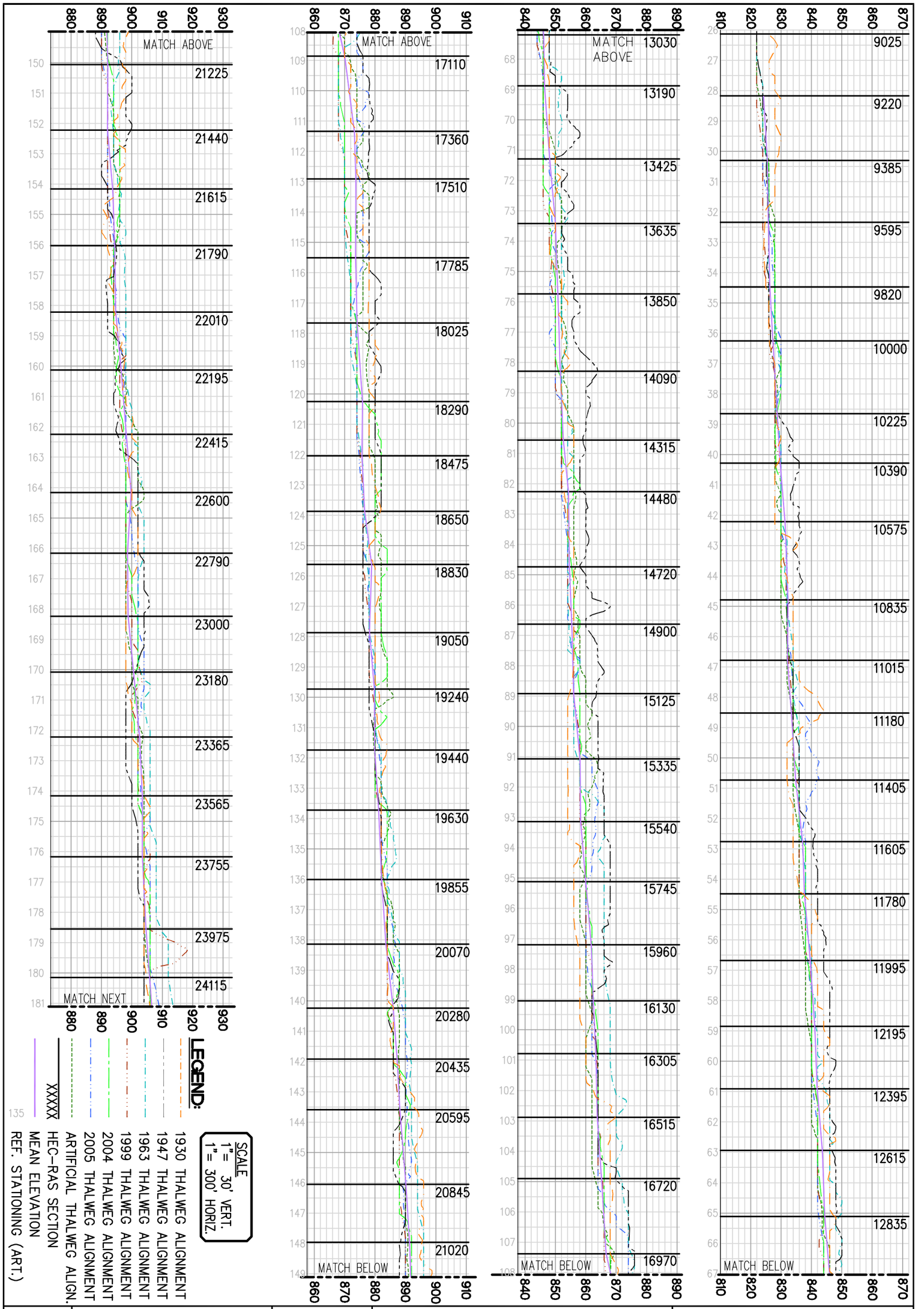


FIGURE A5.3.1J

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1999 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: J By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

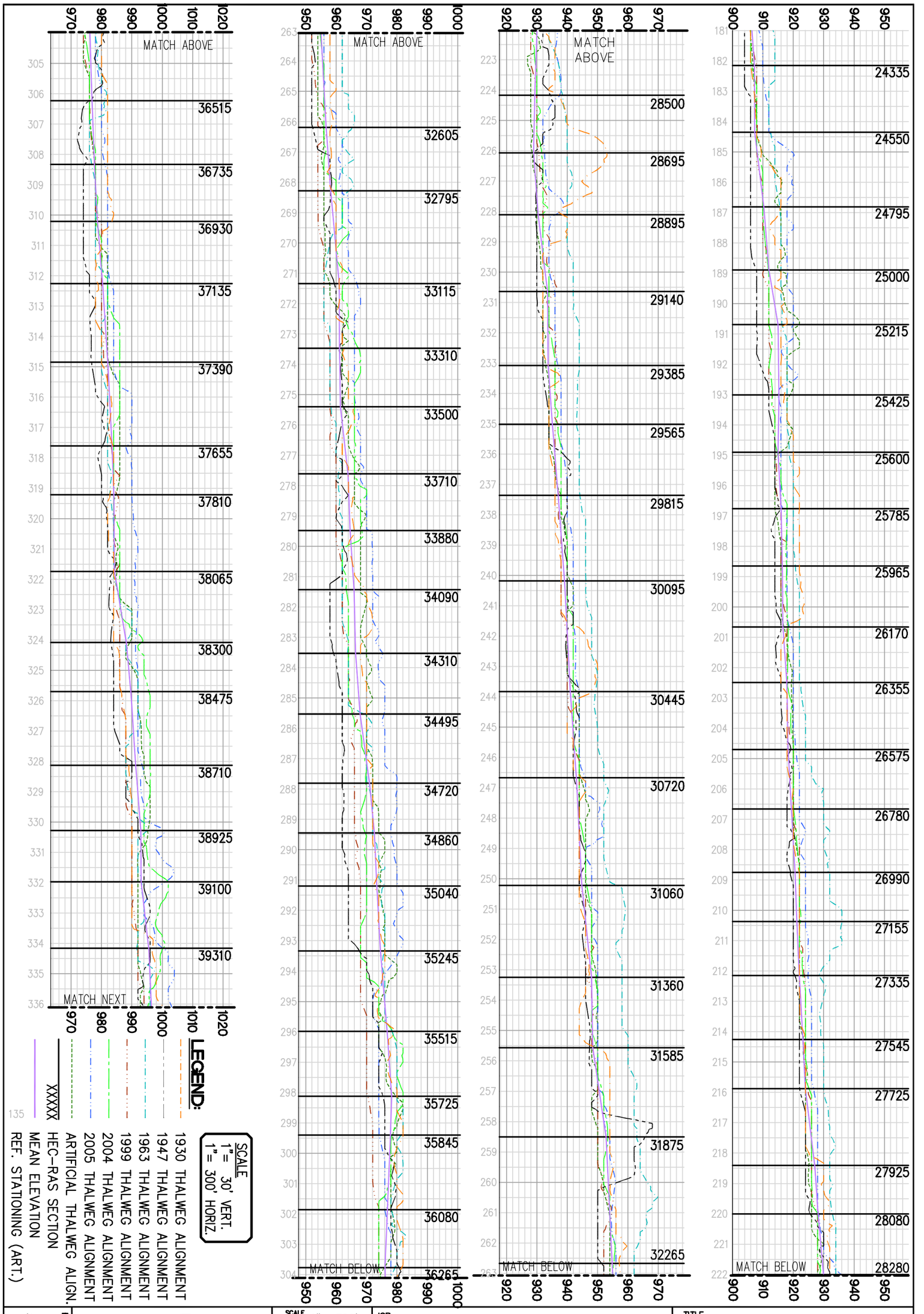


FIGURE A5.3.1K

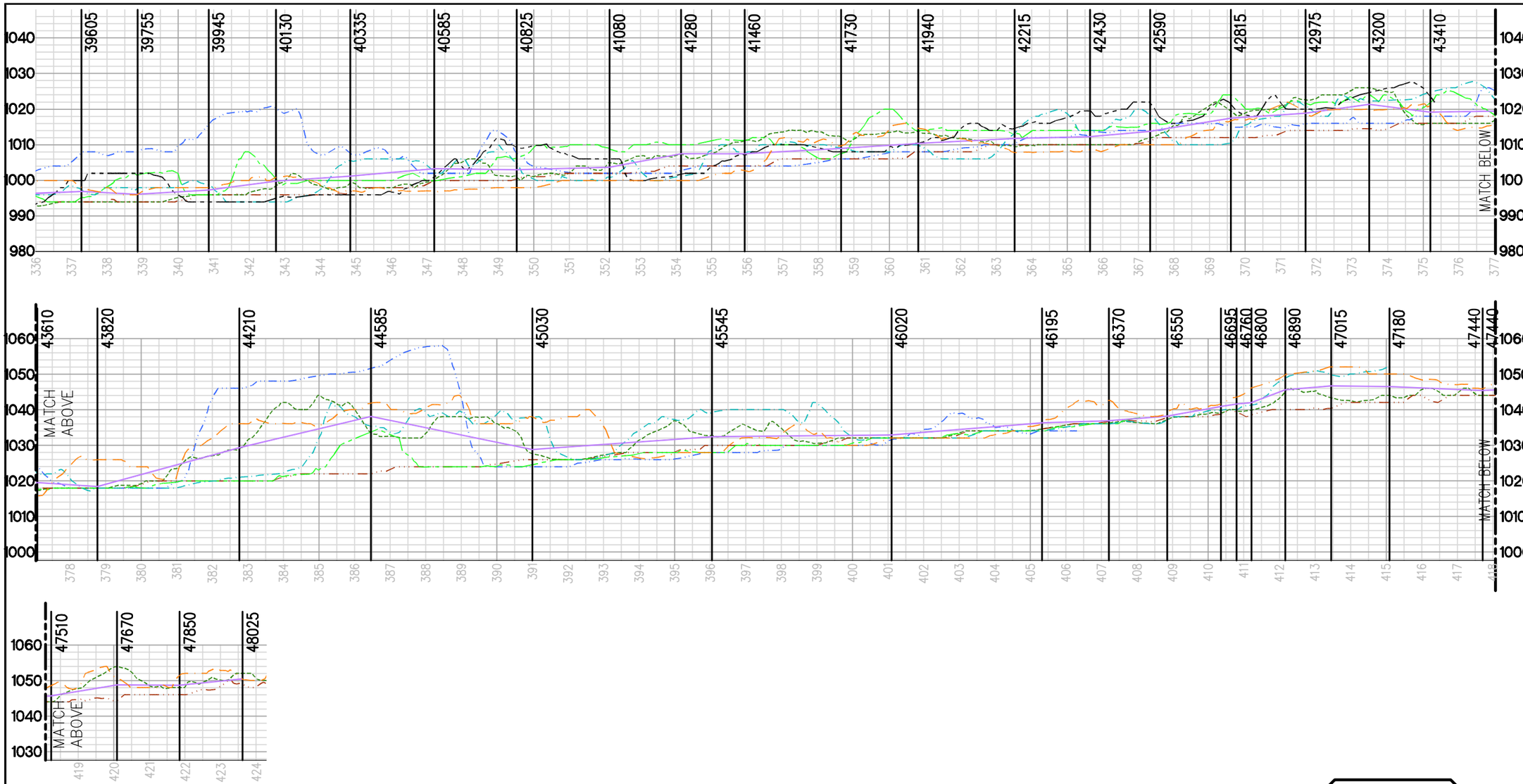
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (1999 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: K By: ddrahn on Mar. 14, 2006 at 05:04 pm



LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

SCALE
1"= 30' VERT.
1"= 300' HORIZ.

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (1999 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE 1"= 300'
DESIGNED DAJ
DRAWN DAD
CHECKED MEK
DATE 09/13/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.1L

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: L By: ddrahn on Mar. 14, 2006 at 05:04 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

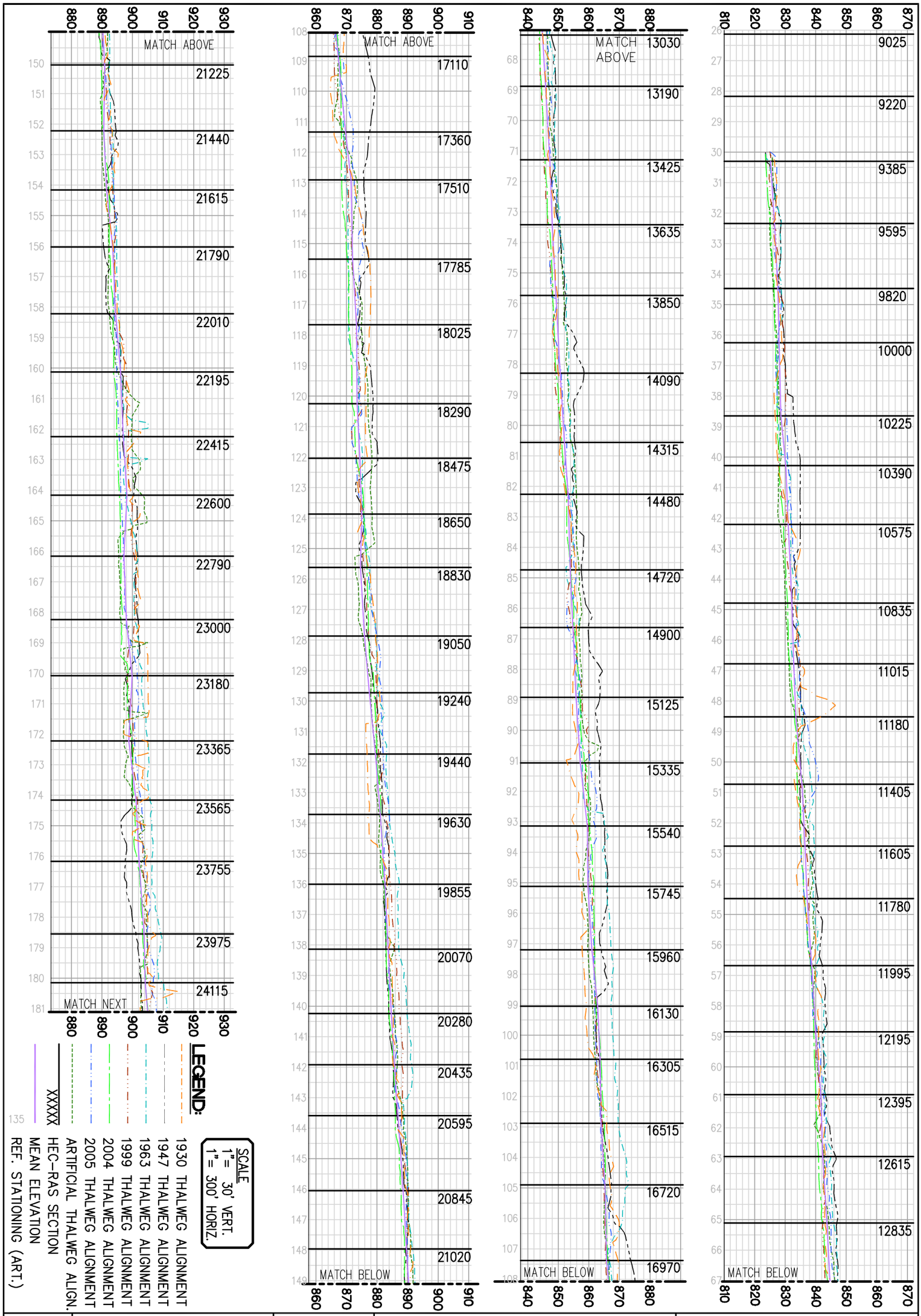


FIGURE A5.3.1M

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (2004 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: M By: ddrahn on Mar. 14, 2006 at 05:03 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

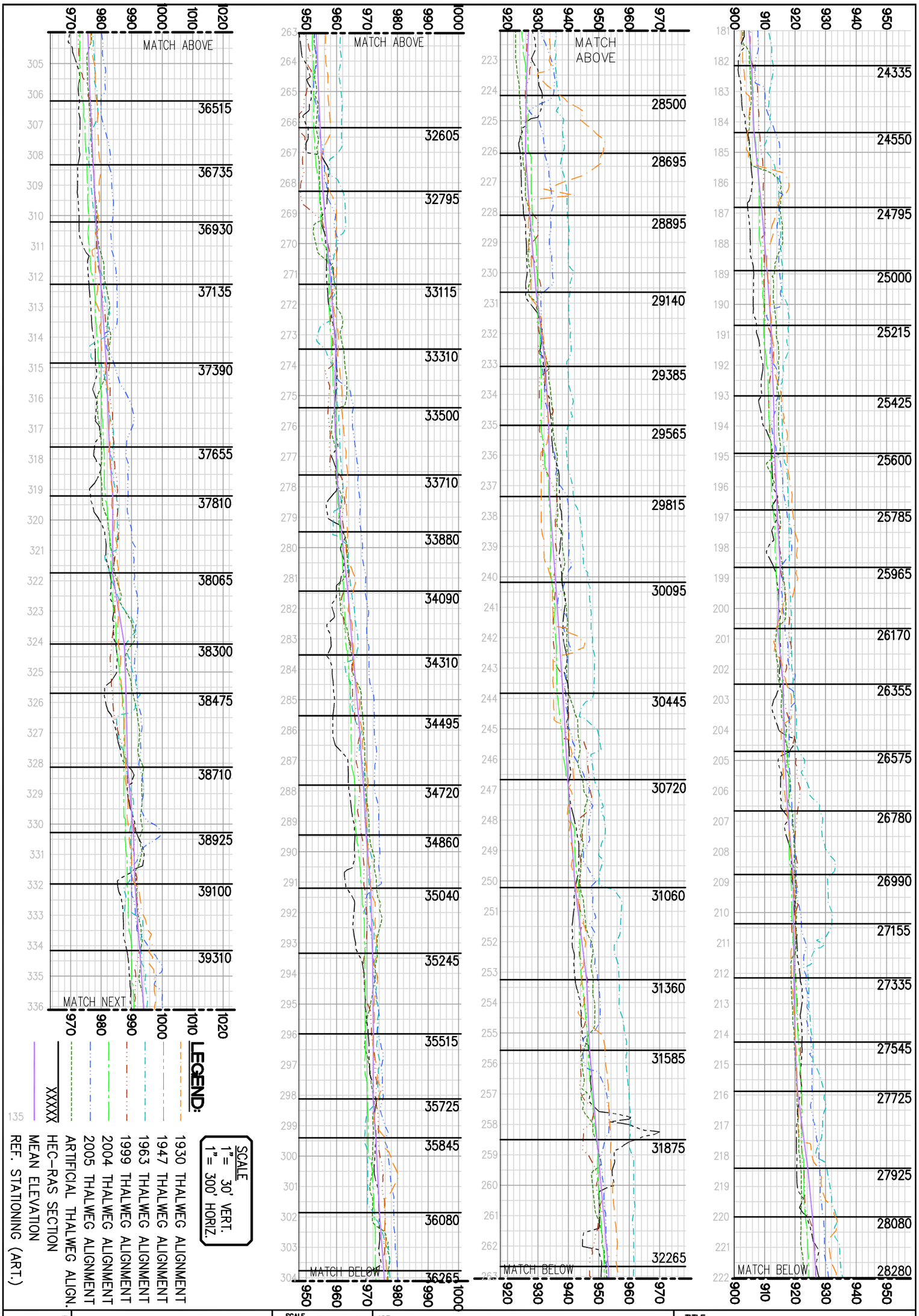


FIGURE A5.8.1N

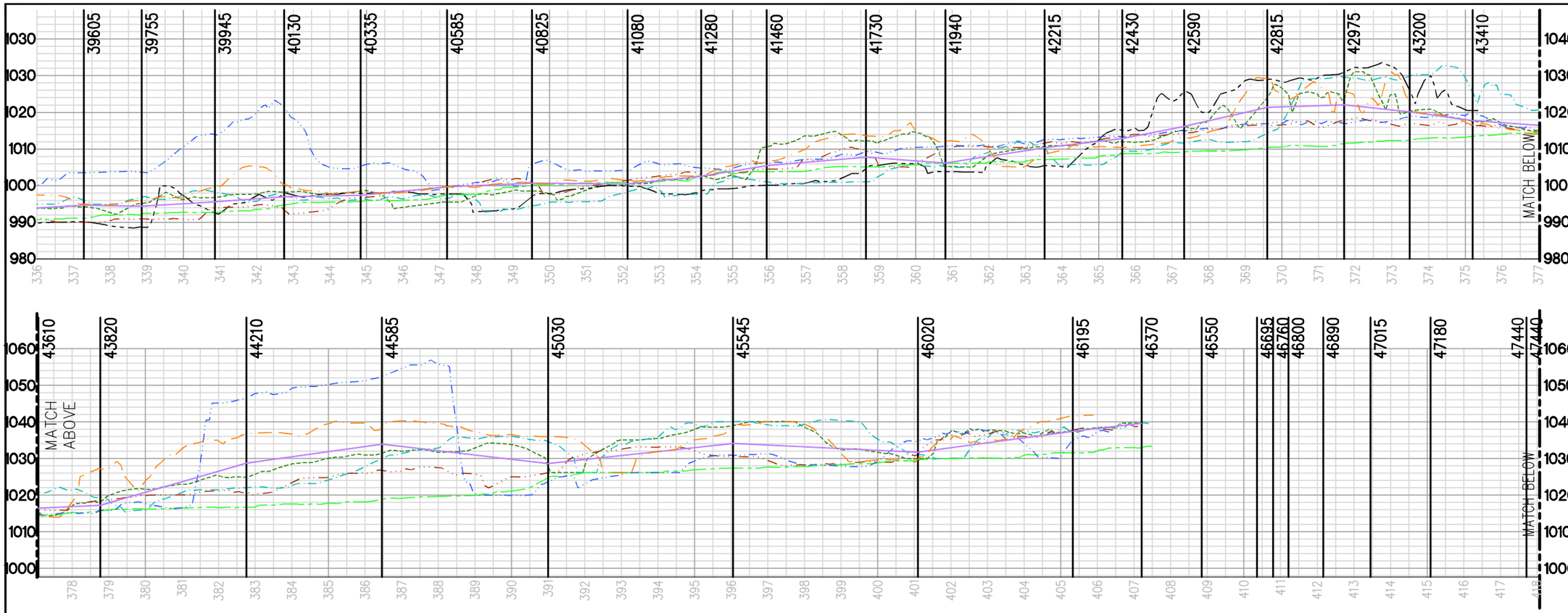
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (2004 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: N By: ddrahn on Mar. 14, 2006 at 05:03 pm



SCALE
1"= 30' VERT.
1"= 300' HORIZ.

LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (2004 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE 1"= 300'
DESIGNED DAJ
DRAWN DAD
CHECKED MEK
DATE 09/13/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.10

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: 0 By: ddrahn on Mar. 14, 2006 at 05:03 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

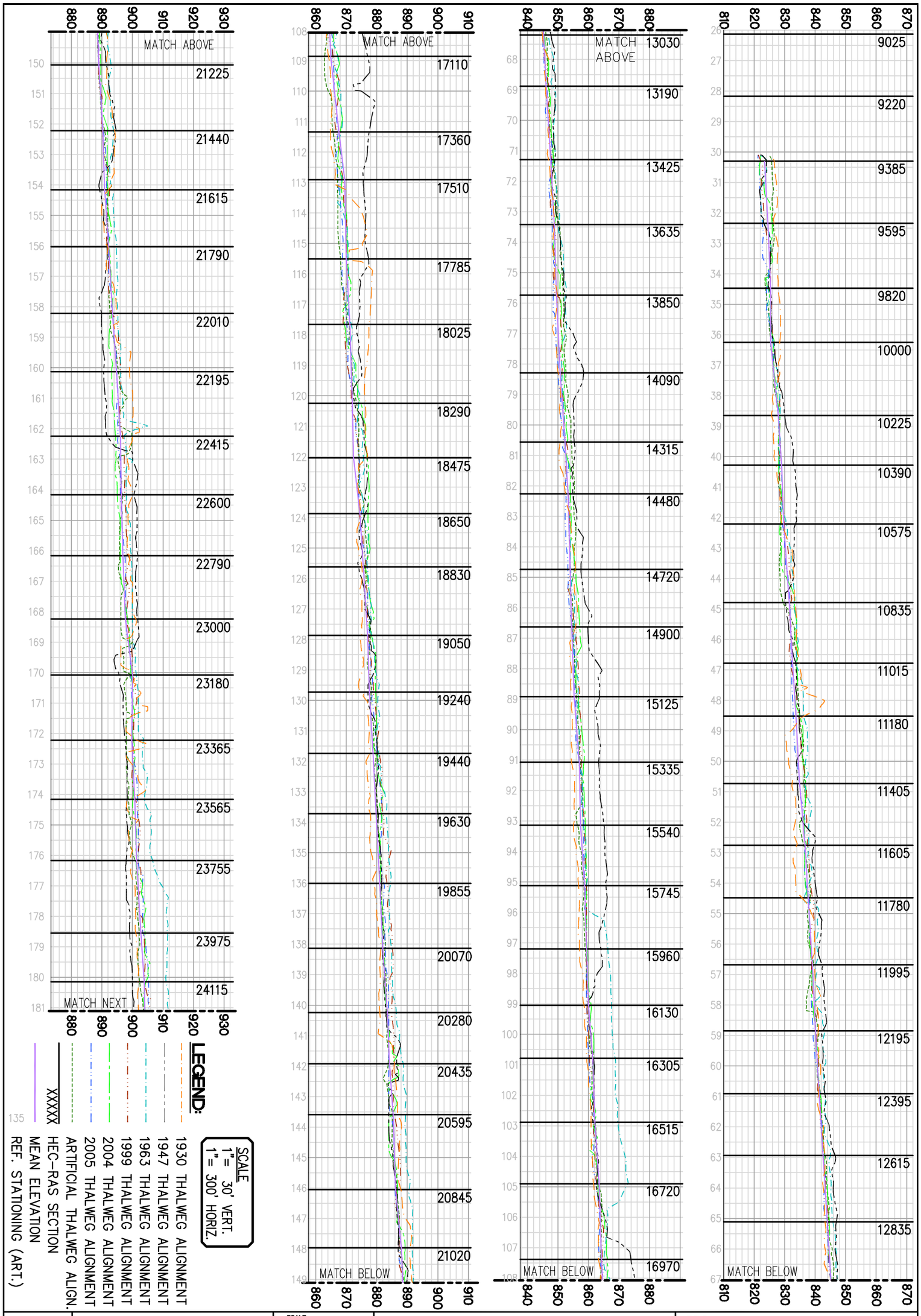


FIGURE A5.8.1P

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (2005 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: P By: ddrahn on Mar. 14, 2006 at 05:03 pm

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1

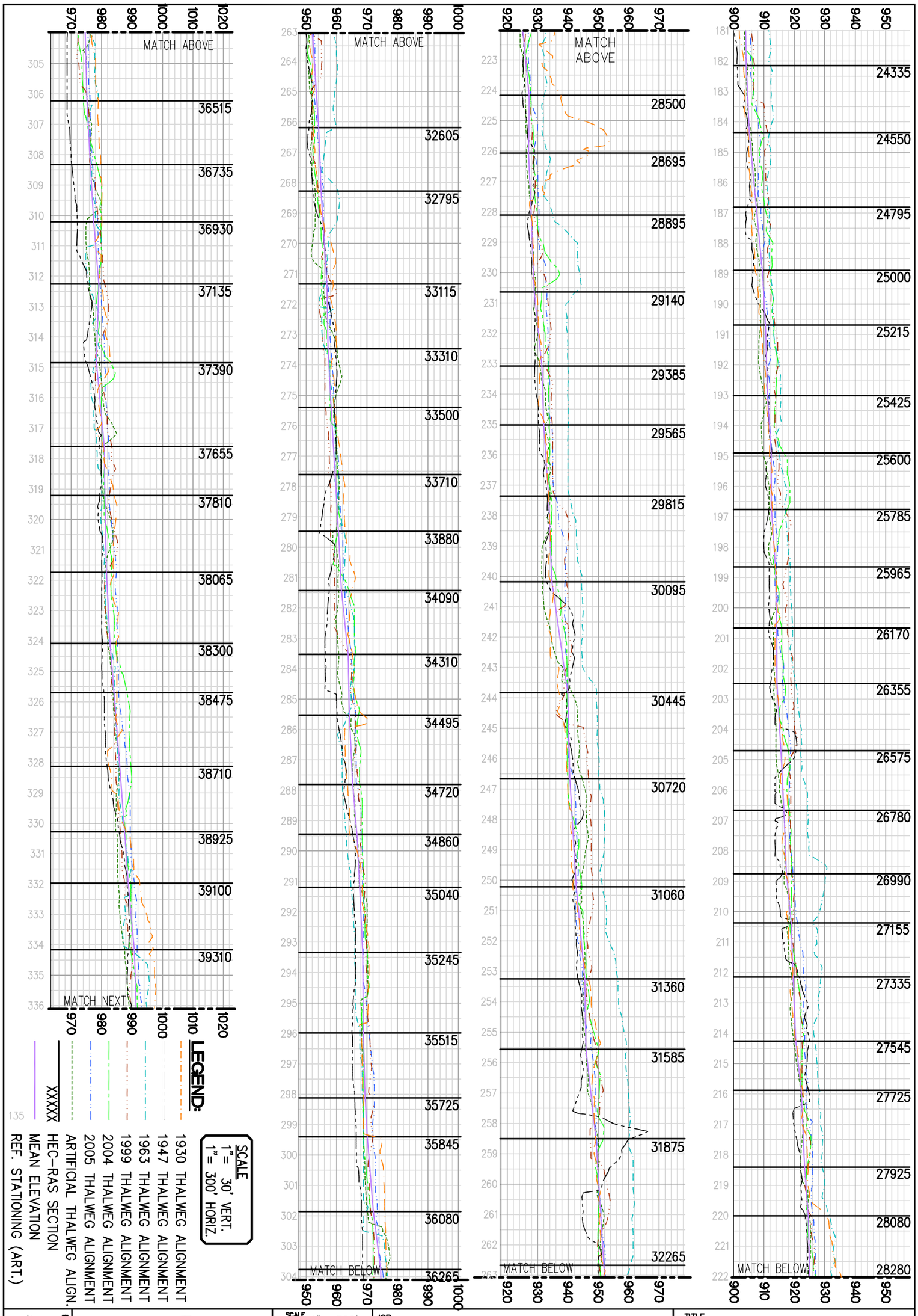


FIGURE A5.3.1Q

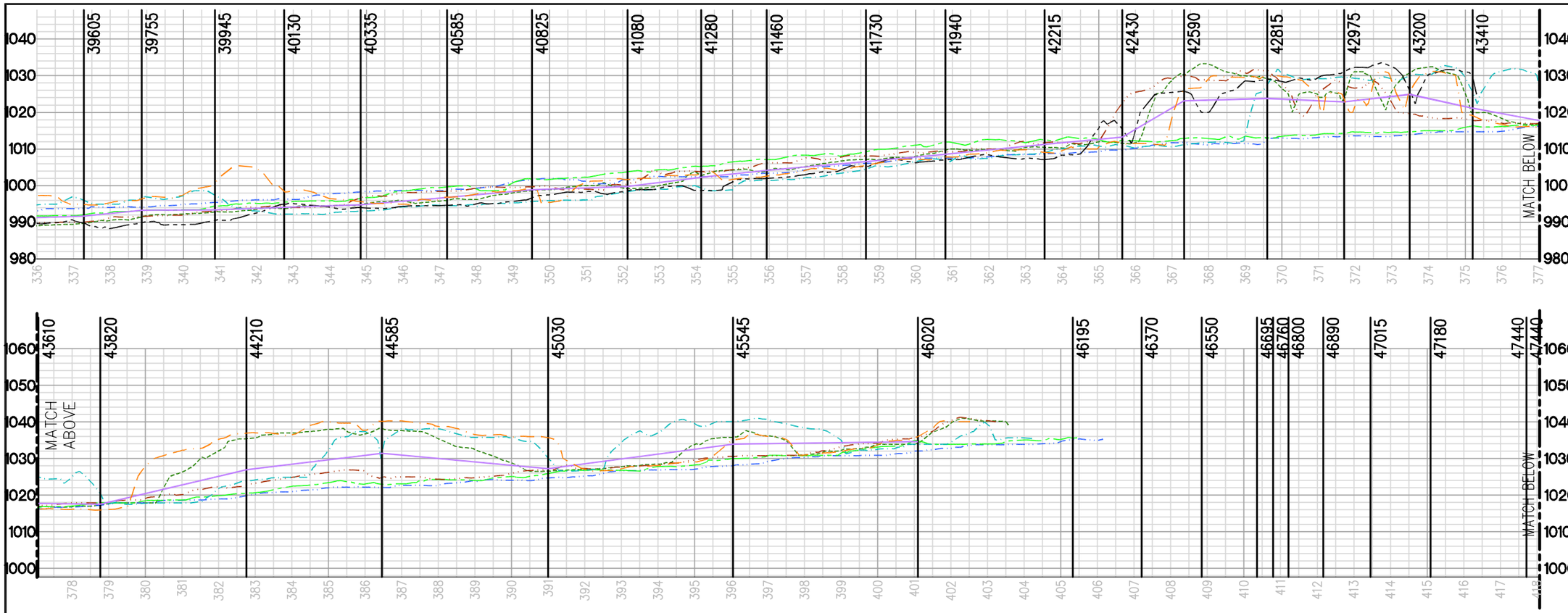
PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

SCALE	1"= 300'
DESIGNED	DAJ
DRAWN	DAD
CHECKED	MEK
DATE	09/13/05
JOB NO.	8197E

JOB
SANTA CLARA RIVER FLUVIAL STUDY
LOS ANGELES COUNTY CA

TITLE
SANTA CLARA RIVER HISTORIC BED PROFILES (2005 TOPO)

P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: Q By: ddrahn on Mar. 14, 2006 at 05:03 pm



SCALE
1"= 30' VERT.
1"= 300' HORIZ.

LEGEND:

- 1930 THALWEG ALIGNMENT
- 1947 THALWEG ALIGNMENT
- 1963 THALWEG ALIGNMENT
- 1999 THALWEG ALIGNMENT
- 2004 THALWEG ALIGNMENT
- 2005 THALWEG ALIGNMENT
- ARTIFICIAL THALWEG ALIGN.
- XXXXX HEC-RAS SECTION
- MEAN ELEVATION
- 135 REF. STATIONING (ART.)

TITLE
SANTA CLARA RIVER
HISTORIC BED
PROFILES (2005 TOPO)

JOB
SANTA CLARA RIVER
FLUVIAL STUDY
LOS ANGELES COUNTY CA

SCALE 1"= 300'
DESIGNED DAJ
DRAWN DAD
CHECKED MEK
DATE 09/13/05
JOB NO. 8197E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
A5.3.1R

Xrefs: 8197-SantaClara-Profiles.dwg; 8197-11x17Exh-Tblk.dwg
Dimscale = 300; LTscale = 0.5; PSltscale = 1; Acad Ver. = 16.2s (LMS Tech); Visretain = 1
P:\8197E\Engineering\GlobalExhibits\8197 Historic Profiles - Santa Clara.dwg - Tab: R By: ddrahn on Mar. 14, 2006 at 05:03 pm

Santa Clara River Fluvial Study

APPENDIX CHAPTER 6.1A

LACH&SM Toe
Existing & Proposed Conditions
Curved & Straight Reaches

PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM -- SANTA CLARA RIVER EXISTING CONDITIONS OUTSIDE CURVED REACH C_{AP} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	18.2	18.2	21.7	18.1	2.8	7.1	0	0.0	1	0.0	0	0.0	1	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	21.2	21.2	24.1	18.1	2.8	8.5	0	0.0	1	0.0	0	0.0	1	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	16.8	16.8	20.3	19.2	2.8	6.4	0	0.0	1	0.0	0	0.0	1	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	22.8	22.8	26.1	16.5	2.8	9.7	0	0.0	1	0.0	0	0.0	1	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	15.5	15.5	19.2	21.1	2.8	5.8	0	0.0	1	0.0	0	0.0	1	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	22.2	22.2	26.2	15.4	2.8	9.7	0	0.0	1	0.0	0	0.0	1	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	21.6	21.6	19.9	19.5	8.1	6.2	0	0.0	1	0.0	0	0.0	1	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	27.1	27.1	26.7	13.8	8.1	10.1	0	0.0	1	0.0	0	0.0	1	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	27.2	27.2	28.8	11.3	8.1	11.5	0	0.0	1	0.0	0	0.0	1	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	26.0	26.0	26.1	12.4	8.1	9.7	0	0.0	1	0.0	0	0.0	1	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	25.6	25.6	26.6	10.8	8.1	10.0	0	0.0	1	0.0	0	0.0	1	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	23.9	23.9	24.1	10.6	8.1	8.5	0	0.0	1	0.0	0	0.0	1	5.5	0.016	878.5	9000	0.0	2.0	5.3	14.0
42590	22.6	22.6	22.6	8.9	8.1	7.6	0	0.0	1	0.0	0	0.0	1	5.1	0.014	1023.2	9000	0.4	2.0	4.5	21.0
42430	21.7	21.7	20.8	9.6	8.1	6.6	0	0.0	1	0.0	0	0.0	1	5.9	0.012	940.5	9000	0.2	2.0	4.8	21.0
42215	15.3	15.3	10.4	14.3	8.1	2.2	0	0.0	1	0.0	0	0.0	1	8.5	0.002	1310.4	9000	1.5	2.0	1.5	15.0
41940	16.1	16.1	11.6	14.3	8.1	2.6	0	0.0	1	0.0	0	0.0	1	7.6	0.002	1321.5	9000	1.6	2.0	1.8	15.0
41730	16.0	16.0	11.8	14.7	8.1	2.7	0	0.0	1	0.0	0	0.0	1	8.0	0.002	1229.5	9000	1.3	2.0	1.9	15.0
41460	16.4	16.4	11.5	16.2	8.1	2.6	0	0.0	1	0.0	0	0.0	1	7.6	0.002	1329.0	9000	1.9	2.0	1.8	15.0
41280	15.4	15.4	16.5	14.3	5.2	4.5	0	0.0	1	0.0	0	0.0	1	8.2	0.004	852.1	9000	0.0	2.0	3.7	12.5
41080	18.7	18.7	19.9	12.1	5.2	6.2	0	0.0	1	0.0	0	0.0	1	6.7	0.007	874.2	9000	0.0	2.0	5.3	14.0
40825	21.0	17.4	18.0	11.5	5.2	5.2	0	0.0	1	0.0	0	0.0	1	6.2	0.007	1039.9	9000	0.5	2.0	4.4	21.0
40585	18.0	16.3	17.0	11.7	5.2	4.7	0	0.0	1	0.0	0	0.0	1	6.8	0.006	1005.9	9000	0.4	2.0	3.9	18.0
40335	15.0	13.5	11.1	14.5	5.2	2.4	0	0.0	1	0.0	0	0.0	1	7.1	0.002	1504.8	9000	2.2	2.0	1.7	15.0
40130	15.0	14.2	11.2	15.1	5.2	2.5	0	0.0	1	0.0	0	0.0	1	6.9	0.002	1636.5	9000	2.8	2.0	1.7	15.0
39945	15.0	13.8	10.3	16.1	5.2	2.2	0	0.0	1	0.0	0	0.0	1	7.6	0.001	1648.1	9000	3.0	2.0	1.4	15.0
39755	18.0	15.9	15.4	13.5	5.2	4.0	0	0.0	1	0.0	0	0.0	1	6.6	0.003	1251.4	9000	1.5	2.0	3.2	18.0
39605	21.0	19.0	19.4	11.4	5.2	5.9	0	0.0	1	0.0	0	0.0	1	5.8	0.007	1100.6	9000	0.8	2.0	5.1	21.0
39310	18.0	16.2	16.0	12.4	5.2	4.3	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1204.5	9000	1.3	2.0	3.5	18.0
39100	15.0	13.8	12.4	14.1	5.2	2.9	0	0.0	1	0.0	0	0.0	1	7.8	0.002	1294.8	9000	1.6	2.0	2.1	15.0
38925	15.0	12.7	11.4	14.5	5.2	2.5	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1181.3	9000	1.2	2.0	1.8	15.0
38710	15.0	9.2	10.6	15.9	2.7	2.3	0	0.0	1	0.0	0	0.0	1	10.8	0.001	1043.1	9000	0.7	2.0	1.5	15.0
38475	14.1	14.1	17.8	14.0	2.7	5.1	0	0.0	1	0.0	0	0.0	1	8.8	0.004	755.4	9000	0.0	2.0	4.3	12.5
38300	17.3	17.3	22.7	9.8	2.7	7.7	0	0.0	1	0.0	0	0.0	1	7.4	0.010	688.1	9000	0.0	2.0	4.9	14.0
38065	10.9	10.9	14.1	14.2	2.7	3.5	0	0.0	1	0.0	0	0.0	1	12.0	0.002	678.3	9000	0.0	2.0	2.7	10.0
37810	14.5	14.5	18.2	12.2	2.7	5.3	0	0.0	1	0.0	0	0.0	1	10.2	0.004	622.3	9000	0.0	2.0	4.5	14.0
37655	16.7	16.7	21.2	10.3	2.7	6.8	0	0.0	1	0.0	0	0.0	1	7.4	0.009	735.9	9000	0.0	2.0	5.1	14.0
37390	16.1	16.1	23.9	6.1	2.7	8.4	0	0.0	1	0.0	0	0.0	1	5.4	0.017	892.2	9000	0.0	2.0	3.1	14.0
37135	18.0	13.9	17.0	8.0	2.7	4.8	0	0.0	1	0.0	0	0.0	1	6.4	0.006	1088.9	9000	0.5	2.0	3.9	18.0
36930	21.0	14.6	18.3	7.9	2.7	5.4	0	0.0	1	0.0	0	0.0	1	6.0	0.007	1112.0	9000	0.6	2.0	3.9	21.0
36735	18.0	12.5	15.0	9.6	2.7	3.9	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1195.7	9000	0.9	2.0	3.0	18.0
36515	18.0	14.3	16.7	9.6	2.7	4.6	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1306.1	9000	1.2	2.0	3.8	18.0
36265	15.0	11.5	13.0	11.2	2.7	3.1	0	0.0	1	0.0	0	0.0	1	6.4	0.003	1373.1	9000	1.4	2.0	2.3	15.0
36080	15.0	11.8	12.5	11.7	3.2	2.9	0	0.0	1	0.0	0	0.0	1	6.4	0.004	1455.4	9000	1.6	2.0	2.1	15.0
35845	15.0	11.2	10.9	13.5	3.2	2.4	0	0.0	1	0.0	0	0.0	1	7.4	0.002	1496.2	9000	2.1	2.0	1.6	15.0
35725	15.0	13.9	14.7	13.0	3.2	3.8	0	0.0	1	0.0	0	0.0	1	6.3	0.003	1431.2	9000	2.1	2.0	2.9	15.0
35515	18.0	15.7	17.1	11.9	3.2	4.8	0	0.0	1	0.0	0	0.0	1	5.7	0.005	1353.4	9000	1.8	2.0	3.9	18.0
35245	15.0	14.1	14.5	12.5	3.2	3.7	0	0.0	1	0.0	0	0.0	1	5.8	0.003	1555.5	9000	2.4	2.0	2.8	15.0
35040	21.0	17.9	19.5	10.7	3.2	5.9	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1355.9	9000	1.7	2.0	5.1	21.0
34860	21.0	16.2	18.1	10.1	3.2	5.3	0	0.0	1	0.0	0	0.0	1	4.8	0.008	1338.9	9000	1.3	2.0	4.4	21.0
34720	21.0	16.3	18.2	9.3	3.2	5.3	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1411.5	9000	1.4	2.0	4.4	21.0
34495	21.0	15.8	18.1	8.9	3.2	5.3	0	0.0	1	0.0	0	0.0	1	5.0	0.009	1277.2	9000	1.0	2.0	4.4	21.0
34310	18.0	15.5	17.6	9.0	3.2	5.0	0	0.0	1	0.0	0	0.0	1	5.7	0.005	1280.8	9000	1.1	2.0	4.2	18.0
34090	18.0	14.9	17.2	8.6	3.2	4.8	0	0.0	1	0.0	0	0.0	1	5.4	0.007	1267.8	9000	1.0	2.0	4.0	18.0
33880	18.0	14.1	15.8	9.8	3.4	4.2	0	0.0	1	0.0	0	0.0	1	5.6	0.005	1310.6	9000	1.2	2.0	3.3	18.0
33710	18.0	14.9	16.5	9.4	3.4	4.6	0	0.0	1	0.0	0	0.0	1	5.2	0.007	1355.1	9000	1.3	2.0	3.7	18.0
33500	18.0	14.5	15.8	9.5	3.4	4.2	0	0.0	1	0.0	0	0.0	1	5.4	0.006	1474.3	9000	1.5	2.0	3.4	18.0
33310	18.0	15.1	15.9	9.1	3.4	4.3	0	0.0	1	0.0	0	0.0	1	4.2	0.006	1744.5	9000	2.1	2.0	3.4	18.0
33115	18.0	14.2	15.5	8.7	3.4	4.1	0	0.0	1	0.0	0	0.0	1	4.8	0.009	1573.2	9000	1.5	2.0	3.3	18.0
32795	15.0	12.5	12.2	11.0	3.4	2.8	0	0.0	1	0.0	0	0.0	1	5.5	0.003	1732.9	9000	2.3	2.0	2.0	15.0
32605	15.0	13.0	14.1	11.5	3.4	3.5	0	0.0	1	0.0	0	0.0	1	6.2	0.004	1344.6	9000	1.4	2.0	2.7	15.0
32265	18.0	14.8	16.7	10.2	2.0	4.6	0	0.0	1	0.0	0	0.0	1	4.6	0.007	1829.9	9000	2.5	2.0	3.8	18.0
31875	15.0	11.2	10.9	11.0	2.0	2.4	0	0.0	1	0.0	0	0.0	1	5.2	0.004	2482.2	9000	3.3	2.0	1.6	15.0
31585	18.0	15.2	16.6	9.8	2.0	4.6	0	0.0	1	0.0	0	0.0	1	4.0	0.009	2120.3	9000	2.9	2.0	3.7	18.0
31360	12.0	10.3	9.8	13.9	2.0	2.0	0	0.0	1	0.0	0	0.0	1	7.8	0.001	1884.4	9000	3.0	2.0	1.3	12.0
31060	12.0	9.0	7.9	15.9	2.0	1.5	0	0.0	1	0.0	0	0.0	1	10.5	0.001	1711.5	9000	2.7	2.0	0.8	12.0
30720	12.0	9.1	6.4	18.0	2.0	1.1	0	0.0	1	0.0	0	0.0	1	11.6	0.000	1891.7	9000	3.5	2.0	0.6	12.0
30445	12.0	9.0	6.0	19.9	2.0	1.0	0	0.0	1	0.0	0	0.0	1	13.1	0.000	1783.7	9000	3.5	2.0	0.5	12.0
30095	12.0	9.8	6.6	21.7	2.0	1.1	0	0.0	1	0.0	0	0.0	1	12.7	0.000	1730.3	9000	4.1	2.0	0.6	12.0
29815	12.0	10.5	7.7	22.4	2.0	1.4	0	0.0	1	0.0	0	0.0	1	11.7	0.000	1675.2	9000	4.3	2.0	0.8	12.0
29565	12.0	10.7	7.4	23.3	2.0	1.3	0	0.0	1	0.0	0	0.0	1	11.8	0.000	1717.4	9000	4.6	2.0	0.7	12.0
29385	12.0	11.4	8.5	24.0	2.0	1.6	0	0.0	1	0.0	0	0.0	1	10.8	0.000	1675.1	9000	4.8	2.0	1.0	12.0
29140	15.0	14.3	10.1	24.3	4.4	2.1	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1557.6	9000	4.4	2.0	1.4	15.0
28895	21.0	19.2	19.7	22.4	4.4	6.0	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1062.3	9000	1.6	2.0	5.2	21.0
28695	25.0	25.0	27.5	16.0	4.4	10.6	0	0.0	1	0.0	0	0.0	1	9.4	0.009	544.9	9000	0.0	2.0	8.0	14.0
28500	24.5	24.5	28.6	13.6	4.4	11.4	0	0.0	1	0.0	0	0.0	1	9.8	0.010	503.7	9000	0.0	2.0	6.8	14.0
28280	24.4	24.4	29.7	11.8	4.4	12.1	0	0.0	1	0.0	0	0.0	1	8.8	0.011	549.3	9000	0.0	2.0	5.9	14.0
28080	23.1	23.1	28.1	11.4	4.4	11.0	0	0.0	1	0.0	0	0.0	1	9.2	0.011	547.6	9000	0.0	2.0	5.7	14.0
27925	15.9	15.9	18.0	17.5	4.4	5.2	0	0.0	1	0.0	0	0.0	1	13.0	0.002	612.7	9000	0.0	2.0	4.3	12.5
27725	18.6	18.6	20.5	16.3	4.4	6.5	0	0.0	1	0.0	0	0.0	1	12.1	0.003	587.1	9000	0.0	2.0	5.7	14.0
27545	21.8	21.8	24.7	13.2	4.4	8.8	0	0.0	1	0.0	0	0.0	1	9.5	0.007	613.0	9000	0.0	2.0	6.6	14.0
27335	21.7	21.7	25.5	12.0	4.4	9.3	0	0.0	1	0.0	0	0.0	1	8.1	0.008	691.0	9000	0.0	2.0	6.0	14.0
27155	20.4	20.4	22.3	13.2	4.4	7.4	0	0.0	1	0.0	0	0.0	1	8.0	0.005	856.6	9000	0.0	2.0	6.6	14.0
26990	21.0	18.2	23.5	11.2	2.0	8.1	0	0.0	1	0.0	0	0.0	1	6.0	0.010	1008.2	9000	0.5	2.0	5.6	21.0
26780	21.0	18.9	23.9	11.0	2.0	8.4	0	0.0	1	0.0	0	0.0	1	5.6	0.010	1131.7	9000	1.0	2.0	5.5	21.0
26575	21.5	21.5	21.0	11.0	2.0	6.7	0	0.0	1	0.0	0	0.0	1	5.5	0.013	1216.4	3000	5.3	2.0	5.5	21.0
26355	18.6	18.6	15.8	13.4	2.0	4.2	0	0.0	1	0.0	0	0.0	1	7.5	0.003	1282.4	3000	7.0	2.0	3.4	18.0
26170	21.3	21.3	18.0	13.0	2.0	5.2	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1347.9	3000	7.7	2.0	4.4	18.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25965	20.9	20.9	17.9	13.0	2.0	5.2	0	0.0	1	0.0	0	0.0	1	7.0	0.004	1288.3	3000	7.4	2.0	4.3	18.0
25785	22.1	22.1	19.5	11.7	2.0	6.0	0	0.0	1	0.0	0	0.0	1	6.2	0.005	1336.9	3000	7.0	2.0	5.2	21.0
25600	24.5	24.5	20.6	11.3	2.0	6.5	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1596.5	3000	8.3	2.0	5.6	21.0
25425	24.3	24.3	20.0	11.3	2.0	6.2	0	0.0	1	0.0	0	0.0	1	4.4	0.008	1773.8	3000	8.7	2.0	5.4	21.0
25215	19.6	19.6	14.5	13.6	2.0	3.7	0	0.0	1	0.0	0	0.0	1	6.1	0.003	1748.6	3000	9.0	2.0	2.8	15.0
25000	23.5	23.5	17.4	12.2	2.0	5.0	0	0.0	1	0.0	0	0.0	1	4.4	0.006	2103.2	3000	10.5	2.0	4.1	18.0
24795	25.4	25.4	19.0	11.4	2.0	5.7	0	0.0	1	0.0	0	0.0	1	3.9	0.007	2311.7	3000	10.8	2.0	4.9	21.0
24550	26.5	26.5	21.3	10.8	2.0	6.9	0	0.0	1	0.0	0	0.0	1	3.8	0.009	2227.0	3000	10.2	2.0	5.4	21.0
24335	20.7	20.7	14.5	13.1	2.0	3.7	0	0.0	1	0.0	0	0.0	1	5.7	0.003	2089.5	3000	10.2	2.0	2.8	15.0
24115	23.1	23.1	18.8	11.1	2.0	5.6	0	0.0	1	0.0	0	0.0	1	4.5	0.008	2015.8	3000	8.7	2.0	4.8	21.0
23975	22.3	22.3	19.0	10.2	2.0	5.7	0	0.0	1	0.0	0	0.0	1	4.6	0.008	1913.7	3000	7.7	2.0	4.9	21.0
23755	20.4	20.4	16.7	10.9	2.0	4.6	0	0.0	1	0.0	0	0.0	1	5.1	0.006	1935.4	3000	8.0	2.0	3.8	18.0
23565	19.8	19.8	14.5	12.7	2.0	3.7	0	0.0	1	0.0	0	0.0	1	5.6	0.004	2039.5	3000	9.3	2.0	2.8	15.0
23365	20.1	20.1	17.0	10.8	2.0	4.8	0	0.0	1	0.0	0	0.0	1	5.4	0.006	1781.4	3000	7.4	2.0	3.9	18.0
23180	18.7	18.7	13.2	11.8	2.0	3.2	0	0.0	1	0.0	0	0.0	1	6.6	0.002	2084.2	3000	9.2	2.0	2.3	15.0
23000	14.7	14.7	8.9	13.0	2.0	1.7	0	0.0	1	0.0	0	0.0	1	7.7	0.001	2069.1	3000	7.9	2.0	1.1	12.0
22790	14.9	14.9	9.4	13.1	2.0	1.9	0	0.0	1	0.0	0	0.0	1	7.8	0.001	1949.0	3000	7.8	2.0	1.2	12.0
22600	17.6	17.6	11.4	14.1	2.0	2.5	0	0.0	1	0.0	0	0.0	1	7.9	0.001	1865.2	3000	9.3	2.0	1.7	15.0
22415	17.3	17.3	11.8	14.1	2.0	2.7	0	0.0	1	0.0	0	0.0	1	8.1	0.002	1705.6	3000	8.7	2.0	1.9	15.0
22195	17.3	17.3	14.1	13.7	2.0	3.5	0	0.0	1	0.0	0	0.0	1	7.8	0.003	1322.2	3000	7.1	2.0	2.7	15.0
22010	19.9	19.9	16.0	14.4	2.0	4.3	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1328.0	3000	8.2	2.0	3.5	18.0
21790	21.2	21.2	19.7	11.6	2.0	6.0	0	0.0	1	0.0	0	0.0	1	6.5	0.006	1145.7	3000	5.9	2.0	5.2	21.0
21615	21.0	19.4	21.4	8.5	2.0	6.9	0	0.0	1	0.0	0	0.0	1	5.8	0.010	1161.3	3000	4.2	2.0	4.3	21.0
21440	21.7	21.7	20.1	9.7	2.0	6.3	0	0.0	1	0.0	0	0.0	1	5.0	0.008	1574.6	3000	6.6	2.0	4.8	21.0
21225	24.8	24.8	19.5	10.6	2.0	5.9	0	0.0	1	0.0	0	0.0	1	3.9	0.008	2217.7	3000	9.7	2.0	5.1	21.0
21020	21.5	21.5	20.8	8.9	2.0	6.6	0	0.0	1	0.0	0	0.0	1	4.6	0.009	1676.4	3000	6.5	2.0	4.4	21.0
20845	22.3	22.3	17.1	10.4	2.0	4.8	0	0.0	1	0.0	0	0.0	1	4.2	0.006	2369.3	3000	9.6	2.0	3.9	18.0
20595	21.4	21.4	15.2	10.9	2.0	4.0	0	0.0	1	0.0	0	0.0	1	4.7	0.003	2463.7	3000	10.3	2.0	3.1	18.0
20435	20.7	20.7	12.9	12.2	2.0	3.1	0	0.0	1	0.0	0	0.0	1	5.4	0.002	2582.7	3000	11.3	2.0	2.3	15.0
20280	21.1	21.1	14.0	11.8	2.0	3.5	0	0.0	1	0.0	0	0.0	1	5.0	0.003	2589.6	3000	11.0	2.0	2.6	15.0
20070	21.6	21.6	20.2	9.2	2.0	6.3	0	0.0	1	0.0	0	0.0	1	4.7	0.009	1767.5	3000	6.7	2.0	4.6	21.0
19855	21.3	21.3	17.8	9.9	2.0	5.1	0	0.0	1	0.0	0	0.0	1	4.8	0.006	1975.1	3000	7.9	2.0	4.3	18.0
19630	20.0	20.0	17.9	8.9	2.0	5.2	0	0.0	1	0.0	0	0.0	1	4.9	0.006	1836.2	3000	6.6	2.0	4.3	18.0
19440	17.5	17.5	11.9	12.1	2.0	2.7	0	0.0	1	0.0	0	0.0	1	6.5	0.002	2095.3	3000	8.9	2.0	1.9	15.0
19240	18.8	18.8	13.9	11.4	2.0	3.5	0	0.0	1	0.0	0	0.0	1	5.6	0.003	2091.7	3000	8.7	2.0	2.6	15.0
19050	17.1	17.1	11.0	12.9	2.0	2.4	0	0.0	1	0.0	0	0.0	1	6.7	0.002	2160.8	3000	9.1	2.0	1.6	15.0
18830	17.9	17.9	10.7	14.6	2.0	2.3	0	0.0	1	0.0	0	0.0	1	7.1	0.002	2094.4	3000	10.1	2.0	1.5	15.0
18650	17.5	17.5	9.9	15.0	2.0	2.1	0	0.0	1	0.0	0	0.0	1	8.0	0.001	2022.7	3000	10.1	2.0	1.3	12.0
18475	16.1	16.1	8.1	16.6	2.0	1.5	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1944.4	3000	9.7	2.0	0.9	12.0
18290	16.6	16.6	8.7	16.8	2.0	1.7	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1843.7	3000	9.9	2.0	1.0	12.0
18025	8.0	6.3	7.8	18.2	2.0	1.5	0	0.0	1	0.0	0	0.0	1	11.5	0.001	1610.9	17000	0.0	2.0	0.8	8.0
17785	8.0	6.7	8.7	19.8	2.0	1.7	0	0.0	1	0.0	0	0.0	1	11.6	0.001	1417.5	17000	0.0	2.0	1.0	8.0
17510	10.1	10.1	14.0	18.0	2.0	3.5	0	0.0	1	0.0	0	0.0	1	8.5	0.002	1243.6	17000	0.0	2.0	2.6	10.0
17360	12.7	12.7	17.0	16.9	2.0	4.8	0	0.0	1	0.0	0	0.0	1	8.9	0.004	936.6	17000	0.0	2.0	3.9	12.5
17110	17.5	17.5	21.7	15.4	2.0	7.1	0	0.0	1	0.0	0	0.0	1	5.6	0.006	1274.3	17000	0.0	2.0	6.4	14.0
16970	18.6	18.6	22.9	13.6	2.0	7.8	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1125.6	17000	0.0	2.0	6.8	14.0
16720	17.6	17.6	25.2	9.0	2.0	9.1	0	0.0	1	0.0	0	0.0	1	4.1	0.018	1404.6	17000	0.0	2.0	4.5	14.0
16515	15.7	15.7	21.5	9.5	2.0	7.0	0	0.0	1	0.0	0	0.0	1	4.3	0.012	1622.6	17000	0.0	2.0	4.8	14.0
16305	21.0	16.1	21.5	9.6	2.0	7.0	0	0.0	1	0.0	0	0.0	1	4.2	0.011	1812.8	17000	0.3	2.0	4.8	21.0
16130	18.0	12.3	16.1	10.2	2.0	4.3	0	0.0	1	0.0	0	0.0	1	5.2	0.005	1945.1	17000	0.5	2.0	3.5	18.0
15960	18.0	12.3	15.8	9.3	2.0	4.2	0	0.0	1	0.0	0	0.0	1	4.1	0.011	2180.9	17000	0.7	2.0	3.4	18.0
15745	15.0	8.9	10.9	10.6	2.0	2.4	0	0.0	1	0.0	0	0.0	1	5.7	0.003	2279.0	17000	0.9	2.0	1.6	15.0
15540	15.0	9.0	11.0	10.6	2.0	2.4	0	0.0	1	0.0	0	0.0	1	5.8	0.003	2324.2	17000	1.0	2.0	1.6	15.0
15335	15.0	10.1	12.7	10.5	2.0	3.0	0	0.0	1	0.0	0	0.0	1	4.9	0.005	2302.1	17000	1.0	2.0	2.2	15.0
15125	12.5	11.9	16.2	9.6	2.0	4.4	0	0.0	1	0.0	0	0.0	1	5.5	0.007	1618.5	17000	0.0	2.0	3.5	12.5
14900	15.0	10.6	14.5	10.4	2.0	3.7	0	0.0	1	0.0	0	0.0	1	6.1	0.004	1704.5	17000	0.1	2.0	2.9	15.0
14720	18.0	12.7	16.8	9.3	2.0	4.7	0	0.0	1	0.0	0	0.0	1	5.1	0.008	1763.5	17000	0.1	2.0	3.8	18.0
14480	15.0	10.6	14.3	10.2	2.0	3.6	0	0.0	1	0.0	0	0.0	1	6.0	0.004	1801.7	17000	0.2	2.0	2.7	15.0
14315	15.0	11.1	14.8	9.4	2.0	3.8	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1868.1	17000	0.3	2.0	3.0	15.0
14090	15.0	10.1	13.8	9.0	2.0	3.4	0	0.0	1	0.0	0	0.0	1	5.9	0.005	1766.8	17000	0.1	2.0	2.6	15.0
13850	18.0	11.5	15.6	8.4	2.0	4.2	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1727.3	17000	0.1	2.0	3.3	18.0
13635	12.5	11.3	15.4	10.3	2.0	4.1	0	0.0	1	0.0	0	0.0	1	6.4	0.004	1691.9	17000	0.0	2.0	3.2	12.5
13425	18.0	13.2	17.3	8.3	2.0	4.9	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1854.4	17000	0.3	2.0	4.0	18.0
13190	15.0	9.1	12.2	9.5	2.0	2.8	0	0.0	1	0.0	0	0.0	1	6.4	0.003	1847.3	17000	0.3	2.0	2.0	15.0
13030	15.0	10.4	14.2	9.6	2.0	3.6	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1763.0	17000	0.2	2.0	2.7	15.0
12835	10.0	9.6	13.3	10.1	2.0	3.2	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	9.0	12.4	10.9	2.0	2.9	0	0.0	1	0.0	0	0.0	1	8.7	0.002	1471.0	17000	0.0	2.0	2.1	10.0
12395	10.0	8.9	12.3	11.5	2.0	2.9	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1438.4	17000	0.0	2.0	2.0	10.0
12195	10.0	7.8	10.6	12.5	2.0	2.3	0	0.0	1	0.0	0	0.0	1	10.3	0.001	1389.3	17000	0.0	2.0	1.5	10.0
11995	10.0	9.2	12.7	13.7	2.0	3.0	0	0.0	1	0.0	0	0.0	1	9.8	0.002	1281.1	17000	0.0	2.0	2.2	10.0
11780	10.0	9.0	12.5	14.4	2.0	2.9	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1400.9	17000	0.0	2.0	2.1	10.0
11605	10.2	10.2	14.1	13.7	2.0	3.5	0	0.0	1	0.0	0	0.0	1	8.7	0.002	1282.9	17000	0.0	2.0	2.7	10.0
11405	10.0	9.5	13.2	15.1	2.0	3.2	0	0.0	1	0.0	0	0.0	1	10.1	0.002	1130.2	17000	0.0	2.0	2.3	10.0
11180	12.5	12.3	16.6	13.9	2.0	4.6	0	0.0	1	0.0	0	0.0	1	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.7	14.7	19.1	13.3	2.0	5.7	0	0.0	1	0.0	0	0.0	1	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	16.7	16.7	21.9	10.9	2.0	7.2	0	0.0	1	0.0	0	0.0	1	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	16.2	16.2	24.1	7.5	2.0	8.5	0	0.0	1	0.0	0	0.0	1	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	16.1	16.1	22.7	8.8	2.0	7.7	0	0.0	1	0.0	0	0.0	1	5.8	0.008	1247.1	17000	0.0	2.0	4.4	14.0
10225	13.4	13.4	17.8	9.5	2.0	5.1	0	0.0	1	0.0	0	0.0	1	5.9	0.007	1373.8	17000	0.0	2.0	4.3	12.5
10000	10.9	10.9	14.9	11.1	2.0	3.9	0	0.0	1	0.0	0	0.0	1	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.2	14.2	18.6	10.0	2.0	5.5	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1336.6	17000	0.0	2.0	4.7	14.0
9595	10.6	10.6	14.6	10.3	2.0	3.7	0	0.0	1	0.0	0	0.0	1	6.6	0.005	1619.7	17000	0.0	2.0	2.9	10.0
9385	18.0	11.7	15.8	9.5	2.0	4.2	0	0.0	1	0.0	0	0.0	1	5.3	0.006	1770.4	17000	0.2	2.0	3.4	18.0
9220	18.0	12.3	16.4	8.9	2.0	4.5	0	0.0	1	0.0	0	0.0	1	4.9	0.008	1771.4	17000	0.1	2.0	3.6	18.0
9025	18.0	11.8	15.9	8.9	2.0	4.3	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1736.9	17000	0.1	2.0	3.4	18.0
MAX=	27.2	27.2			8.1	12.1						0.0					17000.0	11.3	2.0	8.3	21.0
MIN=	8.0	6.3			2.0	1.0						0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM -- SANTA CLARA RIVER EXISTING CONDITIONS STRAIGHT-INSIDE CURVED REACH,Q_b n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	18.2	18.2	21.7	18.1	2.8	7.1	0	0.0	1	0.0	0	0.0	0	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	21.2	21.2	24.1	18.1	2.8	8.5	0	0.0	1	0.0	0	0.0	0	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	16.8	16.8	20.3	19.2	2.8	6.4	0	0.0	1	0.0	0	0.0	0	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	22.8	22.8	26.1	16.5	2.8	9.7	0	0.0	1	0.0	0	0.0	0	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	15.5	15.5	19.2	21.1	2.8	5.8	0	0.0	1	0.0	0	0.0	0	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	22.2	22.2	26.2	15.4	2.8	9.7	0	0.0	1	0.0	0	0.0	0	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	21.6	21.6	19.9	19.5	8.1	6.2	0	0.0	1	0.0	0	0.0	0	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	27.1	27.1	26.7	13.8	8.1	10.1	0	0.0	1	0.0	0	0.0	0	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	27.2	27.2	28.8	11.3	8.1	11.5	0	0.0	1	0.0	0	0.0	0	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	26.0	26.0	26.1	12.4	8.1	9.7	0	0.0	1	0.0	0	0.0	0	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	25.6	25.6	26.6	10.8	8.1	10.0	0	0.0	1	0.0	0	0.0	0	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	23.9	23.9	24.1	10.6	8.1	8.5	0	0.0	1	0.0	0	0.0	0	5.5	0.016	878.5	9000	0.0	2.0	5.3	14.0
42590	22.2	22.2	22.6	8.9	8.1	7.6	0	0.0	1	0.0	0	0.0	0	5.1	0.014	1023.2	9000	0.0	2.0	4.5	14.0
42430	21.6	21.6	20.8	9.6	8.1	6.6	0	0.0	1	0.0	0	0.0	0	5.9	0.012	940.5	9000	0.0	2.0	4.8	14.0
42215	13.8	13.8	10.4	14.3	8.1	2.2	0	0.0	1	0.0	0	0.0	0	8.5	0.002	1310.4	9000	0.0	2.0	1.5	10.0
41940	14.5	14.5	11.6	14.3	8.1	2.6	0	0.0	1	0.0	0	0.0	0	7.6	0.002	1321.5	9000	0.0	2.0	1.8	10.0
41730	14.6	14.6	11.8	14.7	8.1	2.7	0	0.0	1	0.0	0	0.0	0	8.0	0.002	1229.5	9000	0.0	2.0	1.9	10.0
41460	14.5	14.5	11.5	16.2	8.1	2.6	0	0.0	1	0.0	0	0.0	0	7.6	0.002	1329.0	9000	0.0	2.0	1.8	10.0
41280	15.4	15.4	16.5	14.3	5.2	4.5	0	0.0	1	0.0	0	0.0	0	8.2	0.004	852.1	9000	0.0	2.0	3.7	12.5
41080	18.7	18.7	19.9	12.1	5.2	6.2	0	0.0	1	0.0	0	0.0	0	6.7	0.007	874.2	9000	0.0	2.0	5.3	14.0
40825	16.8	16.8	18.0	11.5	5.2	5.2	0	0.0	1	0.0	0	0.0	0	6.2	0.007	1039.9	9000	0.0	2.0	4.4	14.0
40585	15.8	15.8	17.0	11.7	5.2	4.7	0	0.0	1	0.0	0	0.0	0	6.8	0.006	1005.9	9000	0.0	2.0	3.9	12.5
40335	11.3	11.3	11.1	14.5	5.2	2.4	0	0.0	1	0.0	0	0.0	0	7.1	0.002	1504.8	9000	0.0	2.0	1.7	10.0
40130	11.3	11.3	11.2	15.1	5.2	2.5	0	0.0	1	0.0	0	0.0	0	6.9	0.002	1636.5	9000	0.0	2.0	1.7	10.0
39945	10.8	10.8	10.3	16.1	5.2	2.2	0	0.0	1	0.0	0	0.0	0	7.6	0.001	1648.1	9000	0.0	2.0	1.4	10.0
39755	14.4	14.4	15.4	13.5	5.2	4.0	0	0.0	1	0.0	0	0.0	0	6.6	0.003	1251.4	9000	0.0	2.0	3.2	12.5
39605	18.1	18.1	19.4	11.4	5.2	5.9	0	0.0	1	0.0	0	0.0	0	5.8	0.007	1100.6	9000	0.0	2.0	5.1	14.0
39310	15.0	15.0	16.0	12.4	5.2	4.3	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1204.5	9000	0.0	2.0	3.5	12.5
39100	12.1	12.1	12.4	14.1	5.2	2.9	0	0.0	1	0.0	0	0.0	0	7.8	0.002	1294.8	9000	0.0	2.0	2.1	10.0
38925	11.5	11.5	11.4	14.5	5.2	2.5	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1181.3	9000	0.0	2.0	1.8	10.0
38710	10.0	8.5	10.6	15.9	2.7	2.3	0	0.0	1	0.0	0	0.0	0	10.8	0.001	1043.1	9000	0.0	2.0	1.5	10.0
38475	14.1	14.1	17.8	14.0	2.7	5.1	0	0.0	1	0.0	0	0.0	0	8.8	0.004	755.4	9000	0.0	2.0	4.3	12.5
38300	17.3	17.3	22.7	9.8	2.7	7.7	0	0.0	1	0.0	0	0.0	0	7.4	0.010	688.1	9000	0.0	2.0	4.9	14.0
38065	10.9	10.9	14.1	14.2	2.7	3.5	0	0.0	1	0.0	0	0.0	0	12.0	0.002	678.3	9000	0.0	2.0	2.7	10.0
37810	14.5	14.5	18.2	12.2	2.7	5.3	0	0.0	1	0.0	0	0.0	0	10.2	0.004	622.3	9000	0.0	2.0	4.5	14.0
37655	16.7	16.7	21.2	10.3	2.7	6.8	0	0.0	1	0.0	0	0.0	0	7.4	0.009	735.9	9000	0.0	2.0	5.1	14.0
37390	16.1	16.1	23.9	6.1	2.7	8.4	0	0.0	1	0.0	0	0.0	0	5.4	0.017	892.2	9000	0.0	2.0	3.1	14.0
37135	13.4	13.4	17.0	8.0	2.7	4.8	0	0.0	1	0.0	0	0.0	0	6.4	0.006	1088.9	9000	0.0	2.0	3.9	12.5
36930	14.0	14.0	18.3	7.9	2.7	5.4	0	0.0	1	0.0	0	0.0	0	6.0	0.007	1112.0	9000	0.0	2.0	3.9	14.0
36735	12.5	11.6	15.0	9.6	2.7	3.9	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1195.7	9000	0.0	2.0	3.0	12.5
36515	13.1	13.1	16.7	9.6	2.7	4.6	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1306.1	9000	0.0	2.0	3.8	12.5
36265	10.1	10.1	13.0	11.2	2.7	3.1	0	0.0	1	0.0	0	0.0	0	6.4	0.003	1373.1	9000	0.0	2.0	2.3	10.0
36080	10.2	10.2	12.5	11.7	3.2	2.9	0	0.0	1	0.0	0	0.0	0	6.4	0.004	1455.4	9000	0.0	2.0	2.1	10.0
35845	10.0	9.1	10.9	13.5	3.2	2.4	0	0.0	1	0.0	0	0.0	0	7.4	0.002	1496.2	9000	0.0	2.0	1.6	10.0
35725	11.8	11.8	14.7	13.0	3.2	3.8	0	0.0	1	0.0	0	0.0	0	6.3	0.003	1431.2	9000	0.0	2.0	2.9	10.0
35515	13.9	13.9	17.1	11.9	3.2	4.8	0	0.0	1	0.0	0	0.0	0	5.7	0.005	1353.4	9000	0.0	2.0	3.9	12.5
35245	11.7	11.7	14.5	12.5	3.2	3.7	0	0.0	1	0.0	0	0.0	0	5.8	0.003	1555.5	9000	0.0	2.0	2.8	10.0
35040	16.2	16.2	19.5	10.7	3.2	5.9	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1355.9	9000	0.0	2.0	5.1	14.0
34860	14.8	14.8	18.1	10.1	3.2	5.3	0	0.0	1	0.0	0	0.0	0	4.8	0.008	1338.9	9000	0.0	2.0	4.4	14.0
34720	14.9	14.9	18.2	9.3	3.2	5.3	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1411.5	9000	0.0	2.0	4.4	14.0
34495	14.8	14.8	18.1	8.9	3.2	5.3	0	0.0	1	0.0	0	0.0	0	5.0	0.009	1277.2	9000	0.0	2.0	4.4	14.0
34310	14.4	14.4	17.6	9.0	3.2	5.0	0	0.0	1	0.0	0	0.0	0	5.7	0.005	1280.8	9000	0.0	2.0	4.2	12.5
34090	14.0	14.0	17.2	8.6	3.2	4.8	0	0.0	1	0.0	0	0.0	0	5.4	0.007	1267.8	9000	0.0	2.0	4.0	12.5
33880	12.9	12.9	15.8	9.8	3.4	4.2	0	0.0	1	0.0	0	0.0	0	5.6	0.005	1310.6	9000	0.0	2.0	3.3	12.5
33710	13.6	13.6	16.5	9.4	3.4	4.6	0	0.0	1	0.0	0	0.0	0	5.2	0.007	1355.1	9000	0.0	2.0	3.7	12.5
33500	13.0	13.0	15.8	9.5	3.4	4.2	0	0.0	1	0.0	0	0.0	0	5.4	0.006	1474.3	9000	0.0	2.0	3.4	12.5
33310	13.0	13.0	15.9	9.1	3.4	4.3	0	0.0	1	0.0	0	0.0	0	4.2	0.006	1744.5	9000	0.0	2.0	3.4	12.5
33115	12.7	12.7	15.5	8.7	3.4	4.1	0	0.0	1	0.0	0	0.0	0	4.8	0.009	1573.2	9000	0.0	2.0	3.3	12.5
32795	10.2	10.2	12.2	11.0	3.4	2.8	0	0.0	1	0.0	0	0.0	0	5.5	0.003	1732.9	9000	0.0	2.0	2.0	10.0
32605	11.6	11.6	14.1	11.5	3.4	3.5	0	0.0	1	0.0	0	0.0	0	6.2	0.004	1344.6	9000	0.0	2.0	2.7	10.0
32265	12.5	12.4	16.7	10.2	2.0	4.6	0	0.0	1	0.0	0	0.0	0	4.6	0.007	1829.9	9000	0.0	2.0	3.8	12.5
31875	10.0	8.0	10.9	11.0	2.0	2.4	0	0.0	1	0.0	0	0.0	0	5.2	0.004	2482.2	9000	0.0	2.0	1.6	10.0
31585	12.5	12.3	16.6	9.8	2.0	4.6	0	0.0	1	0.0	0	0.0	0	4.0	0.009	2120.3	9000	0.0	2.0	3.7	12.5
31360	8.0	7.3	9.8	13.9	2.0	2.0	0	0.0	1	0.0	0	0.0	0	7.8	0.001	1884.4	9000	0.0	2.0	1.3	8.0
31060	8.0	6.3	7.9	15.9	2.0	1.5	0	0.0	1	0.0	0	0.0	0	10.5	0.001	1711.5	9000	0.0	2.0	0.8	8.0
30720	8.0	5.6	6.4	18.0	2.0	1.1	0	0.0	1	0.0	0	0.0	0	11.6	0.000	1891.7	9000	0.0	2.0	0.6	8.0
30445	8.0	5.5	6.0	19.9	2.0	1.0	0	0.0	1	0.0	0	0.0	0	13.1	0.000	1783.7	9000	0.0	2.0	0.5	8.0
30095	8.0	5.7	6.6	21.7	2.0	1.1	0	0.0	1	0.0	0	0.0	0	12.7	0.000	1730.3	9000	0.0	2.0	0.6	8.0
29815	8.0	6.2	7.7	22.4	2.0	1.4	0	0.0	1	0.0	0	0.0	0	11.7	0.000	1675.2	9000	0.0	2.0	0.8	8.0
29565	8.0	6.1	7.4	23.3	2.0	1.3	0	0.0	1	0.0	0	0.0	0	11.8	0.000	1717.4	9000	0.0	2.0	0.7	8.0
29385	8.0	6.6	8.5	24.0	2.0	1.6	0	0.0	1	0.0	0	0.0	0	10.8	0.000	1675.1	9000	0.0	2.0	1.0	8.0
29140	10.0	9.8	10.1	24.3	4.4	2.1	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1557.6	9000	0.0	2.0	1.4	10.0
28895	17.6	17.6	19.7	22.4	4.4	6.0	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1062.3	9000	0.0	2.0	5.2	14.0
28695	25.0	25.0	27.5	16.0	4.4	10.6	0	0.0	1	0.0	0	0.0	0	9.4	0.009	544.9	9000	0.0	2.0	8.0	14.0
28500	24.5	24.5	28.6	13.6	4.4	11.4	0	0.0	1	0.0	0	0.0	0	9.8	0.010	503.7	9000	0.0	2.0	6.8	14.0
28280	24.4	24.4	29.7	11.8	4.4	12.1	0	0.0	1	0.0	0	0.0	0	8.8	0.011	549.3	9000	0.0	2.0	5.9	14.0
28080	23.1	23.1	28.1	11.4	4.4	11.0	0	0.0	1	0.0	0	0.0	0	9.2	0.011	547.6	9000	0.0	2.0	5.7	14.0
27925	15.9	15.9	18.0	17.5	4.4	5.2	0	0.0	1	0.0	0	0.0	0	13.0	0.002	612.7	9000	0.0	2.0	4.3	12.5
27725	18.6	18.6	20.5	16.3	4.4	6.5	0	0.0	1	0.0	0	0.0	0	12.1	0.003	587.1	9000	0.0	2.0	5.7	14.0
27545	21.8	21.8	24.7	13.2	4.4	8.8	0	0.0	1	0.0	0	0.0	0	9.5	0.007	613.0	9000	0.0	2.0	6.6	14.0
27335	21.7	21.7	25.5	12.0	4.4	9.3	0	0.0	1	0.0	0	0.0	0	8.1	0.008	691.0	9000	0.0	2.0	6.0	14.0
27155	20.4	20.4	22.3	13.2	4.4	7.4	0	0.0	1	0.0	0	0.0	0	8.0	0.005	856.6	9000	0.0	2.0	6.6	14.0
26990	17.7	17.7	23.5	11.2	2.0	8.1	0	0.0	1	0.0	0	0.0	0	6.0	0.010	1008.2	9000	0.0	2.0	5.6	14.0
26780	17.9	17.9	23.9	11.0	2.0	8.4	0	0.0	1	0.0	0	0.0	0	5.6	0.010	1131.7	9000	0.0	2.0	5.5	14.0
26575	16.2	16.2	21.0	11.0	2.0	6.7	0	0.0	1	0.0	0	0.0	0	5.5	0.013	1216.4	3000	0.0	2.0	5.5	14.0
26355	12.5	11.6	15.8	13.4	2.0	4.2	0	0.0	1	0.0	0	0.0	0	7.5	0.003	1282.4	3000	0.0	2.0	3.4	12.5
26170	13.6	13.6	18.0	13.0	2.0	5.2	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1347.9	3000	0.0	2.0	4.4	12.5
25965	13.5	13.5	17.9	13.0	2.0	5.2	0	0.0	1	0.0	0	0.0	0	7.0	0.004	1288.3	3000	0.0	2.0	4.3	12.5

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25785	15.1	15.1	19.5	11.7	2.0	6.0	0	0.0	1	0.0	0	0.0	0	6.2	0.005	1336.9	3000	0.0	2.0	5.2	14.0
25600	16.1	16.1	20.6	11.3	2.0	6.5	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1596.5	3000	0.0	2.0	5.6	14.0
25425	15.6	15.6	20.0	11.3	2.0	6.2	0	0.0	1	0.0	0	0.0	0	4.4	0.008	1773.8	3000	0.0	2.0	5.4	14.0
25215	10.5	10.5	14.5	13.6	2.0	3.7	0	0.0	1	0.0	0	0.0	0	6.1	0.003	1748.6	3000	0.0	2.0	2.8	10.0
25000	13.0	13.0	17.4	12.2	2.0	5.0	0	0.0	1	0.0	0	0.0	0	4.4	0.006	2103.2	3000	0.0	2.0	4.1	12.5
24795	14.5	14.5	19.0	11.4	2.0	5.7	0	0.0	1	0.0	0	0.0	0	3.9	0.007	2311.7	3000	0.0	2.0	4.9	14.0
24550	16.3	16.3	21.3	10.8	2.0	6.9	0	0.0	1	0.0	0	0.0	0	3.8	0.009	2227.0	3000	0.0	2.0	5.4	14.0
24335	10.5	10.5	14.5	13.1	2.0	3.7	0	0.0	1	0.0	0	0.0	0	5.7	0.003	2089.5	3000	0.0	2.0	2.8	10.0
24115	14.4	14.4	18.8	11.1	2.0	5.6	0	0.0	1	0.0	0	0.0	0	4.5	0.008	2015.8	3000	0.0	2.0	4.8	14.0
23975	14.6	14.6	19.0	10.2	2.0	5.7	0	0.0	1	0.0	0	0.0	0	4.6	0.008	1913.7	3000	0.0	2.0	4.9	14.0
23755	12.5	12.4	16.7	10.9	2.0	4.6	0	0.0	1	0.0	0	0.0	0	5.1	0.006	1935.4	3000	0.0	2.0	3.8	12.5
23565	10.5	10.5	14.5	12.7	2.0	3.7	0	0.0	1	0.0	0	0.0	0	5.6	0.004	2039.5	3000	0.0	2.0	2.8	10.0
23365	12.7	12.7	17.0	10.8	2.0	4.8	0	0.0	1	0.0	0	0.0	0	5.4	0.006	1781.4	3000	0.0	2.0	3.9	12.5
23180	10.0	9.5	13.2	11.8	2.0	3.2	0	0.0	1	0.0	0	0.0	0	6.6	0.002	2084.2	3000	0.0	2.0	2.3	10.0
23000	8.0	6.8	8.9	13.0	2.0	1.7	0	0.0	1	0.0	0	0.0	0	7.7	0.001	2069.1	3000	0.0	2.0	1.1	8.0
22790	8.0	7.1	9.4	13.1	2.0	1.9	0	0.0	1	0.0	0	0.0	0	7.8	0.001	1949.0	3000	0.0	2.0	1.2	8.0
22600	10.0	8.3	11.4	14.1	2.0	2.5	0	0.0	1	0.0	0	0.0	0	7.9	0.001	1865.2	3000	0.0	2.0	1.7	10.0
22415	10.0	8.5	11.8	14.1	2.0	2.7	0	0.0	1	0.0	0	0.0	0	8.1	0.002	1705.6	3000	0.0	2.0	1.9	10.0
22195	10.2	10.2	14.1	13.7	2.0	3.5	0	0.0	1	0.0	0	0.0	0	7.8	0.003	1322.2	3000	0.0	2.0	2.7	10.0
22010	12.5	11.8	16.0	14.4	2.0	4.3	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1328.0	3000	0.0	2.0	3.5	12.5
21790	15.3	15.3	19.7	11.6	2.0	6.0	0	0.0	1	0.0	0	0.0	0	6.5	0.006	1145.7	3000	0.0	2.0	5.2	14.0
21615	15.2	15.2	21.4	8.5	2.0	6.9	0	0.0	1	0.0	0	0.0	0	5.8	0.010	1161.3	3000	0.0	2.0	4.3	14.0
21440	15.1	15.1	20.1	9.7	2.0	6.3	0	0.0	1	0.0	0	0.0	0	5.0	0.008	1574.6	3000	0.0	2.0	4.8	14.0
21225	15.0	15.0	19.5	10.6	2.0	5.9	0	0.0	1	0.0	0	0.0	0	3.9	0.008	2217.7	3000	0.0	2.0	5.1	14.0
21020	15.1	15.1	20.8	8.9	2.0	6.6	0	0.0	1	0.0	0	0.0	0	4.6	0.009	1676.4	3000	0.0	2.0	4.4	14.0
20845	12.7	12.7	17.1	10.4	2.0	4.8	0	0.0	1	0.0	0	0.0	0	4.2	0.006	2369.3	3000	0.0	2.0	3.9	12.5
20595	12.5	11.1	15.2	10.9	2.0	4.0	0	0.0	1	0.0	0	0.0	0	4.7	0.003	2463.7	3000	0.0	2.0	3.1	12.5
20435	10.0	9.3	12.9	12.2	2.0	3.1	0	0.0	1	0.0	0	0.0	0	5.4	0.002	2582.7	3000	0.0	2.0	2.3	10.0
20280	10.1	10.1	14.0	11.8	2.0	3.5	0	0.0	1	0.0	0	0.0	0	5.0	0.003	2589.6	3000	0.0	2.0	2.6	10.0
20070	14.9	14.9	20.2	9.2	2.0	6.3	0	0.0	1	0.0	0	0.0	0	4.7	0.009	1767.5	3000	0.0	2.0	4.6	14.0
19855	13.4	13.4	17.8	9.9	2.0	5.1	0	0.0	1	0.0	0	0.0	0	4.8	0.006	1975.1	3000	0.0	2.0	4.3	12.5
19630	13.5	13.5	17.9	8.9	2.0	5.2	0	0.0	1	0.0	0	0.0	0	4.9	0.006	1836.2	3000	0.0	2.0	4.3	12.5
19440	10.0	8.7	11.9	12.1	2.0	2.7	0	0.0	1	0.0	0	0.0	0	6.5	0.002	2095.3	3000	0.0	2.0	1.9	10.0
19240	10.1	10.1	13.9	11.4	2.0	3.5	0	0.0	1	0.0	0	0.0	0	5.6	0.003	2091.7	3000	0.0	2.0	2.6	10.0
19050	10.0	8.0	11.0	12.9	2.0	2.4	0	0.0	1	0.0	0	0.0	0	6.7	0.002	2160.8	3000	0.0	2.0	1.6	10.0
18830	10.0	7.8	10.7	14.6	2.0	2.3	0	0.0	1	0.0	0	0.0	0	7.1	0.002	2094.4	3000	0.0	2.0	1.5	10.0
18650	8.0	7.4	9.9	15.0	2.0	2.1	0	0.0	1	0.0	0	0.0	0	8.0	0.001	2022.7	3000	0.0	2.0	1.3	8.0
18475	8.0	6.4	8.1	16.6	2.0	1.5	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1944.4	3000	0.0	2.0	0.9	8.0
18290	8.0	6.7	8.7	16.8	2.0	1.7	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1843.7	3000	0.0	2.0	1.0	8.0
18025	8.0	6.3	7.8	18.2	2.0	1.5	0	0.0	1	0.0	0	0.0	0	11.5	0.001	1610.9	17000	0.0	2.0	0.8	8.0
17785	8.0	6.7	8.7	19.8	2.0	1.7	0	0.0	1	0.0	0	0.0	0	11.6	0.001	1417.5	17000	0.0	2.0	1.0	8.0
17510	10.1	10.1	14.0	18.0	2.0	3.5	0	0.0	1	0.0	0	0.0	0	8.5	0.002	1243.6	17000	0.0	2.0	2.6	10.0
17360	12.7	12.7	17.0	16.9	2.0	4.8	0	0.0	1	0.0	0	0.0	0	8.9	0.004	936.6	17000	0.0	2.0	3.9	12.5
17110	17.5	17.5	21.7	15.4	2.0	7.1	0	0.0	1	0.0	0	0.0	0	5.6	0.006	1274.3	17000	0.0	2.0	6.4	14.0
16970	18.6	18.6	22.9	13.6	2.0	7.8	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1125.6	17000	0.0	2.0	6.8	14.0
16720	17.6	17.6	25.2	9.0	2.0	9.1	0	0.0	1	0.0	0	0.0	0	4.1	0.018	1404.6	17000	0.0	2.0	4.5	14.0
16515	15.7	15.7	21.5	9.5	2.0	7.0	0	0.0	1	0.0	0	0.0	0	4.3	0.012	1622.6	17000	0.0	2.0	4.8	14.0
16305	15.8	15.8	21.5	9.6	2.0	7.0	0	0.0	1	0.0	0	0.0	0	4.2	0.011	1812.8	17000	0.0	2.0	4.8	14.0
16130	12.5	11.8	16.1	10.2	2.0	4.3	0	0.0	1	0.0	0	0.0	0	5.2	0.005	1945.1	17000	0.0	2.0	3.5	12.5
15960	12.5	11.6	15.8	9.3	2.0	4.2	0	0.0	1	0.0	0	0.0	0	4.1	0.011	2180.9	17000	0.0	2.0	3.4	12.5
15745	10.0	8.0	10.9	10.6	2.0	2.4	0	0.0	1	0.0	0	0.0	0	5.7	0.003	2279.0	17000	0.0	2.0	1.6	10.0
15540	10.0	8.1	11.0	10.6	2.0	2.4	0	0.0	1	0.0	0	0.0	0	5.8	0.003	2324.2	17000	0.0	2.0	1.6	10.0
15335	10.0	9.2	12.7	10.5	2.0	3.0	0	0.0	1	0.0	0	0.0	0	4.9	0.005	2302.1	17000	0.0	2.0	2.2	10.0
15125	12.5	11.9	16.2	9.6	2.0	4.4	0	0.0	1	0.0	0	0.0	0	5.5	0.007	1618.5	17000	0.0	2.0	3.5	12.5
14900	10.6	10.6	14.5	10.4	2.0	3.7	0	0.0	1	0.0	0	0.0	0	6.1	0.004	1704.5	17000	0.0	2.0	2.9	10.0
14720	12.5	12.5	16.8	9.3	2.0	4.7	0	0.0	1	0.0	0	0.0	0	5.1	0.008	1763.5	17000	0.0	2.0	3.8	12.5
14480	10.3	10.3	14.3	10.2	2.0	3.6	0	0.0	1	0.0	0	0.0	0	6.0	0.004	1801.7	17000	0.0	2.0	2.7	10.0
14315	10.8	10.8	14.8	9.4	2.0	3.8	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1868.1	17000	0.0	2.0	3.0	10.0
14090	10.0	9.9	13.8	9.0	2.0	3.4	0	0.0	1	0.0	0	0.0	0	5.9	0.005	1766.8	17000	0.0	2.0	2.6	10.0
13850	12.5	11.4	15.6	8.4	2.0	4.2	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1727.3	17000	0.0	2.0	3.3	12.5
13635	12.5	11.3	15.4	10.3	2.0	4.1	0	0.0	1	0.0	0	0.0	0	6.4	0.004	1691.9	17000	0.0	2.0	3.2	12.5
13425	12.9	12.9	17.3	8.3	2.0	4.9	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1854.4	17000	0.0	2.0	4.0	12.5
13190	10.0	8.8	12.2	9.5	2.0	2.8	0	0.0	1	0.0	0	0.0	0	6.4	0.003	1847.3	17000	0.0	2.0	2.0	10.0
13030	10.3	10.3	14.2	9.6	2.0	3.6	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1763.0	17000	0.0	2.0	2.7	10.0
12835	10.0	9.6	13.3	10.1	2.0	3.2	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	9.0	12.4	10.9	2.0	2.9	0	0.0	1	0.0	0	0.0	0	8.7	0.002	1471.0	17000	0.0	2.0	2.1	10.0
12395	10.0	8.9	12.3	11.5	2.0	2.9	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1438.4	17000	0.0	2.0	2.0	10.0
12195	10.0	7.8	10.6	12.5	2.0	2.3	0	0.0	1	0.0	0	0.0	0	10.3	0.001	1389.3	17000	0.0	2.0	1.5	10.0
11995	10.0	9.2	12.7	13.7	2.0	3.0	0	0.0	1	0.0	0	0.0	0	9.8	0.002	1281.1	17000	0.0	2.0	2.2	10.0
11780	10.0	9.0	12.5	14.4	2.0	2.9	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1400.9	17000	0.0	2.0	2.1	10.0
11605	10.2	10.2	14.1	13.7	2.0	3.5	0	0.0	1	0.0	0	0.0	0	8.7	0.002	1282.9	17000	0.0	2.0	2.7	10.0
11405	10.0	9.5	13.2	15.1	2.0	3.2	0	0.0	1	0.0	0	0.0	0	10.1	0.002	1130.2	17000	0.0	2.0	2.3	10.0
11180	12.5	12.3	16.6	13.9	2.0	4.6	0	0.0	1	0.0	0	0.0	0	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.7	14.7	19.1	13.3	2.0	5.7	0	0.0	1	0.0	0	0.0	0	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	16.7	16.7	21.9	10.9	2.0	7.2	0	0.0	1	0.0	0	0.0	0	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	16.2	16.2	24.1	7.5	2.0	8.5	0	0.0	1	0.0	0	0.0	0	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	16.1	16.1	22.7	8.8	2.0	7.7	0	0.0	1	0.0	0	0.0	0	5.8	0.008	1247.1	17000	0.0	2.0	4.4	14.0
10225	13.4	13.4	17.8	9.5	2.0	5.1	0	0.0	1	0.0	0	0.0	0	5.9	0.007	1373.8	17000	0.0	2.0	4.3	12.5
10000	10.9	10.9	14.9	11.1	2.0	3.9	0	0.0	1	0.0	0	0.0	0	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.2	14.2	18.6	10.0	2.0	5.5	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1336.6	17000	0.0	2.0	4.7	14.0
9595	10.6	10.6	14.6	10.3	2.0	3.7	0	0.0	1	0.0	0	0.0	0	6.6	0.005	1619.7	17000	0.0	2.0	2.9	10.0
9385	12.5	11.6	15.8	9.5	2.0	4.2	0	0.0	1	0.0	0	0.0	0	5.3	0.006	1770.4	17000	0.0	2.0	3.4	12.5
9220	12.5	12.1	16.4	8.9	2.0	4.5	0	0.0	1	0.0	0	0.0	0	4.9	0.008	1771.4	17000	0.0	2.0	3.6	12.5
9025	12.5	11.7	15.9	8.9	2.0	4.3	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1736.9	17000	0.0	2.0	3.4	12.5
MAX=	27.2	27.2			8.1	12.1						0.0					17000.0	0.0	2.0	8.3	14.0
MIN=	8.0	5.5			2.0	1.0						0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM -- SANTA CLARA RIVER PROPOSED CONDITIONS OUTSIDE CURVED REACH C_{-AB} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG} +	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	18.2	18.2	21.7	18.1	2.8	7.1	0	0.0	1	0.0	0	0.0	1	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	21.2	21.2	24.1	18.1	2.8	8.5	0	0.0	1	0.0	0	0.0	1	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	16.8	16.8	20.3	19.2	2.8	6.4	0	0.0	1	0.0	0	0.0	1	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	22.8	22.8	26.1	16.5	2.8	9.7	0	0.0	1	0.0	0	0.0	1	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	15.5	15.5	19.2	21.1	2.8	5.8	0	0.0	1	0.0	0	0.0	1	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	22.2	22.2	26.2	15.4	2.8	9.7	0	0.0	1	0.0	0	0.0	1	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	21.6	21.6	19.9	19.5	8.1	6.2	0	0.0	1	0.0	0	0.0	1	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	27.1	27.1	26.7	13.8	8.1	10.1	0	0.0	1	0.0	0	0.0	1	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	27.2	27.2	28.8	11.3	8.1	11.5	0	0.0	1	0.0	0	0.0	1	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	26.0	26.0	26.1	12.4	8.1	9.7	0	0.0	1	0.0	0	0.0	1	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	25.6	25.6	26.6	10.8	8.1	10.0	0	0.0	1	0.0	0	0.0	1	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	23.8	23.8	23.9	10.7	8.1	8.4	0	0.0	1	0.0	0	0.0	1	5.6	0.016	864.3	9000	0.0	2.0	5.4	14.0
42590	22.6	22.6	22.4	9.2	8.1	7.5	0	0.0	1	0.0	0	0.0	1	5.2	0.014	1013.1	9000	0.4	2.0	4.6	21.0
42430	21.4	21.4	19.6	10.7	8.1	6.0	0	0.0	1	0.0	0	0.0	1	6.4	0.009	915.8	9000	0.1	2.0	5.2	21.0
42215	21.0	20.6	18.5	11.2	8.1	5.5	0	0.0	1	0.0	0	0.0	1	6.1	0.009	1019.0	9000	0.5	2.0	4.6	21.0
41940	16.0	16.0	11.6	14.3	8.1	2.6	0	0.0	1	0.0	0	0.0	1	7.7	0.002	1284.2	9000	1.4	2.0	1.8	15.0
41730	15.8	15.8	11.8	14.7	8.1	2.7	0	0.0	1	0.0	0	0.0	1	8.2	0.002	1190.9	9000	1.2	2.0	1.9	15.0
41460	15.4	15.4	11.6	16.2	8.1	2.6	0	0.0	1	0.0	0	0.0	1	9.1	0.002	1093.5	9000	0.9	2.0	1.8	15.0
41280	15.3	15.3	16.4	14.4	5.2	4.5	0	0.0	1	0.0	0	0.0	1	8.3	0.004	852.3	9000	0.0	2.0	3.6	12.5
41080	18.7	18.7	19.9	12.1	5.2	6.2	0	0.0	1	0.0	0	0.0	1	6.7	0.008	874.1	9000	0.0	2.0	5.4	14.0
40825	21.0	17.4	18.0	11.5	5.2	5.2	0	0.0	1	0.0	0	0.0	1	6.2	0.007	1040.4	9000	0.5	2.0	4.4	21.0
40585	18.0	16.3	17.0	11.7	5.2	4.8	0	0.0	1	0.0	0	0.0	1	6.8	0.006	1005.8	9000	0.4	2.0	3.9	18.0
40335	15.0	12.3	10.5	15.1	5.2	2.3	0	0.0	1	0.0	0	0.0	1	8.8	0.002	1249.6	9000	1.4	2.0	1.5	15.0
40130	15.0	12.7	11.3	15.5	5.2	2.5	0	0.0	1	0.0	0	0.0	1	8.8	0.002	1195.6	9000	1.3	2.0	1.7	15.0
39945	15.0	12.5	11.0	16.3	5.2	2.4	0	0.0	1	0.0	0	0.0	1	9.3	0.002	1173.3	9000	1.3	2.0	1.6	15.0
39755	15.4	15.4	16.5	13.3	5.2	4.5	0	0.0	1	0.0	0	0.0	1	8.1	0.004	894.5	9000	0.0	2.0	3.7	12.5
39605	18.5	18.5	19.7	11.5	5.2	6.1	0	0.0	1	0.0	0	0.0	1	7.1	0.007	849.7	9000	0.0	2.0	5.2	14.0
39310	18.0	15.6	16.5	12.7	5.2	4.6	0	0.0	1	0.0	0	0.0	1	8.1	0.004	931.1	9000	0.2	2.0	3.7	18.0
39100	19.1	19.1	20.9	10.4	5.2	6.7	0	0.0	1	0.0	0	0.0	1	7.2	0.009	761.1	9000	0.0	2.0	5.2	14.0
38925	12.5	12.5	12.8	14.3	5.2	3.0	0	0.0	1	0.0	0	0.0	1	10.3	0.002	873.5	9000	0.0	2.0	2.2	10.0
38710	10.0	9.4	12.0	15.6	2.7	2.8	0	0.0	1	0.0	0	0.0	1	11.7	0.002	820.3	9000	0.0	2.0	2.0	10.0
38475	14.2	14.2	17.9	14.0	2.7	5.2	0	0.0	1	0.0	0	0.0	1	9.8	0.004	659.7	9000	0.0	2.0	4.3	12.5
38300	17.4	17.4	22.5	10.3	2.7	7.6	0	0.0	1	0.0	0	0.0	1	7.7	0.010	666.3	9000	0.0	2.0	5.1	14.0
38065	11.3	11.3	14.5	14.0	2.7	3.7	0	0.0	1	0.0	0	0.0	1	12.0	0.002	658.4	9000	0.0	2.0	2.9	10.0
37810	14.5	14.5	18.2	12.2	2.7	5.3	0	0.0	1	0.0	0	0.0	1	10.2	0.004	618.2	9000	0.0	2.0	4.5	14.0
37655	16.6	16.6	20.9	10.5	2.7	6.7	0	0.0	1	0.0	0	0.0	1	7.8	0.008	706.7	9000	0.0	2.0	5.3	14.0
37390	16.2	16.2	23.7	6.5	2.7	8.3	0	0.0	1	0.0	0	0.0	1	5.9	0.015	823.8	9000	0.0	2.0	3.3	14.0
37135	13.0	13.0	16.6	9.3	2.7	4.6	0	0.0	1	0.0	0	0.0	1	8.5	0.005	821.4	9000	0.0	2.0	3.7	12.5
36930	14.8	14.8	19.8	8.1	2.7	6.1	0	0.0	1	0.0	0	0.0	1	7.2	0.008	812.4	9000	0.0	2.0	4.1	14.0
36735	12.6	12.6	16.1	9.8	2.7	4.4	0	0.0	1	0.0	0	0.0	1	8.0	0.005	896.9	9000	0.0	2.0	3.5	12.5
36515	15.0	10.4	12.9	12.0	2.7	3.1	0	0.0	1	0.0	0	0.0	1	9.0	0.002	994.7	9000	0.4	2.0	2.2	15.0
36265	15.0	10.5	12.3	12.5	2.7	2.9	0	0.0	1	0.0	0	0.0	1	7.9	0.003	1176.0	9000	0.9	2.0	2.1	15.0
36080	26.0	26.0	14.7	11.6	3.2	3.8	0.9	2.0	1	0.0	0	13.3	1	6.7	0.006	1176.0	9000	0.9	2.0	2.9	15.0
35845	15.0	10.9	11.0	13.6	3.2	2.4	0	0.0	1	0.0	0	0.0	1	7.9	0.002	1401.7	9000	1.7	2.0	1.6	15.0
35725	15.0	13.9	15.0	13.0	3.2	3.9	0	0.0	1	0.0	0	0.0	1	6.5	0.004	1377.9	9000	1.8	2.0	3.0	15.0
35515	18.0	15.6	17.1	12.0	3.2	4.8	0	0.0	1	0.0	0	0.0	1	6.0	0.005	1354.8	9000	1.7	2.0	3.9	18.0
35245	18.0	15.6	17.3	11.3	3.2	4.9	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1328.3	9000	1.5	2.0	4.0	18.0
35040	21.0	18.0	19.6	10.7	3.2	6.0	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1354.8	9000	1.7	2.0	5.2	21.0
34860	21.0	16.3	18.4	10.0	3.2	5.4	0	0.0	1	0.0	0	0.0	1	4.9	0.009	1285.7	9000	1.2	2.0	4.6	21.0
34720	21.0	16.5	18.4	9.2	3.2	5.4	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1411.2	9000	1.4	2.0	4.6	21.0
34495	18.0	15.2	17.4	9.0	3.2	5.0	0	0.0	1	0.0	0	0.0	1	5.2	0.009	1283.9	9000	1.0	2.0	4.1	18.0
34310	18.0	14.8	16.8	9.3	3.2	4.7	0	0.0	1	0.0	0	0.0	1	5.9	0.005	1308.5	9000	1.2	2.0	3.8	18.0
34090	18.0	14.8	17.0	8.6	3.2	4.8	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1295.5	9000	1.0	2.0	3.9	18.0
33880	18.0	14.8	16.6	9.3	3.4	4.6	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1318.4	9000	1.2	2.0	3.7	18.0
33710	18.0	13.9	15.4	9.7	3.4	4.1	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1372.1	9000	1.3	2.0	3.2	18.0
33500	18.0	14.8	16.2	9.3	3.4	4.4	0	0.0	1	0.0	0	0.0	1	5.1	0.007	1496.0	9000	1.5	2.0	3.5	18.0
33310	18.0	15.1	15.8	9.0	3.4	4.2	0	0.0	1	0.0	0	0.0	1	4.2	0.006	1770.4	9000	2.1	2.0	3.4	18.0
33115	15.0	11.2	10.4	10.6	3.4	2.2	0	0.0	1	0.0	0	0.0	1	6.1	0.003	1847.3	9000	2.1	2.0	1.4	15.0
32795	15.0	13.0	13.0	10.6	3.4	3.1	0	0.0	1	0.0	0	0.0	1	5.2	0.004	1735.6	9000	2.3	2.0	2.3	15.0
32605	15.0	14.2	14.4	11.1	3.4	3.6	0	0.0	1	0.0	0	0.0	1	5.0	0.005	1699.9	9000	2.3	2.0	2.8	15.0
32265	18.0	14.2	15.9	10.5	2.0	4.3	0	0.0	1	0.0	0	0.0	1	4.8	0.006	1853.2	9000	2.5	2.0	3.4	18.0
31875	15.0	12.0	12.4	10.4	2.0	2.9	0	0.0	1	0.0	0	0.0	1	4.7	0.006	2409.2	9000	3.0	2.0	2.1	15.0
31585	15.0	11.0	10.9	11.9	2.0	2.4	0	0.0	1	0.0	0	0.0	1	5.9	0.003	2182.2	9000	3.0	2.0	1.6	15.0
31360	15.0	10.4	10.3	13.5	2.0	2.2	0	0.0	1	0.0	0	0.0	1	7.4	0.002	1878.7	9000	2.8	2.0	1.4	15.0
31060	12.0	9.1	8.2	15.5	2.0	1.6	0	0.0	1	0.0	0	0.0	1	10.1	0.001	1708.2	9000	2.6	2.0	0.9	12.0
30720	12.0	9.1	6.7	17.5	2.0	1.2	0	0.0	1	0.0	0	0.0	1	11.2	0.001	1888.6	9000	3.3	2.0	0.6	12.0
30445	12.0	8.9	6.3	19.5	2.0	1.1	0	0.0	1	0.0	0	0.0	1	12.7	0.000	1779.7	9000	3.3	2.0	0.5	12.0
30095	12.0	9.2	6.7	21.3	2.0	1.2	0	0.0	1	0.0	0	0.0	1	13.4	0.000	1622.7	9000	3.5	2.0	0.6	12.0
29815	12.0	9.1	7.7	21.9	2.0	1.4	0	0.0	1	0.0	0	0.0	1	13.5	0.000	1433.2	9000	2.9	2.0	0.8	12.0
29565	12.0	8.4	7.4	22.9	2.0	1.3	0	0.0	1	0.0	0	0.0	1	14.8	0.000	1323.8	9000	2.4	2.0	0.7	12.0
29385	12.0	8.6	8.3	23.6	2.0	1.6	0	0.0	1	0.0	0	0.0	1	14.4	0.000	1237.4	9000	2.1	2.0	0.9	12.0
29140	12.0	10.6	9.2	24.1	4.4	1.8	0	0.0	1	0.0	0	0.0	1	14.1	0.001	1087.2	9000	1.2	2.0	1.1	12.0
28895	21.0	17.5	18.8	22.5	4.4	5.6	0	0.0	1	0.0	0	0.0	1	9.9	0.002	972.1	9000	0.8	2.0	4.8	21.0
28695	24.9	24.9	28.9	14.0	4.4	11.5	0	0.0	1	0.0	0	0.0	1	5.4	0.025	899.4	9000	0.0	2.0	7.0	14.0
28500	20.6	20.6	22.4	16.1	4.4	7.5	0	0.0	1	0.0	0	0.0	1	11.4	0.006	552.2	9000	0.0	2.0	6.8	14.0
28280	24.1	24.1	29.6	10.8	4.4	12.0	0	0.0	1	0.0	0	0.0	1	5.8	0.013	944.5	9000	0.3	2.0	5.4	21.0
28080	15.0	10.8	11.3	19.1	4.4	2.5	0	0.0	1	0.0	0	0.0	1	14.7	0.001	926.4	9000	0.2	2.0	1.7	15.0
27925	11.8	11.8	13.1	19.3	4.4	3.1	0	0.0	1	0.0	0	0.0	1	13.8	0.001	866.6	9000	0.0	2.0	2.3	10.0
27725	17.0	17.0	19.0	16.7	4.4	5.7	0	0.0	1	0.0	0	0.0	1	10.4	0.003	786.6	9000	0.0	2.0	4.9	14.0
27545	21.2	21.2	22.9	14.1	4.4	7.8	0	0.0	1	0.0	0	0.0	1	9.9	0.005	643.2	9000	0.0	2.0	7.0	14.0
27335	21.3	21.3	24.6	12.3	4.4	8.7	0	0.0	1	0.0	0	0.0	1	8.3	0.008	703.5	9000	0.0	2.0	6.2	14.0
27155	17.0	17.0	19.1	14.8	4.4	5.7	0	0.0	1	0.0	0	0.0	1	9.2	0.003	888.4	9000	0.0	2.0	4.9	14.0
26990	21.0	17.5	22.6	11.5	2.0	7.6	0	0.0	1	0.0	0	0.0	1	6.8	0.011	922.3	9000	0.1	2.0	5.7	21.0
26780	21.0	18.2	23.1	11.3	2.0	7.9	0	0.0	1	0.0	0	0.0	1	6.2	0.009	1043.3	9000	0.6	2.0	5.6	21.0
26575	21.3	21.3	20.7	11.1	2.0	6.6	0	0.0	1	0.0	0	0.0	1	5.7	0.012	1187.3	3000	5.2	2.0	5.6	21.0
26355	18.3	18.3	15.9	13.4	2.0	4.3	0	0.0	1	0.0	0	0.0	1	7.5	0.004	1260.4	3000	6.7	2.0	3.4	18.0
26170	20.1	20.1	17.0	13.5	2.0	4.8	0	0.0	1	0.0	0	0.0	1	7.6	0.003	1269.0	3000	7.4	2.0	3.9	18.0
25965	21.1	21.1	18.2	12.9	2.0	5.3	0	0.0	1	0.0	0	0.0	1	6.9	0.004	1281.3	3000	7.3	2.0	4.5	21.0
25785	21.0	21.0	18.9	12.1	2.0	5.7	0	0.0	1	0.0	0	0.0	1	6.9	0.005	1219.7	3000	6.5	2.0	4.8	21.0
25600	21.0	20.1	18.5	12.4	2.0	5.5	0	0.0	1	0.0	0	0.0	1	7.6	0.005	1109.4	3000	6.0	2.0	4.6	21.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{RS}+	Z_t+	H/2	Z_{DM}=
25425	21.0	19.2	18.3	12.5	2.0	5.4	0	0.0	1	0.0	0	0.0	1	7.1	0.007	1082.2	3000	5.3	2.0	4.5	21.0
25215	16.3	16.3	14.3	14.7	2.0	3.6	0	0.0	1	0.0	0	0.0	1	9.0	0.003	1097.3	3000	6.0	2.0	2.7	15.0
25000	15.5	15.5	13.2	15.5	2.0	3.2	0	0.0	1	0.0	0	0.0	1	10.1	0.002	1062.4	3000	6.0	2.0	2.3	15.0
24795	15.8	15.8	14.1	15.6	2.0	3.5	0	0.0	1	0.0	0	0.0	1	10.5	0.002	957.4	3000	5.6	2.0	2.7	15.0
24550	18.0	16.4	15.1	16.5	2.0	3.9	0	0.0	1	0.0	0	0.0	1	11.0	0.003	856.1	3000	5.4	2.0	3.1	18.0
24335	21.0	18.3	18.2	15.0	2.0	5.3	0	0.0	1	0.0	0	0.0	1	10.1	0.004	764.8	3000	4.5	2.0	4.5	21.0
24115	21.0	19.7	20.0	13.8	2.0	6.2	0	0.0	1	0.0	0	0.0	1	9.4	0.006	754.2	3000	4.1	2.0	5.4	21.0
23975	21.0	20.5	20.8	12.9	2.0	6.6	0	0.0	1	0.0	0	0.0	1	8.7	0.007	783.2	3000	4.1	2.0	5.8	21.0
23755	21.0	18.5	18.1	14.7	2.0	5.3	0	0.0	1	0.0	0	0.0	1	9.7	0.004	815.7	3000	4.8	2.0	4.4	21.0
23565	21.0	20.8	20.2	14.3	2.0	6.3	0	0.0	1	0.0	0	0.0	1	8.2	0.007	850.9	3000	4.9	2.0	5.5	21.0
23365	21.0	19.7	18.4	14.3	2.0	5.4	0	0.0	1	0.0	0	0.0	1	8.7	0.004	939.0	3000	5.7	2.0	4.6	21.0
23180	23.0	23.0	21.9	12.6	2.0	7.2	0	0.0	1	0.0	0	0.0	1	8.0	0.005	916.6	3000	5.5	2.0	6.3	21.0
23000	21.0	20.3	22.0	11.3	2.0	7.3	0	0.0	1	0.0	0	0.0	1	8.2	0.010	784.0	3000	3.4	2.0	5.6	21.0
22790	31.9	31.9	17.9	13.0	2.0	5.2	0.9	2.0	1	0.0	0	14.7	1	10.0	0.005	784.0	3000	3.7	2.0	4.3	18.0
22600	21.0	20.9	19.8	12.8	2.0	6.1	0	0.0	1	0.0	0	0.0	1	7.6	0.006	999.0	3000	5.5	2.0	5.3	21.0
22415	21.0	20.9	21.3	10.8	2.0	6.9	0	0.0	1	0.0	0	0.0	1	6.6	0.010	1039.1	3000	4.6	2.0	5.4	21.0
22195	16.5	16.5	13.6	14.0	2.0	3.4	0	0.0	1	0.0	0	0.0	1	8.7	0.003	1309.6	3000	6.6	2.0	2.5	15.0
22010	19.5	19.5	16.1	14.3	2.0	4.4	0	0.0	1	0.0	0	0.0	1	7.6	0.003	1254.1	3000	7.6	2.0	3.5	18.0
21790	21.2	21.2	19.7	11.6	2.0	6.1	0	0.0	1	0.0	0	0.0	1	6.5	0.006	1144.5	3000	5.9	2.0	5.2	21.0
21615	21.0	19.2	21.3	8.5	2.0	6.9	0	0.0	1	0.0	0	0.0	1	5.8	0.011	1163.0	3000	4.1	2.0	4.3	21.0
21440	18.9	18.9	17.5	11.0	2.0	5.0	0	0.0	1	0.0	0	0.0	1	6.9	0.005	1286.1	3000	5.8	2.0	4.1	18.0
21225	21.4	21.4	18.1	11.7	2.0	5.2	0	0.0	1	0.0	0	0.0	1	5.6	0.005	1559.0	3000	7.7	2.0	4.4	21.0
21020	21.0	18.8	20.3	9.7	2.0	6.3	0	0.0	1	0.0	0	0.0	1	7.8	0.007	903.0	3000	3.6	2.0	4.9	21.0
20845	18.9	18.9	15.1	12.7	2.0	3.9	0	0.0	1	0.0	0	0.0	1	6.7	0.003	1563.7	3000	7.9	2.0	3.1	18.0
20595	16.8	16.8	12.4	13.4	2.0	2.9	0	0.0	1	0.0	0	0.0	1	8.3	0.002	1548.8	3000	7.8	2.0	2.1	15.0
20435	17.0	17.0	12.1	14.3	2.0	2.8	0	0.0	1	0.0	0	0.0	1	8.8	0.001	1528.3	3000	8.3	2.0	2.0	15.0
20280	19.4	19.4	15.6	12.8	2.0	4.1	0	0.0	1	0.0	0	0.0	1	6.8	0.003	1531.3	3000	8.0	2.0	3.3	18.0
20070	22.5	22.5	19.3	11.1	2.0	5.9	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1526.6	3000	7.5	2.0	5.0	21.0
19855	21.0	21.0	20.6	10.2	2.0	6.5	0	0.0	1	0.0	0	0.0	1	6.0	0.008	1205.4	3000	5.4	2.0	5.1	21.0
19630	21.0	18.8	20.6	8.9	2.0	6.5	0	0.0	1	0.0	0	0.0	1	6.6	0.009	1060.3	3000	3.8	2.0	4.4	21.0
19440	15.4	15.4	13.1	13.4	2.0	3.2	0	0.0	1	0.0	0	0.0	1	9.2	0.002	1194.5	3000	5.9	2.0	2.3	15.0
19240	18.0	17.3	15.9	11.9	2.0	4.3	0	0.0	1	0.0	0	0.0	1	7.4	0.004	1216.9	3000	5.6	2.0	3.4	18.0
19050	21.0	19.8	18.8	10.5	2.0	5.6	0	0.0	1	0.0	0	0.0	1	5.8	0.009	1321.4	3000	5.4	2.0	4.8	21.0
18830	17.7	17.7	13.3	14.6	2.0	3.2	0	0.0	1	0.0	0	0.0	1	7.4	0.003	1531.5	3000	8.1	2.0	2.4	15.0
18650	17.5	17.5	12.1	15.0	2.0	2.8	0	0.0	1	0.0	0	0.0	1	8.0	0.002	1604.5	3000	8.8	2.0	2.0	15.0
18475	15.4	15.4	8.9	16.9	2.0	1.8	0	0.0	1	0.0	0	0.0	1	9.9	0.001	1621.5	3000	8.5	2.0	1.1	12.0
18290	16.2	16.2	9.8	16.9	2.0	2.0	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1594.2	3000	8.9	2.0	1.3	12.0
18025	8.0	6.3	7.9	18.5	2.0	1.5	0	0.0	1	0.0	0	0.0	1	11.9	0.001	1520.2	17000	0.0	2.0	0.8	8.0
17785	8.0	6.6	8.5	20.2	2.0	1.6	0	0.0	1	0.0	0	0.0	1	12.0	0.001	1398.1	17000	0.0	2.0	1.0	8.0
17510	10.0	8.0	11.0	19.2	2.0	2.4	0	0.0	1	0.0	0	0.0	1	10.2	0.001	1350.7	17000	0.0	2.0	1.6	10.0
17360	12.8	12.8	17.1	15.9	2.0	4.8	0	0.0	1	0.0	0	0.0	1	8.8	0.004	943.2	17000	0.0	2.0	3.9	12.5
17110	18.1	18.1	22.3	15.2	2.0	7.4	0	0.0	1	0.0	0	0.0	1	5.8	0.007	1175.4	17000	0.0	2.0	6.7	14.0
16970	18.6	18.6	23.1	13.6	2.0	7.9	0	0.0	1	0.0	0	0.0	1	5.9	0.010	1067.0	17000	0.0	2.0	6.8	14.0
16720	17.2	17.2	24.4	9.2	2.0	8.6	0	0.0	1	0.0	0	0.0	1	5.2	0.019	1122.9	17000	0.0	2.0	4.6	14.0
16515	15.0	15.0	19.4	10.4	2.0	5.9	0	0.0	1	0.0	0	0.0	1	5.8	0.010	1249.9	17000	0.0	2.0	5.1	14.0
16305	10.0	8.4	11.6	14.6	2.0	2.6	0	0.0	1	0.0	0	0.0	1	9.4	0.002	1360.5	17000	0.0	2.0	1.8	10.0
16130	12.5	11.5	15.7	12.3	2.0	4.2	0	0.0	1	0.0	0	0.0	1	7.1	0.005	1326.5	17000	0.0	2.0	3.3	12.5
15960	13.3	13.3	17.7	11.0	2.0	5.1	0	0.0	1	0.0	0	0.0	1	5.9	0.008	1386.0	17000	0.0	2.0	4.2	12.5
15745	10.0	8.9	12.3	13.3	2.0	2.9	0	0.0	1	0.0	0	0.0	1	8.4	0.003	1363.9	17000	0.0	2.0	2.0	10.0
15540	10.0	7.8	10.6	13.7	2.0	2.3	0	0.0	1	0.0	0	0.0	1	9.4	0.002	1426.6	17000	0.0	2.0	1.5	10.0
15335	12.5	12.0	16.2	12.1	2.0	4.4	0	0.0	1	0.0	0	0.0	1	8.2	0.006	1064.1	17000	0.0	2.0	3.5	12.5
15125	30.9	30.9	17.9	11.6	2.0	5.2	0.9	4.0	1	0.0	0	17.4	1	8.0	0.007	1000.5	17000	0.0	2.0	4.3	12.5
14900	14.7	14.7	19.3	9.8	2.0	5.8	0	0.0	1	0.0	0	0.0	1	6.3	0.009	1626.5	17000	0.0	2.0	4.9	14.0
14720	21.0	13.7	18.1	9.8	2.0	5.3	0	0.0	1	0.0	0	0.0	1	6.0	0.008	1722.3	17000	0.1	2.0	4.4	21.0
14480	21.0	14.2	19.0	8.9	2.0	5.7	0	0.0	1	0.0	0	0.0	1	5.2	0.010	1726.7	17000	0.1	2.0	4.4	21.0
14315	15.0	10.4	14.0	9.9	2.0	3.5	0	0.0	1	0.0	0	0.0	1	5.8	0.005	1881.0	17000	0.3	2.0	2.6	15.0
14090	15.0	10.5	14.3	8.5	2.0	3.6	0	0.0	1	0.0	0	0.0	1	5.6	0.006	1772.8	17000	0.1	2.0	2.8	15.0
13850	15.0	9.2	12.6	9.7	2.0	3.0	0	0.0	1	0.0	0	0.0	1	6.5	0.004	1741.6	17000	0.1	2.0	2.2	15.0
13635	18.0	11.4	15.5	10.3	2.0	4.1	0	0.0	1	0.0	0	0.0	1	6.3	0.004	1705.8	17000	0.1	2.0	3.2	18.0
13425	21.0	13.4	18.0	7.8	2.0	5.2	0	0.0	1	0.0	0	0.0	1	4.3	0.011	1850.7	17000	0.2	2.0	3.9	21.0
13190	15.0	9.1	12.2	9.5	2.0	2.8	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1847.4	17000	0.3	2.0	2.0	15.0
13030	15.0	10.4	14.2	9.6	2.0	3.6	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1763.0	17000	0.2	2.0	2.7	15.0
12835	10.0	9.6	13.3	10.1	2.0	3.2	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	9.0	12.5	10.9	2.0	2.9	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1470.8	17000	0.0	2.0	2.1	10.0
12395	10.0	8.9	12.3	11.5	2.0	2.9	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1438.1	17000	0.0	2.0	2.0	10.0
12195	10.0	7.8	10.6	12.5	2.0	2.3	0	0.0	1	0.0	0	0.0	1	10.3	0.001	1383.7	17000	0.0	2.0	1.5	10.0
11995	10.0	9.3	12.8	13.6	2.0	3.0	0	0.0	1	0.0	0	0.0	1	9.7	0.002	1280.5	17000	0.0	2.0	2.2	10.0
11780	10.0	9.1	12.6	14.4	2.0	3.0	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1422.2	17000	0.0	2.0	2.1	10.0
11605	10.1	10.1	13.9	13.8	2.0	3.5	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1325.5	17000	0.0	2.0	2.6	10.0
11405	10.0	9.5	13.2	15.1	2.0	3.2	0	0.0	1	0.0	0	0.0	1	10.3	0.002	1114.6	17000	0.0	2.0	2.3	10.0
11180	12.5	12.3	16.6	13.9	2.0	4.6	0	0.0	1	0.0	0	0.0	1	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.7	14.7	19.1	13.3	2.0	5.7	0	0.0	1	0.0	0	0.0	1	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	16.7	16.7	21.9	10.9	2.0	7.2	0	0.0	1	0.0	0	0.0	1	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	16.2	16.2	24.1	7.5	2.0	8.5	0	0.0	1	0.0	0	0.0	1	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	16.1	16.1	22.7	8.8	2.0	7.7	0	0.0	1	0.0	0	0.0	1	5.8	0.008	1247.0	17000	0.0	2.0	4.4	14.0
10225	13.4	13.4	17.8	9.5	2.0	5.1	0	0.0	1	0.0	0	0.0	1	5.9	0.007	1374.1	17000	0.0	2.0	4.3	12.5
10000	10.9	10.9	14.9	11.1	2.0	3.9	0	0.0	1	0.0	0	0.0	1	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.2	14.2	18.6	10.0	2.0	5.5	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1402.3	17000	0.0	2.0	4.7	14.0
9595	10.6	10.6	14.6	10.3	2.0	3.7	0	0.0	1	0.0	0	0.0	1	6.6	0.005	1619.5	17000	0.0	2.0	2.9	10.0
9385	18.0	11.7	15.8	9.5	2.0	4.2	0	0.0	1	0.0	0	0.0	1	5.3	0.006	1770.4	17000	0.2	2.0	3.4	18.0
9220	18.0	12.3	16.4	8.9	2.0	4.5	0	0.0	1	0.0	0	0.0	1	4.9	0.008	1771.4	17000	0.1	2.0	3.6	18.0
9025	18.0	11.8	15.9	8.9	2.0	4.3	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1736.9	17000	0.1	2.0	3.4	18.0
MAX=	31.9	31.9			8.1	12.0						17.4					17000.0	8.9	2.0	8.3	21.0
MIN=	8.0	6.3			2.0	1.1						0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM -- SANTA CLARA RIVER PROPOSED CONDITIONS STRAIGHT-INSIDE CURVED REACH,Q_{50} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	18.2	18.2	21.7	18.1	2.8	7.1	0	0.0	1	0.0	0	0.0	0	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	21.2	21.2	24.1	18.1	2.8	8.5	0	0.0	1	0.0	0	0.0	0	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	16.8	16.8	20.3	19.2	2.8	6.4	0	0.0	1	0.0	0	0.0	0	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	22.8	22.8	26.1	16.5	2.8	9.7	0	0.0	1	0.0	0	0.0	0	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	15.5	15.5	19.2	21.1	2.8	5.8	0	0.0	1	0.0	0	0.0	0	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	22.2	22.2	26.2	15.4	2.8	9.7	0	0.0	1	0.0	0	0.0	0	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	21.6	21.6	19.9	19.5	8.1	6.2	0	0.0	1	0.0	0	0.0	0	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	27.1	27.1	26.7	13.8	8.1	10.1	0	0.0	1	0.0	0	0.0	0	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	27.2	27.2	28.8	11.3	8.1	11.5	0	0.0	1	0.0	0	0.0	0	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	26.0	26.0	26.1	12.4	8.1	9.7	0	0.0	1	0.0	0	0.0	0	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	25.6	25.6	26.6	10.8	8.1	10.0	0	0.0	1	0.0	0	0.0	0	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	23.8	23.8	23.9	10.7	8.1	8.4	0	0.0	1	0.0	0	0.0	0	5.6	0.016	864.3	9000	0.0	2.0	5.4	14.0
42590	22.2	22.2	22.4	9.2	8.1	7.5	0	0.0	1	0.0	0	0.0	0	5.2	0.014	1013.1	9000	0.0	2.0	4.6	14.0
42430	21.3	21.3	19.6	10.7	8.1	6.0	0	0.0	1	0.0	0	0.0	0	6.4	0.009	915.8	9000	0.0	2.0	5.2	14.0
42215	20.2	20.2	18.5	11.2	8.1	5.5	0	0.0	1	0.0	0	0.0	0	6.1	0.009	1019.0	9000	0.0	2.0	4.6	14.0
41940	14.5	14.5	11.6	14.3	8.1	2.6	0	0.0	1	0.0	0	0.0	0	7.7	0.002	1284.2	9000	0.0	2.0	1.8	10.0
41730	14.7	14.7	11.8	14.7	8.1	2.7	0	0.0	1	0.0	0	0.0	0	8.2	0.002	1190.9	9000	0.0	2.0	1.9	10.0
41460	14.5	14.5	11.6	16.2	8.1	2.6	0	0.0	1	0.0	0	0.0	0	9.1	0.002	1093.5	9000	0.0	2.0	1.8	10.0
41280	15.3	15.3	16.4	14.4	5.2	4.5	0	0.0	1	0.0	0	0.0	0	8.3	0.004	852.3	9000	0.0	2.0	3.6	12.5
41080	18.7	18.7	19.9	12.1	5.2	6.2	0	0.0	1	0.0	0	0.0	0	6.7	0.008	874.1	9000	0.0	2.0	5.4	14.0
40825	16.8	16.8	18.0	11.5	5.2	5.2	0	0.0	1	0.0	0	0.0	0	6.2	0.007	1040.4	9000	0.0	2.0	4.4	14.0
40585	15.8	15.8	17.0	11.7	5.2	4.8	0	0.0	1	0.0	0	0.0	0	6.8	0.006	1005.8	9000	0.0	2.0	3.9	12.5
40335	11.0	11.0	10.5	15.1	5.2	2.3	0	0.0	1	0.0	0	0.0	0	8.8	0.002	1249.6	9000	0.0	2.0	1.5	10.0
40130	11.4	11.4	11.3	15.5	5.2	2.5	0	0.0	1	0.0	0	0.0	0	8.8	0.002	1195.6	9000	0.0	2.0	1.7	10.0
39945	11.2	11.2	11.0	16.3	5.2	2.4	0	0.0	1	0.0	0	0.0	0	9.3	0.002	1173.3	9000	0.0	2.0	1.6	10.0
39755	15.4	15.4	16.5	13.3	5.2	4.5	0	0.0	1	0.0	0	0.0	0	8.1	0.004	894.5	9000	0.0	2.0	3.7	12.5
39605	18.5	18.5	19.7	11.5	5.2	6.1	0	0.0	1	0.0	0	0.0	0	7.1	0.007	849.7	9000	0.0	2.0	5.2	14.0
39310	15.4	15.4	16.5	12.7	5.2	4.6	0	0.0	1	0.0	0	0.0	0	8.1	0.004	931.1	9000	0.0	2.0	3.7	12.5
39100	19.1	19.1	20.9	10.4	5.2	6.7	0	0.0	1	0.0	0	0.0	0	7.2	0.009	761.1	9000	0.0	2.0	5.2	14.0
38925	12.5	12.5	12.8	14.3	5.2	3.0	0	0.0	1	0.0	0	0.0	0	10.3	0.002	873.5	9000	0.0	2.0	2.2	10.0
38710	10.0	9.4	12.0	15.6	2.7	2.8	0	0.0	1	0.0	0	0.0	0	11.7	0.002	820.3	9000	0.0	2.0	2.0	10.0
38475	14.2	14.2	17.9	14.0	2.7	5.2	0	0.0	1	0.0	0	0.0	0	9.8	0.004	659.7	9000	0.0	2.0	4.3	12.5
38300	17.4	17.4	22.5	10.3	2.7	7.6	0	0.0	1	0.0	0	0.0	0	7.7	0.010	666.3	9000	0.0	2.0	5.1	14.0
38065	11.3	11.3	14.5	14.0	2.7	3.7	0	0.0	1	0.0	0	0.0	0	12.0	0.002	658.4	9000	0.0	2.0	2.9	10.0
37810	14.5	14.5	18.2	12.2	2.7	5.3	0	0.0	1	0.0	0	0.0	0	10.2	0.004	618.2	9000	0.0	2.0	4.5	14.0
37655	16.6	16.6	20.9	10.5	2.7	6.7	0	0.0	1	0.0	0	0.0	0	7.8	0.008	706.7	9000	0.0	2.0	5.3	14.0
37390	16.2	16.2	23.7	6.5	2.7	8.3	0	0.0	1	0.0	0	0.0	0	5.9	0.015	823.8	9000	0.0	2.0	3.3	14.0
37135	13.0	13.0	16.6	9.3	2.7	4.6	0	0.0	1	0.0	0	0.0	0	8.5	0.005	821.4	9000	0.0	2.0	3.7	12.5
36930	14.8	14.8	19.8	8.1	2.7	6.1	0	0.0	1	0.0	0	0.0	0	7.2	0.008	812.4	9000	0.0	2.0	4.1	14.0
36735	12.6	12.6	16.1	9.8	2.7	4.4	0	0.0	1	0.0	0	0.0	0	8.0	0.005	896.9	9000	0.0	2.0	3.5	12.5
36515	10.0	10.0	12.9	12.0	2.7	3.1	0	0.0	1	0.0	0	0.0	0	9.0	0.002	994.7	9000	0.0	2.0	2.2	10.0
36265	10.0	9.6	12.3	12.5	2.7	2.9	0	0.0	1	0.0	0	0.0	0	7.9	0.003	1176.0	9000	0.0	2.0	2.1	10.0
36080	25.1	25.1	14.7	11.6	3.2	3.8	0.9	2.0	1	0.0	0	13.3	0	6.7	0.006	1176.0	9000	0.0	2.0	2.9	10.0
35845	10.0	9.2	11.0	13.6	3.2	2.4	0	0.0	1	0.0	0	0.0	0	7.9	0.002	1401.7	9000	0.0	2.0	1.6	10.0
35725	12.1	12.1	15.0	13.0	3.2	3.9	0	0.0	1	0.0	0	0.0	0	6.5	0.004	1377.9	9000	0.0	2.0	3.0	10.0
35515	13.9	13.9	17.1	12.0	3.2	4.8	0	0.0	1	0.0	0	0.0	0	6.0	0.005	1354.8	9000	0.0	2.0	3.9	12.5
35245	14.1	14.1	17.3	11.3	3.2	4.9	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1328.3	9000	0.0	2.0	4.0	12.5
35040	16.3	16.3	19.6	10.7	3.2	6.0	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1354.8	9000	0.0	2.0	5.2	14.0
34860	15.1	15.1	18.4	10.0	3.2	5.4	0	0.0	1	0.0	0	0.0	0	4.9	0.009	1285.7	9000	0.0	2.0	4.6	14.0
34720	15.1	15.1	18.4	9.2	3.2	5.4	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1411.2	9000	0.0	2.0	4.6	14.0
34495	14.2	14.2	17.4	9.0	3.2	5.0	0	0.0	1	0.0	0	0.0	0	5.2	0.009	1283.9	9000	0.0	2.0	4.1	12.5
34310	13.6	13.6	16.8	9.3	3.2	4.7	0	0.0	1	0.0	0	0.0	0	5.9	0.005	1308.5	9000	0.0	2.0	3.8	12.5
34090	13.8	13.8	17.0	8.6	3.2	4.8	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1295.5	9000	0.0	2.0	3.9	12.5
33880	13.7	13.7	16.6	9.3	3.4	4.6	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1318.4	9000	0.0	2.0	3.7	12.5
33710	12.6	12.6	15.4	9.7	3.4	4.1	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1372.1	9000	0.0	2.0	3.2	12.5
33500	13.3	13.3	16.2	9.3	3.4	4.4	0	0.0	1	0.0	0	0.0	0	5.1	0.007	1496.0	9000	0.0	2.0	3.5	12.5
33310	13.0	13.0	15.8	9.0	3.4	4.2	0	0.0	1	0.0	0	0.0	0	4.2	0.006	1770.4	9000	0.0	2.0	3.4	12.5
33115	10.0	9.0	10.4	10.6	3.4	2.2	0	0.0	1	0.0	0	0.0	0	6.1	0.003	1847.3	9000	0.0	2.0	1.4	10.0
32795	10.8	10.8	13.0	10.6	3.4	3.1	0	0.0	1	0.0	0	0.0	0	5.2	0.004	1735.6	9000	0.0	2.0	2.3	10.0
32605	11.8	11.8	14.4	11.1	3.4	3.6	0	0.0	1	0.0	0	0.0	0	5.0	0.005	1699.9	9000	0.0	2.0	2.8	10.0
32265	12.5	11.7	15.9	10.5	2.0	4.3	0	0.0	1	0.0	0	0.0	0	4.8	0.006	1853.2	9000	0.0	2.0	3.4	12.5
31875	10.0	9.0	12.4	10.4	2.0	2.9	0	0.0	1	0.0	0	0.0	0	4.7	0.006	2409.2	9000	0.0	2.0	2.1	10.0
31585	10.0	8.0	10.9	11.9	2.0	2.4	0	0.0	1	0.0	0	0.0	0	5.9	0.003	2182.2	9000	0.0	2.0	1.6	10.0
31360	10.0	7.6	10.3	13.5	2.0	2.2	0	0.0	1	0.0	0	0.0	0	7.4	0.002	1878.7	9000	0.0	2.0	1.4	10.0
31060	8.0	6.5	8.2	15.5	2.0	1.6	0	0.0	1	0.0	0	0.0	0	10.1	0.001	1708.2	9000	0.0	2.0	0.9	8.0
30720	8.0	5.7	6.7	17.5	2.0	1.2	0	0.0	1	0.0	0	0.0	0	11.2	0.001	1888.6	9000	0.0	2.0	0.6	8.0
30445	8.0	5.6	6.3	19.5	2.0	1.1	0	0.0	1	0.0	0	0.0	0	12.7	0.000	1779.7	9000	0.0	2.0	0.5	8.0
30095	8.0	5.8	6.7	21.3	2.0	1.2	0	0.0	1	0.0	0	0.0	0	13.4	0.000	1622.7	9000	0.0	2.0	0.6	8.0
29815	8.0	6.2	7.7	21.9	2.0	1.4	0	0.0	1	0.0	0	0.0	0	13.5	0.000	1433.2	9000	0.0	2.0	0.8	8.0
29565	8.0	6.1	7.4	22.9	2.0	1.3	0	0.0	1	0.0	0	0.0	0	14.8	0.000	1323.8	9000	0.0	2.0	0.7	8.0
29385	8.0	6.5	8.3	23.6	2.0	1.6	0	0.0	1	0.0	0	0.0	0	14.4	0.000	1237.4	9000	0.0	2.0	0.9	8.0
29140	9.4	9.4	9.2	24.1	4.4	1.8	0	0.0	1	0.0	0	0.0	0	14.1	0.001	1087.2	9000	0.0	2.0	1.1	8.0
28895	16.8	16.8	18.8	22.5	4.4	5.6	0	0.0	1	0.0	0	0.0	0	9.9	0.002	972.1	9000	0.0	2.0	4.8	14.0
28695	24.9	24.9	28.9	14.0	4.4	11.5	0	0.0	1	0.0	0	0.0	0	5.4	0.025	899.4	9000	0.0	2.0	7.0	14.0
28500	20.6	20.6	22.4	16.1	4.4	7.5	0	0.0	1	0.0	0	0.0	0	11.4	0.006	552.2	9000	0.0	2.0	6.8	14.0
28280	23.8	23.8	29.6	10.8	4.4	12.0	0	0.0	1	0.0	0	0.0	0	5.8	0.013	944.5	9000	0.0	2.0	5.4	14.0
28080	10.6	10.6	11.3	19.1	4.4	2.5	0	0.0	1	0.0	0	0.0	0	14.7	0.001	926.4	9000	0.0	2.0	1.7	10.0
27925	11.8	11.8	13.1	19.3	4.4	3.1	0	0.0	1	0.0	0	0.0	0	13.8	0.001	866.6	9000	0.0	2.0	2.3	10.0
27725	17.0	17.0	19.0	16.7	4.4	5.7	0	0.0	1	0.0	0	0.0	0	10.4	0.003	786.6	9000	0.0	2.0	4.9	14.0
27545	21.2	21.2	22.9	14.1	4.4	7.8	0	0.0	1	0.0	0	0.0	0	9.9	0.005	643.2	9000	0.0	2.0	7.0	14.0
27335	21.3	21.3	24.6	12.3	4.4	8.7	0	0.0	1	0.0	0	0.0	0	8.3	0.008	703.5	9000	0.0	2.0	6.2	14.0
27155	17.0	17.0	19.1	14.8	4.4	5.7	0	0.0	1	0.0	0	0.0	0	9.2	0.003	888.4	9000	0.0	2.0	4.9	14.0
26990	17.3	17.3	22.6	11.5	2.0	7.6	0	0.0	1	0.0	0	0.0	0	6.8	0.011	922.3	9000	0.0	2.0	5.7	14.0
26780	17.5	17.5	23.1	11.3	2.0	7.9	0	0.0	1	0.0	0	0.0	0	6.2	0.009	1043.3	9000	0.0	2.0	5.6	14.0
26575	16.1	16.1	20.7	11.1	2.0	6.6	0	0.0	1	0.0	0	0.0	0	5.7	0.012	1187.3	3000	0.0	2.0	5.6	14.0
26355	12.5	11.7	15.9	13.4	2.0	4.3	0	0.0	1	0.0	0	0.0	0	7.5	0.004	1260.4	3000	0.0	2.0	3.4	12.5
26170	12.7	12.7	17.0	13.5	2.0	4.8	0	0.0	1	0.0	0	0.0	0	7.6	0.003	1269.0	3000	0.0	2.0	3.9	12.5
25965	14.0	13.8	18.2	12.9	2.0	5.3	0	0.0	1	0.0	0	0.0	0	6.9	0.004	1281.3	3000	0.0	2.0	4.5	14.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25785	14.5	14.5	18.9	12.1	2.0	5.7	0	0.0	1	0.0	0	0.0	0	6.9	0.005	1219.7	3000	0.0	2.0	4.8	14.0
25600	14.1	14.1	18.5	12.4	2.0	5.5	0	0.0	1	0.0	0	0.0	0	7.6	0.005	1109.4	3000	0.0	2.0	4.6	14.0
25425	14.0	13.9	18.3	12.5	2.0	5.4	0	0.0	1	0.0	0	0.0	0	7.1	0.007	1082.2	3000	0.0	2.0	4.5	14.0
25215	10.4	10.4	14.3	14.7	2.0	3.6	0	0.0	1	0.0	0	0.0	0	9.0	0.003	1097.3	3000	0.0	2.0	2.7	10.0
25000	10.0	9.5	13.2	15.5	2.0	3.2	0	0.0	1	0.0	0	0.0	0	10.1	0.002	1062.4	3000	0.0	2.0	2.3	10.0
24795	10.2	10.2	14.1	15.6	2.0	3.5	0	0.0	1	0.0	0	0.0	0	10.5	0.002	957.4	3000	0.0	2.0	2.7	10.0
24550	12.5	11.0	15.1	16.5	2.0	3.9	0	0.0	1	0.0	0	0.0	0	11.0	0.003	856.1	3000	0.0	2.0	3.1	12.5
24335	14.0	13.8	18.2	15.0	2.0	5.3	0	0.0	1	0.0	0	0.0	0	10.1	0.004	764.8	3000	0.0	2.0	4.5	14.0
24115	15.6	15.6	20.0	13.8	2.0	6.2	0	0.0	1	0.0	0	0.0	0	9.4	0.006	754.2	3000	0.0	2.0	5.4	14.0
23975	16.5	16.5	20.8	12.9	2.0	6.6	0	0.0	1	0.0	0	0.0	0	8.7	0.007	783.2	3000	0.0	2.0	5.8	14.0
23755	14.0	13.7	18.1	14.7	2.0	5.3	0	0.0	1	0.0	0	0.0	0	9.7	0.004	815.7	3000	0.0	2.0	4.4	14.0
23565	15.8	15.8	20.2	14.3	2.0	6.3	0	0.0	1	0.0	0	0.0	0	8.2	0.007	850.9	3000	0.0	2.0	5.5	14.0
23365	14.0	14.0	18.4	14.3	2.0	5.4	0	0.0	1	0.0	0	0.0	0	8.7	0.004	939.0	3000	0.0	2.0	4.6	14.0
23180	17.5	17.5	21.9	12.6	2.0	7.2	0	0.0	1	0.0	0	0.0	0	8.0	0.005	916.6	3000	0.0	2.0	6.3	14.0
23000	16.9	16.9	22.0	11.3	2.0	7.3	0	0.0	1	0.0	0	0.0	0	8.2	0.010	784.0	3000	0.0	2.0	5.6	14.0
22790	28.2	28.2	17.9	13.0	2.0	5.2	0.9	2.0	1	0.0	0	14.7	0	10.0	0.005	784.0	3000	0.0	2.0	4.3	12.5
22600	15.4	15.4	19.8	12.8	2.0	6.1	0	0.0	1	0.0	0	0.0	0	7.6	0.006	999.0	3000	0.0	2.0	5.3	14.0
22415	16.3	16.3	21.3	10.8	2.0	6.9	0	0.0	1	0.0	0	0.0	0	6.6	0.010	1039.1	3000	0.0	2.0	5.4	14.0
22195	10.0	9.9	13.6	14.0	2.0	3.4	0	0.0	1	0.0	0	0.0	0	8.7	0.003	1309.6	3000	0.0	2.0	2.5	10.0
22010	12.5	11.9	16.1	14.3	2.0	4.4	0	0.0	1	0.0	0	0.0	0	7.6	0.003	1254.1	3000	0.0	2.0	3.5	12.5
21790	15.3	15.3	19.7	11.6	2.0	6.1	0	0.0	1	0.0	0	0.0	0	6.5	0.006	1144.5	3000	0.0	2.0	5.2	14.0
21615	15.1	15.1	21.3	8.5	2.0	6.9	0	0.0	1	0.0	0	0.0	0	5.8	0.011	1163.0	3000	0.0	2.0	4.3	14.0
21440	13.1	13.1	17.5	11.0	2.0	5.0	0	0.0	1	0.0	0	0.0	0	6.9	0.005	1286.1	3000	0.0	2.0	4.1	12.5
21225	14.0	13.6	18.1	11.7	2.0	5.2	0	0.0	1	0.0	0	0.0	0	5.6	0.005	1559.0	3000	0.0	2.0	4.4	14.0
21020	15.2	15.2	20.3	9.7	2.0	6.3	0	0.0	1	0.0	0	0.0	0	7.8	0.007	903.0	3000	0.0	2.0	4.9	14.0
20845	12.5	11.0	15.1	12.7	2.0	3.9	0	0.0	1	0.0	0	0.0	0	6.7	0.003	1563.7	3000	0.0	2.0	3.1	12.5
20595	10.0	9.0	12.4	13.4	2.0	2.9	0	0.0	1	0.0	0	0.0	0	8.3	0.002	1548.8	3000	0.0	2.0	2.1	10.0
20435	10.0	8.7	12.1	14.3	2.0	2.8	0	0.0	1	0.0	0	0.0	0	8.8	0.001	1528.3	3000	0.0	2.0	2.0	10.0
20280	12.5	11.4	15.6	12.8	2.0	4.1	0	0.0	1	0.0	0	0.0	0	6.8	0.003	1531.3	3000	0.0	2.0	3.3	12.5
20070	14.9	14.9	19.3	11.1	2.0	5.9	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1526.6	3000	0.0	2.0	5.0	14.0
19855	15.6	15.6	20.6	10.2	2.0	6.5	0	0.0	1	0.0	0	0.0	0	6.0	0.008	1205.4	3000	0.0	2.0	5.1	14.0
19630	14.9	14.9	20.6	8.9	2.0	6.5	0	0.0	1	0.0	0	0.0	0	6.6	0.009	1060.3	3000	0.0	2.0	4.4	14.0
19440	10.0	9.5	13.1	13.4	2.0	3.2	0	0.0	1	0.0	0	0.0	0	9.2	0.002	1194.5	3000	0.0	2.0	2.3	10.0
19240	12.5	11.7	15.9	11.9	2.0	4.3	0	0.0	1	0.0	0	0.0	0	7.4	0.004	1216.9	3000	0.0	2.0	3.4	12.5
19050	14.4	14.4	18.8	10.5	2.0	5.6	0	0.0	1	0.0	0	0.0	0	5.8	0.009	1321.4	3000	0.0	2.0	4.8	14.0
18830	10.0	9.6	13.3	14.6	2.0	3.2	0	0.0	1	0.0	0	0.0	0	7.4	0.003	1531.5	3000	0.0	2.0	2.4	10.0
18650	10.0	8.7	12.1	15.0	2.0	2.8	0	0.0	1	0.0	0	0.0	0	8.0	0.002	1604.5	3000	0.0	2.0	2.0	10.0
18475	8.0	6.8	8.9	16.9	2.0	1.8	0	0.0	1	0.0	0	0.0	0	9.9	0.001	1621.5	3000	0.0	2.0	1.1	8.0
18290	8.0	7.3	9.8	16.9	2.0	2.0	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1594.2	3000	0.0	2.0	1.3	8.0
18025	8.0	6.3	7.9	18.5	2.0	1.5	0	0.0	1	0.0	0	0.0	0	11.9	0.001	1520.2	17000	0.0	2.0	0.8	8.0
17785	8.0	6.6	8.5	20.2	2.0	1.6	0	0.0	1	0.0	0	0.0	0	12.0	0.001	1398.1	17000	0.0	2.0	1.0	8.0
17510	10.0	8.0	11.0	19.2	2.0	2.4	0	0.0	1	0.0	0	0.0	0	10.2	0.001	1350.7	17000	0.0	2.0	1.6	10.0
17360	12.8	12.8	17.1	15.9	2.0	4.8	0	0.0	1	0.0	0	0.0	0	8.8	0.004	943.2	17000	0.0	2.0	3.9	12.5
17110	18.1	18.1	22.3	15.2	2.0	7.4	0	0.0	1	0.0	0	0.0	0	5.8	0.007	1175.4	17000	0.0	2.0	6.7	14.0
16970	18.6	18.6	23.1	13.6	2.0	7.9	0	0.0	1	0.0	0	0.0	0	5.9	0.010	1067.0	17000	0.0	2.0	6.8	14.0
16720	17.2	17.2	24.4	9.2	2.0	8.6	0	0.0	1	0.0	0	0.0	0	5.2	0.019	1122.9	17000	0.0	2.0	4.6	14.0
16515	15.0	15.0	19.4	10.4	2.0	5.9	0	0.0	1	0.0	0	0.0	0	5.8	0.010	1249.9	17000	0.0	2.0	5.1	14.0
16305	10.0	8.4	11.6	14.6	2.0	2.6	0	0.0	1	0.0	0	0.0	0	9.4	0.002	1360.5	17000	0.0	2.0	1.8	10.0
16130	12.5	11.5	15.7	12.3	2.0	4.2	0	0.0	1	0.0	0	0.0	0	7.1	0.005	1326.5	17000	0.0	2.0	3.3	12.5
15960	13.3	13.3	17.7	11.0	2.0	5.1	0	0.0	1	0.0	0	0.0	0	5.9	0.008	1386.0	17000	0.0	2.0	4.2	12.5
15745	10.0	8.9	12.3	13.3	2.0	2.9	0	0.0	1	0.0	0	0.0	0	8.4	0.003	1363.9	17000	0.0	2.0	2.0	10.0
15540	10.0	7.8	10.6	13.7	2.0	2.3	0	0.0	1	0.0	0	0.0	0	9.4	0.002	1426.6	17000	0.0	2.0	1.5	10.0
15335	12.5	12.0	16.2	12.1	2.0	4.4	0	0.0	1	0.0	0	0.0	0	8.2	0.006	1064.1	17000	0.0	2.0	3.5	12.5
15125	30.9	30.9	17.9	11.6	2.0	5.2	0.9	4.0	1	0.0	0	17.4	0	8.0	0.007	1000.5	17000	0.0	2.0	4.3	12.5
14900	14.7	14.7	19.3	9.8	2.0	5.8	0	0.0	1	0.0	0	0.0	0	6.3	0.009	1626.5	17000	0.0	2.0	4.9	14.0
14720	14.0	13.7	18.1	9.8	2.0	5.3	0	0.0	1	0.0	0	0.0	0	6.0	0.008	1722.3	17000	0.0	2.0	4.4	14.0
14480	14.1	14.1	19.0	8.9	2.0	5.7	0	0.0	1	0.0	0	0.0	0	5.2	0.010	1726.7	17000	0.0	2.0	4.4	14.0
14315	10.1	10.1	14.0	9.9	2.0	3.5	0	0.0	1	0.0	0	0.0	0	5.8	0.005	1881.0	17000	0.0	2.0	2.6	10.0
14090	10.4	10.4	14.3	8.5	2.0	3.6	0	0.0	1	0.0	0	0.0	0	5.6	0.006	1772.8	17000	0.0	2.0	2.8	10.0
13850	10.0	9.1	12.6	9.7	2.0	3.0	0	0.0	1	0.0	0	0.0	0	6.5	0.004	1741.6	17000	0.0	2.0	2.2	10.0
13635	12.5	11.3	15.5	10.3	2.0	4.1	0	0.0	1	0.0	0	0.0	0	6.3	0.004	1705.8	17000	0.0	2.0	3.2	12.5
13425	14.0	13.1	18.0	7.8	2.0	5.2	0	0.0	1	0.0	0	0.0	0	4.3	0.011	1850.7	17000	0.0	2.0	3.9	14.0
13190	10.0	8.8	12.2	9.5	2.0	2.8	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1847.4	17000	0.0	2.0	2.0	10.0
13030	10.3	10.3	14.2	9.6	2.0	3.6	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1763.0	17000	0.0	2.0	2.7	10.0
12835	10.0	9.6	13.3	10.1	2.0	3.2	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	9.0	12.5	10.9	2.0	2.9	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1470.8	17000	0.0	2.0	2.1	10.0
12395	10.0	8.9	12.3	11.5	2.0	2.9	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1438.1	17000	0.0	2.0	2.0	10.0
12195	10.0	7.8	10.6	12.5	2.0	2.3	0	0.0	1	0.0	0	0.0	0	10.3	0.001	1383.7	17000	0.0	2.0	1.5	10.0
11995	10.0	9.3	12.8	13.6	2.0	3.0	0	0.0	1	0.0	0	0.0	0	9.7	0.002	1280.5	17000	0.0	2.0	2.2	10.0
11780	10.0	9.1	12.6	14.4	2.0	3.0	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1422.2	17000	0.0	2.0	2.1	10.0
11605	10.1	10.1	13.9	13.8	2.0	3.5	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1325.5	17000	0.0	2.0	2.6	10.0
11405	10.0	9.5	13.2	15.1	2.0	3.2	0	0.0	1	0.0	0	0.0	0	10.3	0.002	1114.6	17000	0.0	2.0	2.3	10.0
11180	12.5	12.3	16.6	13.9	2.0	4.6	0	0.0	1	0.0	0	0.0	0	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.7	14.7	19.1	13.3	2.0	5.7	0	0.0	1	0.0	0	0.0	0	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	16.7	16.7	21.9	10.9	2.0	7.2	0	0.0	1	0.0	0	0.0	0	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	16.2	16.2	24.1	7.5	2.0	8.5	0	0.0	1	0.0	0	0.0	0	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	16.1	16.1	22.7	8.8	2.0	7.7	0	0.0	1	0.0	0	0.0	0	5.8	0.008	1247.0	17000	0.0	2.0	4.4	14.0
10225	13.4	13.4	17.8	9.5	2.0	5.1	0	0.0	1	0.0	0	0.0	0	5.9	0.007	1374.1	17000	0.0	2.0	4.3	12.5
10000	10.9	10.9	14.9	11.1	2.0	3.9	0	0.0	1	0.0	0	0.0	0	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.2	14.2	18.6	10.0	2.0	5.5	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1402.3	17000	0.0	2.0	4.7	14.0
9595	10.6	10.6	14.6	10.3	2.0	3.7	0	0.0	1	0.0	0	0.0	0	6.6	0.005	1619.5	17000	0.0	2.0	2.9	10.0
9385	12.5	11.6	15.8	9.5	2.0	4.2	0	0.0	1	0.0	0	0.0	0	5.3	0.006	1770.4	17000	0.0	2.0	3.4	12.5
9220	12.5	12.1	16.4	8.9	2.0	4.5	0	0.0	1	0.0	0	0.0	0	4.9	0.008	1771.4	17000	0.0	2.0	3.6	12.5
9025	12.5	11.7	15.9	8.9	2.0	4.3	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1736.9	17000	0.0	2.0	3.4	12.5
MAX=	30.9	30.9			8.1	12.0						17.4					17000.0	0.0	2.0	8.3	14.0
MIN=	8.0	5.6			2.0	1.1						0.0					3000.0	0.0	2.0	0.5	8.0

Santa Clara River Fluvial Study

APPENDIX CHAPTER 6.1B

LACH&SM with SAM Toe
Existing & Proposed Conditions
Curved & Straight Reaches

PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM W/ SAM -- SANTA CLARA RIVER EXISTING CONDITIONS OUTSIDE CURVED REACH C_{-AB} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	14.0	11.1	21.7	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	14.0	12.7	24.1	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	14.0	10.4	20.3	19.2	2.8	0.0	0	0.0	1	0.0	0	0.0	1	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	14.0	13.1	26.1	16.5	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	14.0	9.8	19.2	21.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	14.0	12.5	26.2	15.4	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	15.4	15.4	19.9	19.5	8.1	0.0	0	0.0	1	0.0	0	0.0	1	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	17.0	17.0	26.7	13.8	8.1	0.0	0	0.0	1	0.0	0	0.0	1	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	15.8	15.8	28.8	11.3	8.1	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	16.3	16.3	26.1	12.4	8.1	0.0	0	0.0	1	0.0	0	0.0	1	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	15.5	15.5	26.6	10.8	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	15.4	15.4	24.1	10.6	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.5	0.016	878.5	9000	0.0	2.0	5.3	14.0
42590	21.0	15.0	22.6	8.9	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.1	0.014	1023.2	9000	0.4	2.0	4.5	21.0
42430	21.0	15.1	20.8	9.6	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.9	0.012	940.5	9000	0.2	2.0	4.8	21.0
42215	15.0	13.1	10.4	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	1	8.5	0.002	1310.4	9000	1.5	2.0	1.5	15.0
41940	15.0	13.5	11.6	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	1	7.6	0.002	1321.5	9000	1.6	2.0	1.8	15.0
41730	15.0	13.3	11.8	14.7	8.1	0.0	0	0.0	1	0.0	0	0.0	1	8.0	0.002	1229.5	9000	1.3	2.0	1.9	15.0
41460	15.0	13.8	11.5	16.2	8.1	0.0	0	0.0	1	0.0	0	0.0	1	7.6	0.002	1329.0	9000	1.9	2.0	1.8	15.0
41280	12.5	11.2	16.5	14.3	5.2	0.3	0	0.0	1	0.0	0	0.0	1	8.2	0.004	852.1	9000	0.0	2.0	3.7	12.5
41080	14.0	12.8	19.9	12.1	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.7	0.007	874.2	9000	0.0	2.0	5.3	14.0
40825	21.0	12.4	18.0	11.5	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.2	0.007	1039.9	9000	0.5	2.0	4.4	21.0
40585	18.0	11.8	17.0	11.7	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.8	0.006	1005.9	9000	0.4	2.0	3.9	18.0
40335	15.0	11.4	11.1	14.5	5.2	0.3	0	0.0	1	0.0	0	0.0	1	7.1	0.002	1504.8	9000	2.2	2.0	1.7	15.0
40130	15.0	12.0	11.2	15.1	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.9	0.002	1636.5	9000	2.8	2.0	1.7	15.0
39945	15.0	11.9	10.3	16.1	5.2	0.3	0	0.0	1	0.0	0	0.0	1	7.6	0.001	1648.1	9000	3.0	2.0	1.4	15.0
39755	18.0	12.2	15.4	13.5	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.6	0.003	1251.4	9000	1.5	2.0	3.2	18.0
39605	21.0	13.4	19.4	11.4	5.2	0.3	0	0.0	1	0.0	0	0.0	1	5.8	0.007	1100.6	9000	0.8	2.0	5.1	21.0
39310	18.0	12.2	16.0	12.4	5.2	0.3	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1204.5	9000	1.3	2.0	3.5	18.0
39100	15.0	11.2	12.4	14.1	5.2	0.3	0	0.0	1	0.0	0	0.0	1	7.8	0.002	1294.8	9000	1.6	2.0	2.1	15.0
38925	15.0	10.4	11.4	14.5	5.2	0.3	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1181.3	9000	1.2	2.0	1.8	15.0
38710	15.0	6.9	10.6	15.9	2.7	0.0	0	0.0	1	0.0	0	0.0	1	10.8	0.001	1043.1	9000	0.7	2.0	1.5	15.0
38475	12.5	9.0	17.8	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	1	8.8	0.004	755.4	9000	0.0	2.0	4.3	12.5
38300	14.0	9.6	22.7	9.8	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.010	688.1	9000	0.0	2.0	4.9	14.0
38065	10.0	7.4	14.1	14.2	2.7	0.0	0	0.0	1	0.0	0	0.0	1	12.0	0.002	678.3	9000	0.0	2.0	2.7	10.0
37810	14.0	9.2	18.2	12.2	2.7	0.0	0	0.0	1	0.0	0	0.0	1	10.2	0.004	622.3	9000	0.0	2.0	4.5	14.0
37655	14.0	9.8	21.2	10.3	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.009	735.9	9000	0.0	2.0	5.1	14.0
37390	14.0	7.8	23.9	6.1	2.7	0.0	0	0.0	1	0.0	0	0.0	1	5.4	0.017	892.2	9000	0.0	2.0	3.1	14.0
37135	18.0	9.1	17.0	8.0	2.7	0.0	0	0.0	1	0.0	0	0.0	1	6.4	0.006	1088.9	9000	0.5	2.0	3.9	18.0
36930	21.0	9.2	18.3	7.9	2.7	0.0	0	0.0	1	0.0	0	0.0	1	6.0	0.007	1112.0	9000	0.6	2.0	3.9	21.0
36735	18.0	8.6	15.0	9.6	2.7	0.0	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1195.7	9000	0.9	2.0	3.0	18.0
36515	18.0	9.7	16.7	9.6	2.7	0.0	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1306.1	9000	1.2	2.0	3.8	18.0
36265	15.0	8.4	13.0	11.2	2.7	0.0	0	0.0	1	0.0	0	0.0	1	6.4	0.003	1373.1	9000	1.4	2.0	2.3	15.0
36080	15.0	9.5	12.5	11.7	3.2	0.6	0	0.0	1	0.0	0	0.0	1	6.4	0.004	1455.4	9000	1.6	2.0	2.1	15.0
35845	15.0	9.4	10.9	13.5	3.2	0.6	0	0.0	1	0.0	0	0.0	1	7.4	0.002	1496.2	9000	2.1	2.0	1.6	15.0
35725	15.0	10.7	14.7	13.0	3.2	0.6	0	0.0	1	0.0	0	0.0	1	6.3	0.003	1431.2	9000	2.1	2.0	2.9	15.0
35515	18.0	11.4	17.1	11.9	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.7	0.005	1353.4	9000	1.8	2.0	3.9	18.0
35245	15.0	11.0	14.5	12.5	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.8	0.003	1555.5	9000	2.4	2.0	2.8	15.0
35040	21.0	12.6	19.5	10.7	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1355.9	9000	1.7	2.0	5.1	21.0
34860	21.0	11.5	18.1	10.1	3.2	0.6	0	0.0	1	0.0	0	0.0	1	4.8	0.008	1338.9	9000	1.3	2.0	4.4	21.0
34720	21.0	11.6	18.2	9.3	3.2	0.6	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1411.5	9000	1.4	2.0	4.4	21.0
34495	21.0	11.2	18.1	8.9	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.0	0.009	1277.2	9000	1.0	2.0	4.4	21.0
34310	18.0	11.1	17.6	9.0	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.7	0.005	1280.8	9000	1.1	2.0	4.2	18.0
34090	18.0	10.7	17.2	8.6	3.2	0.6	0	0.0	1	0.0	0	0.0	1	5.4	0.007	1267.8	9000	1.0	2.0	4.0	18.0
33880	18.0	9.9	15.8	9.8	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.6	0.005	1310.6	9000	1.2	2.0	3.3	18.0
33710	18.0	10.3	16.5	9.4	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.2	0.007	1355.1	9000	1.3	2.0	3.7	18.0
33500	18.0	10.3	15.8	9.5	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.4	0.006	1474.3	9000	1.5	2.0	3.4	18.0
33310	18.0	10.9	15.9	9.1	3.4	0.0	0	0.0	1	0.0	0	0.0	1	4.2	0.006	1744.5	9000	2.1	2.0	3.4	18.0
33115	18.0	10.1	15.5	8.7	3.4	0.0	0	0.0	1	0.0	0	0.0	1	4.8	0.009	1573.2	9000	1.5	2.0	3.3	18.0
32795	15.0	9.7	12.2	11.0	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.5	0.003	1732.9	9000	2.3	2.0	2.0	15.0
32605	15.0	9.5	14.1	11.5	3.4	0.0	0	0.0	1	0.0	0	0.0	1	6.2	0.004	1344.6	9000	1.4	2.0	2.7	15.0
32265	18.0	10.2	16.7	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.6	0.007	1829.9	9000	2.5	2.0	3.8	18.0
31875	15.0	8.9	10.9	11.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.2	0.004	2482.2	9000	3.3	2.0	1.6	15.0
31585	18.0	10.6	16.6	9.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.0	0.009	2120.3	9000	2.9	2.0	3.7	18.0
31360	12.0	8.3	9.8	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.8	0.001	1884.4	9000	3.0	2.0	1.3	12.0
31060	12.0	7.6	7.9	15.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.5	0.001	1711.5	9000	2.7	2.0	0.8	12.0
30720	12.0	8.1	6.4	18.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.6	0.000	1891.7	9000	3.5	2.0	0.6	12.0
30445	12.0	8.0	6.0	19.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	13.1	0.000	1783.7	9000	3.5	2.0	0.5	12.0
30095	12.0	8.7	6.6	21.7	2.0	0.0	0	0.0	1	0.0	0	0.0	1	12.7	0.000	1730.3	9000	4.1	2.0	0.6	12.0
29815	12.0	9.1	7.7	22.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.7	0.000	1675.2	9000	4.3	2.0	0.8	12.0
29565	12.0	9.4	7.4	23.3	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.8	0.000	1717.4	9000	4.6	2.0	0.7	12.0
29385	12.0	9.8	8.5	24.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.8	0.000	1675.1	9000	4.8	2.0	1.0	12.0
29140	15.1	15.1	10.1	24.3	4.4	2.9	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1557.6	9000	4.4	2.0	1.4	15.0
28895	21.0	16.1	19.7	22.4	4.4	2.9	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1062.3	9000	1.6	2.0	5.2	21.0
28695	17.3	17.3	27.5	16.0	4.4	2.9	0	0.0	1	0.0	0	0.0	1	9.4	0.009	544.9	9000	0.0	2.0	8.0	14.0
28500	16.1	16.1	28.6	13.6	4.4	2.9	0	0.0	1	0.0	0	0.0	1	9.8	0.010	503.7	9000	0.0	2.0	6.8	14.0
28280	15.2	15.2	29.7	11.8	4.4	2.9	0	0.0	1	0.0	0	0.0	1	8.8	0.011	549.3	9000	0.0	2.0	5.9	14.0
28080	15.0	15.0	28.1	11.4	4.4	2.9	0	0.0	1	0.0	0	0.0	1	9.2	0.011	547.6	9000	0.0	2.0	5.7	14.0
27925	13.6	13.6	18.0	17.5	4.4	2.9	0	0.0	1	0.0	0	0.0	1	13.0	0.002	612.7	9000	0.0	2.0	4.3	12.5
27725	15.0	15.0	20.5	16.3	4.4	2.9	0	0.0	1	0.0	0	0.0	1	12.1	0.003	587.1	9000	0.0	2.0	5.7	14.0
27545	15.9	15.9	24.7	13.2	4.4	2.9	0	0.0	1	0.0	0	0.0	1	9.5	0.007	613.0	9000	0.0	2.0	6.6	14.0
27335	15.3	15.3	25.5	12.0	4.4	2.9	0	0.0	1	0.0	0	0.0	1	8.1	0.008	691.0	9000	0.0	2.0	6.0	14.0
27155	15.9	15.9	22.3	13.2	4.4	2.9	0	0.0	1	0.0	0	0.0	1	8.0	0.005	856.6	9000	0.0	2.0	6.6	14.0
26990	21.0	10.5	23.5	11.2	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.0	0.010	1008.2	9000	0.5	2.0	5.6	21.0
26780	21.0	10.9	23.9	11.0	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.6	0.010	1131.7	9000	1.0	2.0	5.5	21.0
26575	21.0	15.2	21.0	11.0	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.5	0.013	1216.4	3000	5.3	2.0	5.5	21.0
26355	18.0	14.8	15.8	13.4	2.0	0.4	0	0.0	1	0.0	0	0.0	1	7.5	0.003	1282.4	3000	7.0	2.0	3.4	18.0
26170	18.0	16.5	18.0	13.0	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.8	0.004	1347.9	3000	7.7	2.0	4.4	18.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET FROM SAM
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25965	18.0	16.1	17.9	13.0	2.0	0.4	0	0.0	1	0.0	0	0.0	1	7.0	0.004	1288.3	3000	7.4	2.0	4.3	18.0
25785	21.0	16.6	19.5	11.7	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.2	0.005	1336.9	3000	7.0	2.0	5.2	21.0
25600	21.0	18.4	20.6	11.3	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1596.5	3000	8.3	2.0	5.6	21.0
25425	21.0	18.5	20.0	11.3	2.0	0.4	0	0.0	1	0.0	0	0.0	1	4.4	0.008	1773.8	3000	8.7	2.0	5.4	21.0
25215	16.3	16.3	14.5	13.6	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.1	0.003	1748.6	3000	9.0	2.0	2.8	15.0
25000	19.0	19.0	17.4	12.2	2.0	0.4	0	0.0	1	0.0	0	0.0	1	4.4	0.006	2103.2	3000	10.5	2.0	4.1	18.0
24795	21.0	19.7	19.0	11.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	3.9	0.007	2311.7	3000	10.8	2.0	4.9	21.0
24550	21.0	19.6	21.3	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	3.8	0.009	2227.0	3000	10.2	2.0	5.4	21.0
24335	17.0	17.0	14.5	13.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.7	0.003	2089.5	3000	10.2	2.0	2.8	15.0
24115	21.0	17.5	18.8	11.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.5	0.008	2015.8	3000	8.7	2.0	4.8	21.0
23975	21.0	16.6	19.0	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.6	0.008	1913.7	3000	7.7	2.0	4.9	21.0
23755	18.0	15.8	16.7	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.1	0.006	1935.4	3000	8.0	2.0	3.8	18.0
23565	16.1	16.1	14.5	12.7	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.6	0.004	2039.5	3000	9.3	2.0	2.8	15.0
23365	18.0	15.3	17.0	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.4	0.006	1781.4	3000	7.4	2.0	3.9	18.0
23180	15.5	15.5	13.2	11.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.6	0.002	2084.2	3000	9.2	2.0	2.3	15.0
23000	13.0	13.0	8.9	13.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.7	0.001	2069.1	3000	7.9	2.0	1.1	12.0
22790	13.0	13.0	9.4	13.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.8	0.001	1949.0	3000	7.8	2.0	1.2	12.0
22600	15.0	15.0	11.4	14.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.9	0.001	1865.2	3000	9.3	2.0	1.7	15.0
22415	15.0	14.6	11.8	14.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.1	0.002	1705.6	3000	8.7	2.0	1.9	15.0
22195	15.0	14.4	14.1	13.7	2.0	0.6	0	0.0	1	0.0	0	0.0	1	7.8	0.003	1322.2	3000	7.1	2.0	2.7	15.0
22010	18.0	16.2	16.0	14.4	2.0	0.6	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1328.0	3000	8.2	2.0	3.5	18.0
21790	21.0	15.7	19.7	11.6	2.0	0.6	0	0.0	1	0.0	0	0.0	1	6.5	0.006	1145.7	3000	5.9	2.0	5.2	21.0
21615	21.0	13.0	21.4	8.5	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.8	0.010	1161.3	3000	4.2	2.0	4.3	21.0
21440	21.0	16.0	20.1	9.7	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.0	0.008	1574.6	3000	6.6	2.0	4.8	21.0
21225	21.0	19.5	19.5	10.6	2.0	0.6	0	0.0	1	0.0	0	0.0	1	3.9	0.008	2217.7	3000	9.7	2.0	5.1	21.0
21020	21.0	15.5	20.8	8.9	2.0	0.6	0	0.0	1	0.0	0	0.0	1	4.6	0.009	1676.4	3000	6.5	2.0	4.4	21.0
20845	18.1	18.1	17.1	10.4	2.0	0.6	0	0.0	1	0.0	0	0.0	1	4.2	0.006	2369.3	3000	9.6	2.0	3.9	18.0
20595	18.0	18.0	15.2	10.9	2.0	0.6	0	0.0	1	0.0	0	0.0	1	4.7	0.003	2463.7	3000	10.3	2.0	3.1	18.0
20435	18.2	18.2	12.9	12.2	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.4	0.002	2582.7	3000	11.3	2.0	2.3	15.0
20280	18.2	18.2	14.0	11.8	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.0	0.003	2589.6	3000	11.0	2.0	2.6	15.0
20070	21.0	15.9	20.2	9.2	2.0	0.6	0	0.0	1	0.0	0	0.0	1	4.7	0.009	1767.5	3000	6.7	2.0	4.6	21.0
19855	18.0	16.2	17.8	9.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.8	0.006	1975.1	3000	7.9	2.0	4.3	18.0
19630	18.0	14.9	17.9	8.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.9	0.006	1836.2	3000	6.6	2.0	4.3	18.0
19440	15.0	14.8	11.9	12.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.5	0.002	2095.3	3000	8.9	2.0	1.9	15.0
19240	15.3	15.3	13.9	11.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.6	0.003	2091.7	3000	8.7	2.0	2.6	15.0
19050	15.0	14.7	11.0	12.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.7	0.002	2160.8	3000	9.1	2.0	1.6	15.0
18830	15.6	15.6	10.7	14.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.1	0.002	2094.4	3000	10.1	2.0	1.5	15.0
18650	15.5	15.5	9.9	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.0	0.001	2022.7	3000	10.1	2.0	1.3	12.0
18475	14.6	14.6	8.1	16.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1944.4	3000	9.7	2.0	0.9	12.0
18290	14.9	14.9	8.7	16.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1843.7	3000	9.9	2.0	1.0	12.0
18025	8.0	4.8	7.8	18.2	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.5	0.001	1610.9	17000	0.0	2.0	0.8	8.0
17785	8.0	5.0	8.7	19.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.6	0.001	1417.5	17000	0.0	2.0	1.0	8.0
17510	10.0	7.8	14.0	18.0	2.0	1.2	0	0.0	1	0.0	0	0.0	1	8.5	0.002	1243.6	17000	0.0	2.0	2.6	10.0
17360	12.5	9.1	17.0	16.9	2.0	1.2	0	0.0	1	0.0	0	0.0	1	8.9	0.004	936.6	17000	0.0	2.0	3.9	12.5
17110	14.0	11.6	21.7	15.4	2.0	1.2	0	0.0	1	0.0	0	0.0	1	5.6	0.006	1274.3	17000	0.0	2.0	6.4	14.0
16970	14.0	12.0	22.9	13.6	2.0	1.2	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1125.6	17000	0.0	2.0	6.8	14.0
16720	14.0	9.7	25.2	9.0	2.0	1.2	0	0.0	1	0.0	0	0.0	1	4.1	0.018	1404.6	17000	0.0	2.0	4.5	14.0
16515	14.0	10.0	21.5	9.5	2.0	1.2	0	0.0	1	0.0	0	0.0	1	4.3	0.012	1622.6	17000	0.0	2.0	4.8	14.0
16305	21.0	10.3	21.5	9.6	2.0	1.2	0	0.0	1	0.0	0	0.0	1	4.2	0.011	1812.8	17000	0.3	2.0	4.8	21.0
16130	18.0	9.2	16.1	10.2	2.0	1.2	0	0.0	1	0.0	0	0.0	1	5.2	0.005	1945.1	17000	0.5	2.0	3.5	18.0
15960	18.0	9.3	15.8	9.3	2.0	1.2	0	0.0	1	0.0	0	0.0	1	4.1	0.011	2180.9	17000	0.7	2.0	3.4	18.0
15745	15.0	7.7	10.9	10.6	2.0	1.2	0	0.0	1	0.0	0	0.0	1	5.7	0.003	2279.0	17000	0.9	2.0	1.6	15.0
15540	15.0	7.8	11.0	10.6	2.0	1.2	0	0.0	1	0.0	0	0.0	1	5.8	0.003	2324.2	17000	1.0	2.0	1.6	15.0
15335	15.0	8.3	12.7	10.5	2.0	1.2	0	0.0	1	0.0	0	0.0	1	4.9	0.005	2302.1	17000	1.0	2.0	2.2	15.0
15125	12.5	8.1	16.2	9.6	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.5	0.007	1618.5	17000	0.0	2.0	3.5	12.5
14900	15.0	7.5	14.5	10.4	2.0	0.6	0	0.0	1	0.0	0	0.0	1	6.1	0.004	1704.5	17000	0.1	2.0	2.9	15.0
14720	18.0	8.6	16.8	9.3	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.1	0.008	1763.5	17000	0.1	2.0	3.8	18.0
14480	15.0	7.6	14.3	10.2	2.0	0.6	0	0.0	1	0.0	0	0.0	1	6.0	0.004	1801.7	17000	0.2	2.0	2.7	15.0
14315	15.0	7.8	14.8	9.4	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1868.1	17000	0.3	2.0	3.0	15.0
14090	15.0	7.3	13.8	9.0	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.9	0.005	1766.8	17000	0.1	2.0	2.6	15.0
13850	18.0	8.0	15.6	8.4	2.0	0.6	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1727.3	17000	0.1	2.0	3.3	18.0
13635	12.5	7.8	15.4	10.3	2.0	0.6	0	0.0	1	0.0	0	0.0	1	6.4	0.004	1691.9	17000	0.0	2.0	3.2	12.5
13425	18.0	8.9	17.3	8.3	2.0	0.6	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1854.4	17000	0.3	2.0	4.0	18.0
13190	15.0	6.9	12.2	9.5	2.0	0.6	0	0.0	1	0.0	0	0.0	1	6.4	0.003	1847.3	17000	0.3	2.0	2.0	15.0
13030	15.0	6.9	14.2	9.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1763.0	17000	0.2	2.0	2.7	15.0
12835	10.0	6.4	13.3	10.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	6.1	12.4	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.7	0.002	1471.0	17000	0.0	2.0	2.1	10.0
12395	10.0	6.0	12.3	11.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1438.4	17000	0.0	2.0	2.0	10.0
12195	10.0	5.5	10.6	12.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.3	0.001	1389.3	17000	0.0	2.0	1.5	10.0
11995	10.0	6.2	12.7	13.7	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.8	0.002	1281.1	17000	0.0	2.0	2.2	10.0
11780	10.0	6.1	12.5	14.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1400.9	17000	0.0	2.0	2.1	10.0
11605	10.0	6.7	14.1	13.7	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.7	0.002	1282.9	17000	0.0	2.0	2.7	10.0
11405	10.0	6.3	13.2	15.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.1	0.002	1130.2	17000	0.0	2.0	2.3	10.0
11180	12.5	7.7	16.6	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.0	10.3	19.1	13.3	2.0	1.4	0	0.0	1	0.0	0	0.0	1	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	14.0	10.8	21.9	10.9	2.0	1.4	0	0.0	1	0.0	0	0.0	1	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	14.0	9.1	24.1	7.5	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	14.0	9.8	22.7	8.8	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.8	0.008	1247.1	17000	0.0	2.0	4.4	14.0
10225	12.5	9.7	17.8	9.5	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.9	0.007	1373.8	17000	0.0	2.0	4.3	12.5
10000	10.0	8.4	14.9	11.1	2.0	1.4	0	0.0	1	0.0	0	0.0	1	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.0	10.1	18.6	10.0	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1336.6	17000	0.0	2.0	4.7	14.0
9595	10.0	8.3	14.6	10.3	2.0	1.4	0	0.0	1	0.0	0	0.0	1	6.6	0.005	1619.7	17000	0.0	2.0	2.9	10.0
9385	18.0	8.9	15.8	9.5	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.3	0.006	1770.4	17000	0.2	2.0	3.4	18.0
9220	18.0	9.2	16.4	8.9	2.0	1.4	0	0.0	1	0.0	0	0.0	1	4.9	0.008	1771.4	17000	0.1	2.0	3.6	18.0
9025	18.0	8.9	15.9	8.9	2.0	1.4	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1736.9	17000	0.1	2.0	3.4	18.0
MAX=	21.0	19.7			8.1	2.9						0.0					17000.0	11.3	2.0	8.3	21.0
MIN=	8.0	4.8			2.0	0.0						0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM W/ SAM -- SANTA CLARA RIVER EXISTING CONDITIONS STRAIGHT-INSIDE CURVED REACH-Q_{50} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	14.0	11.1	21.7	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	14.0	12.7	24.1	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	14.0	10.4	20.3	19.2	2.8	0.0	0	0.0	1	0.0	0	0.0	0	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	14.0	13.1	26.1	16.5	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	14.0	9.8	19.2	21.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	14.0	12.5	26.2	15.4	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	15.4	15.4	19.9	19.5	8.1	0.0	0	0.0	1	0.0	0	0.0	0	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	17.0	17.0	26.7	13.8	8.1	0.0	0	0.0	1	0.0	0	0.0	0	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	15.8	15.8	28.8	11.3	8.1	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	16.3	16.3	26.1	12.4	8.1	0.0	0	0.0	1	0.0	0	0.0	0	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	15.5	15.5	26.6	10.8	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	15.4	15.4	24.1	10.6	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.5	0.016	878.5	9000	0.0	2.0	5.3	14.0
42590	14.6	14.6	22.6	8.9	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.1	0.014	1023.2	9000	0.0	2.0	4.5	14.0
42430	14.9	14.9	20.8	9.6	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.9	0.012	940.5	9000	0.0	2.0	4.8	14.0
42215	11.6	11.6	10.4	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	0	8.5	0.002	1310.4	9000	0.0	2.0	1.5	10.0
41940	11.9	11.9	11.6	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	0	7.6	0.002	1321.5	9000	0.0	2.0	1.8	10.0
41730	12.0	12.0	11.8	14.7	8.1	0.0	0	0.0	1	0.0	0	0.0	0	8.0	0.002	1229.5	9000	0.0	2.0	1.9	10.0
41460	11.9	11.9	11.5	16.2	8.1	0.0	0	0.0	1	0.0	0	0.0	0	7.6	0.002	1329.0	9000	0.0	2.0	1.8	10.0
41280	12.5	11.2	16.5	14.3	5.2	0.3	0	0.0	1	0.0	0	0.0	0	8.2	0.004	852.1	9000	0.0	2.0	3.7	12.5
41080	14.0	12.8	19.9	12.1	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.7	0.007	874.2	9000	0.0	2.0	5.3	14.0
40825	14.0	11.9	18.0	11.5	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.2	0.007	1039.9	9000	0.0	2.0	4.4	14.0
40585	12.5	11.4	17.0	11.7	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.8	0.006	1005.9	9000	0.0	2.0	3.9	12.5
40335	10.0	9.2	11.1	14.5	5.2	0.3	0	0.0	1	0.0	0	0.0	0	7.1	0.002	1504.8	9000	0.0	2.0	1.7	10.0
40130	10.0	9.2	11.2	15.1	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.9	0.002	1636.5	9000	0.0	2.0	1.7	10.0
39945	10.0	8.9	10.3	16.1	5.2	0.3	0	0.0	1	0.0	0	0.0	0	7.6	0.001	1648.1	9000	0.0	2.0	1.4	10.0
39755	12.5	10.7	15.4	13.5	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.6	0.003	1251.4	9000	0.0	2.0	3.2	12.5
39605	14.0	12.6	19.4	11.4	5.2	0.3	0	0.0	1	0.0	0	0.0	0	5.8	0.007	1100.6	9000	0.0	2.0	5.1	14.0
39310	12.5	11.0	16.0	12.4	5.2	0.3	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1204.5	9000	0.0	2.0	3.5	12.5
39100	10.0	9.6	12.4	14.1	5.2	0.3	0	0.0	1	0.0	0	0.0	0	7.8	0.002	1294.8	9000	0.0	2.0	2.1	10.0
38925	10.0	9.3	11.4	14.5	5.2	0.3	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1181.3	9000	0.0	2.0	1.8	10.0
38710	10.0	6.2	10.6	15.9	2.7	0.0	0	0.0	1	0.0	0	0.0	0	10.8	0.001	1043.1	9000	0.0	2.0	1.5	10.0
38475	12.5	9.0	17.8	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	0	8.8	0.004	755.4	9000	0.0	2.0	4.3	12.5
38300	14.0	9.6	22.7	9.8	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.010	688.1	9000	0.0	2.0	4.9	14.0
38065	10.0	7.4	14.1	14.2	2.7	0.0	0	0.0	1	0.0	0	0.0	0	12.0	0.002	678.3	9000	0.0	2.0	2.7	10.0
37810	14.0	9.2	18.2	12.2	2.7	0.0	0	0.0	1	0.0	0	0.0	0	10.2	0.004	622.3	9000	0.0	2.0	4.5	14.0
37655	14.0	9.8	21.2	10.3	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.009	735.9	9000	0.0	2.0	5.1	14.0
37390	14.0	7.8	23.9	6.1	2.7	0.0	0	0.0	1	0.0	0	0.0	0	5.4	0.017	892.2	9000	0.0	2.0	3.1	14.0
37135	12.5	8.6	17.0	8.0	2.7	0.0	0	0.0	1	0.0	0	0.0	0	6.4	0.006	1088.9	9000	0.0	2.0	3.9	12.5
36930	14.0	8.6	18.3	7.9	2.7	0.0	0	0.0	1	0.0	0	0.0	0	6.0	0.007	1112.0	9000	0.0	2.0	3.9	14.0
36735	12.5	7.7	15.0	9.6	2.7	0.0	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1195.7	9000	0.0	2.0	3.0	12.5
36515	12.5	8.5	16.7	9.6	2.7	0.0	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1306.1	9000	0.0	2.0	3.8	12.5
36265	10.0	7.0	13.0	11.2	2.7	0.0	0	0.0	1	0.0	0	0.0	0	6.4	0.003	1373.1	9000	0.0	2.0	2.3	10.0
36080	10.0	7.9	12.5	11.7	3.2	0.6	0	0.0	1	0.0	0	0.0	0	6.4	0.004	1455.4	9000	0.0	2.0	2.1	10.0
35845	10.0	7.4	10.9	13.5	3.2	0.6	0	0.0	1	0.0	0	0.0	0	7.4	0.002	1496.2	9000	0.0	2.0	1.6	10.0
35725	10.0	8.7	14.7	13.0	3.2	0.6	0	0.0	1	0.0	0	0.0	0	6.3	0.003	1431.2	9000	0.0	2.0	2.9	10.0
35515	12.5	9.7	17.1	11.9	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.7	0.005	1353.4	9000	0.0	2.0	3.9	12.5
35245	10.0	8.6	14.5	12.5	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.8	0.003	1555.5	9000	0.0	2.0	2.8	10.0
35040	14.0	10.9	19.5	10.7	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1355.9	9000	0.0	2.0	5.1	14.0
34860	14.0	10.2	18.1	10.1	3.2	0.6	0	0.0	1	0.0	0	0.0	0	4.8	0.008	1338.9	9000	0.0	2.0	4.4	14.0
34720	14.0	10.2	18.2	9.3	3.2	0.6	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1411.5	9000	0.0	2.0	4.4	14.0
34495	14.0	10.2	18.1	8.9	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.0	0.009	1277.2	9000	0.0	2.0	4.4	14.0
34310	12.5	9.9	17.6	9.0	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.7	0.005	1280.8	9000	0.0	2.0	4.2	12.5
34090	12.5	9.7	17.2	8.6	3.2	0.6	0	0.0	1	0.0	0	0.0	0	5.4	0.007	1267.8	9000	0.0	2.0	4.0	12.5
33880	12.5	8.7	15.8	9.8	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.6	0.005	1310.6	9000	0.0	2.0	3.3	12.5
33710	12.5	9.1	16.5	9.4	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.2	0.007	1355.1	9000	0.0	2.0	3.7	12.5
33500	12.5	8.7	15.8	9.5	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.4	0.006	1474.3	9000	0.0	2.0	3.4	12.5
33310	12.5	8.8	15.9	9.1	3.4	0.0	0	0.0	1	0.0	0	0.0	0	4.2	0.006	1744.5	9000	0.0	2.0	3.4	12.5
33115	12.5	8.6	15.5	8.7	3.4	0.0	0	0.0	1	0.0	0	0.0	0	4.8	0.009	1573.2	9000	0.0	2.0	3.3	12.5
32795	10.0	7.4	12.2	11.0	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.5	0.003	1732.9	9000	0.0	2.0	2.0	10.0
32605	10.0	8.0	14.1	11.5	3.4	0.0	0	0.0	1	0.0	0	0.0	0	6.2	0.004	1344.6	9000	0.0	2.0	2.7	10.0
32265	12.5	7.8	16.7	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.6	0.007	1829.9	9000	0.0	2.0	3.8	12.5
31875	10.0	5.6	10.9	11.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.2	0.004	2482.2	9000	0.0	2.0	1.6	10.0
31585	12.5	7.7	16.6	9.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.0	0.009	2120.3	9000	0.0	2.0	3.7	12.5
31360	8.0	5.3	9.8	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.8	0.001	1884.4	9000	0.0	2.0	1.3	8.0
31060	8.0	4.8	7.9	15.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.5	0.001	1711.5	9000	0.0	2.0	0.8	8.0
30720	8.0	4.6	6.4	18.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.6	0.000	1891.7	9000	0.0	2.0	0.6	8.0
30445	8.0	4.5	6.0	19.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	13.1	0.000	1783.7	9000	0.0	2.0	0.5	8.0
30095	8.0	4.6	6.6	21.7	2.0	0.0	0	0.0	1	0.0	0	0.0	0	12.7	0.000	1730.3	9000	0.0	2.0	0.6	8.0
29815	8.0	4.8	7.7	22.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.7	0.000	1675.2	9000	0.0	2.0	0.8	8.0
29565	8.0	4.7	7.4	23.3	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.8	0.000	1717.4	9000	0.0	2.0	0.7	8.0
29385	8.0	5.0	8.5	24.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.8	0.000	1675.1	9000	0.0	2.0	1.0	8.0
29140	10.6	10.6	10.1	24.3	4.4	2.9	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1557.6	9000	0.0	2.0	1.4	10.0
28895	14.5	14.5	19.7	22.4	4.4	2.9	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1062.3	9000	0.0	2.0	5.2	14.0
28695	17.3	17.3	27.5	16.0	4.4	2.9	0	0.0	1	0.0	0	0.0	0	9.4	0.009	544.9	9000	0.0	2.0	8.0	14.0
28500	16.1	16.1	28.6	13.6	4.4	2.9	0	0.0	1	0.0	0	0.0	0	9.8	0.010	503.7	9000	0.0	2.0	6.8	14.0
28280	15.2	15.2	29.7	11.8	4.4	2.9	0	0.0	1	0.0	0	0.0	0	8.8	0.011	549.3	9000	0.0	2.0	5.9	14.0
28080	15.0	15.0	28.1	11.4	4.4	2.9	0	0.0	1	0.0	0	0.0	0	9.2	0.011	547.6	9000	0.0	2.0	5.7	14.0
27925	13.6	13.6	18.0	17.5	4.4	2.9	0	0.0	1	0.0	0	0.0	0	13.0	0.002	612.7	9000	0.0	2.0	4.3	12.5
27725	15.0	15.0	20.5	16.3	4.4	2.9	0	0.0	1	0.0	0	0.0	0	12.1	0.003	587.1	9000	0.0	2.0	5.7	14.0
27545	15.9	15.9	24.7	13.2	4.4	2.9	0	0.0	1	0.0	0	0.0	0	9.5	0.007	613.0	9000	0.0	2.0	6.6	14.0
27335	15.3	15.3	25.5	12.0	4.4	2.9	0	0.0	1	0.0	0	0.0	0	8.1	0.008	691.0	9000	0.0	2.0	6.0	14.0
27155	15.9	15.9	22.3	13.2	4.4	2.9	0	0.0	1	0.0	0	0.0	0	8.0	0.005	856.6	9000	0.0	2.0	6.6	14.0
26990	14.0	10.0	23.5	11.2	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.0	0.010	1008.2	9000	0.0	2.0	5.6	14.0
26780	14.0	9.9	23.9	11.0	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.6	0.010	1131.7	9000	0.0	2.0	5.5	14.0
26575	14.0	9.9	21.0	11.0	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.5	0.013	1216.4	3000	0.0	2.0	5.5	14.0
26355	12.5	7.8	15.8	13.4	2.0	0.4	0	0.0	1	0.0	0	0.0	0	7.5	0.003	1282.4	3000	0.0	2.0	3.4	12.5
26170	12.5	8.8	18.0	13.0	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.8	0.004	1347.9	3000	0.0	2.0	4.4	12.5
25965	12.5	8.7	17.9	13.0	2.0	0.4	0	0.0	1	0.0	0	0.0	0	7.0	0.004	1288.3	3000	0.0	2.0	4.3	12.5

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET FROM SAM
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25785	14.0	9.6	19.5	11.7	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.2	0.005	1336.9	3000	0.0	2.0	5.2	14.0
25600	14.0	10.0	20.6	11.3	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1596.5	3000	0.0	2.0	5.6	14.0
25425	14.0	9.8	20.0	11.3	2.0	0.4	0	0.0	1	0.0	0	0.0	0	4.4	0.008	1773.8	3000	0.0	2.0	5.4	14.0
25215	10.0	7.2	14.5	13.6	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.1	0.003	1748.6	3000	0.0	2.0	2.8	10.0
25000	12.5	8.5	17.4	12.2	2.0	0.4	0	0.0	1	0.0	0	0.0	0	4.4	0.006	2103.2	3000	0.0	2.0	4.1	12.5
24795	14.0	8.9	19.0	11.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	3.9	0.007	2311.7	3000	0.0	2.0	4.9	14.0
24550	14.0	9.4	21.3	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	3.8	0.009	2227.0	3000	0.0	2.0	5.4	14.0
24335	10.0	6.8	14.5	13.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.7	0.003	2089.5	3000	0.0	2.0	2.8	10.0
24115	14.0	8.8	18.8	11.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.5	0.008	2015.8	3000	0.0	2.0	4.8	14.0
23975	14.0	8.9	19.0	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.6	0.008	1913.7	3000	0.0	2.0	4.9	14.0
23755	12.5	7.8	16.7	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.1	0.006	1935.4	3000	0.0	2.0	3.8	12.5
23565	10.0	6.8	14.5	12.7	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.6	0.004	2039.5	3000	0.0	2.0	2.8	10.0
23365	12.5	7.9	17.0	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.4	0.006	1781.4	3000	0.0	2.0	3.9	12.5
23180	10.0	6.3	13.2	11.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.6	0.002	2084.2	3000	0.0	2.0	2.3	10.0
23000	8.0	5.1	8.9	13.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.7	0.001	2069.1	3000	0.0	2.0	1.1	8.0
22790	8.0	5.2	9.4	13.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.8	0.001	1949.0	3000	0.0	2.0	1.2	8.0
22600	10.0	5.7	11.4	14.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.9	0.001	1865.2	3000	0.0	2.0	1.7	10.0
22415	10.0	5.9	11.8	14.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.1	0.002	1705.6	3000	0.0	2.0	1.9	10.0
22195	10.0	7.3	14.1	13.7	2.0	0.6	0	0.0	1	0.0	0	0.0	0	7.8	0.003	1322.2	3000	0.0	2.0	2.7	10.0
22010	12.5	8.1	16.0	14.4	2.0	0.6	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1328.0	3000	0.0	2.0	3.5	12.5
21790	14.0	9.8	19.7	11.6	2.0	0.6	0	0.0	1	0.0	0	0.0	0	6.5	0.006	1145.7	3000	0.0	2.0	5.2	14.0
21615	14.0	8.9	21.4	8.5	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.8	0.010	1161.3	3000	0.0	2.0	4.3	14.0
21440	14.0	9.4	20.1	9.7	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.0	0.008	1574.6	3000	0.0	2.0	4.8	14.0
21225	14.0	9.7	19.5	10.6	2.0	0.6	0	0.0	1	0.0	0	0.0	0	3.9	0.008	2217.7	3000	0.0	2.0	5.1	14.0
21020	14.0	9.0	20.8	8.9	2.0	0.6	0	0.0	1	0.0	0	0.0	0	4.6	0.009	1676.4	3000	0.0	2.0	4.4	14.0
20845	12.5	8.5	17.1	10.4	2.0	0.6	0	0.0	1	0.0	0	0.0	0	4.2	0.006	2369.3	3000	0.0	2.0	3.9	12.5
20595	12.5	7.7	15.2	10.9	2.0	0.6	0	0.0	1	0.0	0	0.0	0	4.7	0.003	2463.7	3000	0.0	2.0	3.1	12.5
20435	10.0	6.9	12.9	12.2	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.4	0.002	2582.7	3000	0.0	2.0	2.3	10.0
20280	10.0	7.2	14.0	11.8	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.0	0.003	2589.6	3000	0.0	2.0	2.6	10.0
20070	14.0	9.2	20.2	9.2	2.0	0.6	0	0.0	1	0.0	0	0.0	0	4.7	0.009	1767.5	3000	0.0	2.0	4.6	14.0
19855	12.5	8.3	17.8	9.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.8	0.006	1975.1	3000	0.0	2.0	4.3	12.5
19630	12.5	8.3	17.9	8.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.9	0.006	1836.2	3000	0.0	2.0	4.3	12.5
19440	10.0	5.9	11.9	12.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.5	0.002	2095.3	3000	0.0	2.0	1.9	10.0
19240	10.0	6.6	13.9	11.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.6	0.003	2091.7	3000	0.0	2.0	2.6	10.0
19050	10.0	5.6	11.0	12.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.7	0.002	2160.8	3000	0.0	2.0	1.6	10.0
18830	10.0	5.5	10.7	14.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.1	0.002	2094.4	3000	0.0	2.0	1.5	10.0
18650	8.0	5.3	9.9	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.0	0.001	2022.7	3000	0.0	2.0	1.3	8.0
18475	8.0	4.9	8.1	16.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1944.4	3000	0.0	2.0	0.9	8.0
18290	8.0	5.0	8.7	16.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1843.7	3000	0.0	2.0	1.0	8.0
18025	8.0	4.8	7.8	18.2	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.5	0.001	1610.9	17000	0.0	2.0	0.8	8.0
17785	8.0	5.0	8.7	19.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.6	0.001	1417.5	17000	0.0	2.0	1.0	8.0
17510	10.0	7.8	14.0	18.0	2.0	1.2	0	0.0	1	0.0	0	0.0	0	8.5	0.002	1243.6	17000	0.0	2.0	2.6	10.0
17360	12.5	9.1	17.0	16.9	2.0	1.2	0	0.0	1	0.0	0	0.0	0	8.9	0.004	936.6	17000	0.0	2.0	3.9	12.5
17110	14.0	11.6	21.7	15.4	2.0	1.2	0	0.0	1	0.0	0	0.0	0	5.6	0.006	1274.3	17000	0.0	2.0	6.4	14.0
16970	14.0	12.0	22.9	13.6	2.0	1.2	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1125.6	17000	0.0	2.0	6.8	14.0
16720	14.0	9.7	25.2	9.0	2.0	1.2	0	0.0	1	0.0	0	0.0	0	4.1	0.018	1404.6	17000	0.0	2.0	4.5	14.0
16515	14.0	10.0	21.5	9.5	2.0	1.2	0	0.0	1	0.0	0	0.0	0	4.3	0.012	1622.6	17000	0.0	2.0	4.8	14.0
16305	14.0	10.0	21.5	9.6	2.0	1.2	0	0.0	1	0.0	0	0.0	0	4.2	0.011	1812.8	17000	0.0	2.0	4.8	14.0
16130	12.5	8.7	16.1	10.2	2.0	1.2	0	0.0	1	0.0	0	0.0	0	5.2	0.005	1945.1	17000	0.0	2.0	3.5	12.5
15960	12.5	8.6	15.8	9.3	2.0	1.2	0	0.0	1	0.0	0	0.0	0	4.1	0.011	2180.9	17000	0.0	2.0	3.4	12.5
15745	10.0	6.8	10.9	10.6	2.0	1.2	0	0.0	1	0.0	0	0.0	0	5.7	0.003	2279.0	17000	0.0	2.0	1.6	10.0
15540	10.0	6.8	11.0	10.6	2.0	1.2	0	0.0	1	0.0	0	0.0	0	5.8	0.003	2324.2	17000	0.0	2.0	1.6	10.0
15335	10.0	7.4	12.7	10.5	2.0	1.2	0	0.0	1	0.0	0	0.0	0	4.9	0.005	2302.1	17000	0.0	2.0	2.2	10.0
15125	12.5	8.1	16.2	9.6	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.5	0.007	1618.5	17000	0.0	2.0	3.5	12.5
14900	10.0	7.5	14.5	10.4	2.0	0.6	0	0.0	1	0.0	0	0.0	0	6.1	0.004	1704.5	17000	0.0	2.0	2.9	10.0
14720	12.5	8.4	16.8	9.3	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.1	0.008	1763.5	17000	0.0	2.0	3.8	12.5
14480	10.0	7.3	14.3	10.2	2.0	0.6	0	0.0	1	0.0	0	0.0	0	6.0	0.004	1801.7	17000	0.0	2.0	2.7	10.0
14315	10.0	7.6	14.8	9.4	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1868.1	17000	0.0	2.0	3.0	10.0
14090	10.0	7.2	13.8	9.0	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.9	0.005	1766.8	17000	0.0	2.0	2.6	10.0
13850	12.5	7.9	15.6	8.4	2.0	0.6	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1727.3	17000	0.0	2.0	3.3	12.5
13635	12.5	7.8	15.4	10.3	2.0	0.6	0	0.0	1	0.0	0	0.0	0	6.4	0.004	1691.9	17000	0.0	2.0	3.2	12.5
13425	12.5	8.6	17.3	8.3	2.0	0.6	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1854.4	17000	0.0	2.0	4.0	12.5
13190	10.0	6.6	12.2	9.5	2.0	0.6	0	0.0	1	0.0	0	0.0	0	6.4	0.003	1847.3	17000	0.0	2.0	2.0	10.0
13030	10.0	6.7	14.2	9.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1763.0	17000	0.0	2.0	2.7	10.0
12835	10.0	6.4	13.3	10.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	6.1	12.4	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.7	0.002	1471.0	17000	0.0	2.0	2.1	10.0
12395	10.0	6.0	12.3	11.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1438.4	17000	0.0	2.0	2.0	10.0
12195	10.0	5.5	10.6	12.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.3	0.001	1389.3	17000	0.0	2.0	1.5	10.0
11995	10.0	6.2	12.7	13.7	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.8	0.002	1281.1	17000	0.0	2.0	2.2	10.0
11780	10.0	6.1	12.5	14.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1400.9	17000	0.0	2.0	2.1	10.0
11605	10.0	6.7	14.1	13.7	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.7	0.002	1282.9	17000	0.0	2.0	2.7	10.0
11405	10.0	6.3	13.2	15.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.1	0.002	1130.2	17000	0.0	2.0	2.3	10.0
11180	12.5	7.7	16.6	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.0	10.3	19.1	13.3	2.0	1.4	0	0.0	1	0.0	0	0.0	0	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	14.0	10.8	21.9	10.9	2.0	1.4	0	0.0	1	0.0	0	0.0	0	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	14.0	9.1	24.1	7.5	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	14.0	9.8	22.7	8.8	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.8	0.008	1247.1	17000	0.0	2.0	4.4	14.0
10225	12.5	9.7	17.8	9.5	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.9	0.007	1373.8	17000	0.0	2.0	4.3	12.5
10000	10.0	8.4	14.9	11.1	2.0	1.4	0	0.0	1	0.0	0	0.0	0	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.0	10.1	18.6	10.0	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1336.6	17000	0.0	2.0	4.7	14.0
9595	10.0	8.3	14.6	10.3	2.0	1.4	0	0.0	1	0.0	0	0.0	0	6.6	0.005	1619.7	17000	0.0	2.0	2.9	10.0
9385	12.5	8.8	15.8	9.5	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.3	0.006	1770.4	17000	0.0	2.0	3.4	12.5
9220	12.5	9.0	16.4	8.9	2.0	1.4	0	0.0	1	0.0	0	0.0	0	4.9	0.008	1771.4	17000	0.0	2.0	3.6	12.5
9025	12.5	8.8	15.9	8.9	2.0	1.4	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1736.9	17000	0.0	2.0	3.4	12.5
MAX=	17.3	17.3			8.1	2.9						0.0					17000.0	0.0	2.0	8.3	14.0
MIN=	8.0	4.5			2.0	0.0						0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM W/ SAM -- SANTA CLARA RIVER PROPOSED CONDITIONS OUTSIDE CURVED REACH Q_{-AP} n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	14.0	11.1	21.7	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	14.0	12.7	24.1	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	14.0	10.4	20.3	19.2	2.8	0.0	0	0.0	1	0.0	0	0.0	1	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	14.0	13.1	26.1	16.5	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	14.0	9.8	19.2	21.1	2.8	0.0	0	0.0	1	0.0	0	0.0	1	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	14.0	12.5	26.2	15.4	2.8	0.0	0	0.0	1	0.0	0	0.0	1	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	15.4	15.4	19.9	19.5	8.1	0.0	0	0.0	1	0.0	0	0.0	1	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	17.0	17.0	26.7	13.8	8.1	0.0	0	0.0	1	0.0	0	0.0	1	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	15.8	15.8	28.8	11.3	8.1	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	16.3	16.3	26.1	12.4	8.1	0.0	0	0.0	1	0.0	0	0.0	1	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	15.5	15.5	26.6	10.8	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	15.5	15.5	23.9	10.7	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.6	0.016	864.3	9000	0.0	2.0	5.4	14.0
42590	21.0	15.1	22.4	9.2	8.1	0.0	0	0.0	1	0.0	0	0.0	1	5.2	0.014	1013.1	9000	0.4	2.0	4.6	21.0
42430	21.0	15.4	19.6	10.7	8.1	0.0	0	0.0	1	0.0	0	0.0	1	6.4	0.009	915.8	9000	0.1	2.0	5.2	21.0
42215	21.0	15.2	18.5	11.2	8.1	0.0	0	0.0	1	0.0	0	0.0	1	6.1	0.009	1019.0	9000	0.5	2.0	4.6	21.0
41940	15.0	13.4	11.6	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	1	7.7	0.002	1284.2	9000	1.4	2.0	1.8	15.0
41730	15.0	13.2	11.8	14.7	8.1	0.0	0	0.0	1	0.0	0	0.0	1	8.2	0.002	1190.9	9000	1.2	2.0	1.9	15.0
41460	15.0	12.8	11.6	16.2	8.1	0.0	0	0.0	1	0.0	0	0.0	1	9.1	0.002	1093.5	9000	0.9	2.0	1.8	15.0
41280	12.5	10.9	16.4	14.4	5.2	0.1	0	0.0	1	0.0	0	0.0	1	8.3	0.004	852.3	9000	0.0	2.0	3.6	12.5
41080	14.0	12.7	19.9	12.1	5.2	0.1	0	0.0	1	0.0	0	0.0	1	6.7	0.008	874.1	9000	0.0	2.0	5.4	14.0
40825	21.0	12.2	18.0	11.5	5.2	0.1	0	0.0	1	0.0	0	0.0	1	6.2	0.007	1040.4	9000	0.5	2.0	4.4	21.0
40585	18.0	11.6	17.0	11.7	5.2	0.1	0	0.0	1	0.0	0	0.0	1	6.8	0.006	1005.8	9000	0.4	2.0	3.9	18.0
40335	15.0	10.2	10.5	15.1	5.2	0.1	0	0.0	1	0.0	0	0.0	1	8.8	0.002	1249.6	9000	1.4	2.0	1.5	15.0
40130	15.0	10.3	11.3	15.5	5.2	0.1	0	0.0	1	0.0	0	0.0	1	8.8	0.002	1195.6	9000	1.3	2.0	1.7	15.0
39945	15.0	10.2	11.0	16.3	5.2	0.1	0	0.0	1	0.0	0	0.0	1	9.3	0.002	1173.3	9000	1.3	2.0	1.6	15.0
39755	12.5	11.0	16.5	13.3	5.2	0.1	0	0.0	1	0.0	0	0.0	1	8.1	0.004	894.5	9000	0.0	2.0	3.7	12.5
39605	14.0	12.5	19.7	11.5	5.2	0.1	0	0.0	1	0.0	0	0.0	1	7.1	0.007	849.7	9000	0.0	2.0	5.2	14.0
39310	18.0	11.2	16.5	12.7	5.2	0.1	0	0.0	1	0.0	0	0.0	1	8.1	0.004	931.1	9000	0.2	2.0	3.7	18.0
39100	14.0	12.5	20.9	10.4	5.2	0.1	0	0.0	1	0.0	0	0.0	1	7.2	0.009	761.1	9000	0.0	2.0	5.2	14.0
38925	10.0	9.5	12.8	14.3	5.2	0.1	0	0.0	1	0.0	0	0.0	1	10.3	0.002	873.5	9000	0.0	2.0	2.2	10.0
38710	10.0	6.7	12.0	15.6	2.7	0.0	0	0.0	1	0.0	0	0.0	1	11.7	0.002	820.3	9000	0.0	2.0	2.0	10.0
38475	12.5	9.0	17.9	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	1	9.8	0.004	659.7	9000	0.0	2.0	4.3	12.5
38300	14.0	9.8	22.5	10.3	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.7	0.010	666.3	9000	0.0	2.0	5.1	14.0
38065	10.0	7.6	14.5	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	1	12.0	0.002	658.4	9000	0.0	2.0	2.9	10.0
37810	14.0	9.2	18.2	12.2	2.7	0.0	0	0.0	1	0.0	0	0.0	1	10.2	0.004	618.2	9000	0.0	2.0	4.5	14.0
37655	14.0	10.0	20.9	10.5	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.8	0.008	706.7	9000	0.0	2.0	5.3	14.0
37390	14.0	8.0	23.7	6.5	2.7	0.0	0	0.0	1	0.0	0	0.0	1	5.9	0.015	823.8	9000	0.0	2.0	3.3	14.0
37135	12.5	8.4	16.6	9.3	2.7	0.0	0	0.0	1	0.0	0	0.0	1	8.5	0.005	821.4	9000	0.0	2.0	3.7	12.5
36930	14.0	8.8	19.8	8.1	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.2	0.008	812.4	9000	0.0	2.0	4.1	14.0
36735	12.5	8.2	16.1	9.8	2.7	0.0	0	0.0	1	0.0	0	0.0	1	8.0	0.005	896.9	9000	0.0	2.0	3.5	12.5
36515	15.0	7.3	12.9	12.0	2.7	0.0	0	0.0	1	0.0	0	0.0	1	9.0	0.002	994.7	9000	0.4	2.0	2.2	15.0
36265	15.0	7.7	12.3	12.5	2.7	0.0	0	0.0	1	0.0	0	0.0	1	7.9	0.003	1176.0	9000	0.9	2.0	2.1	15.0
36080	22.9	22.9	14.7	11.6	3.2	0.7	0.9	2.0	1	0.0	0	13.3	1	6.7	0.006	1176.0	9000	0.9	2.0	2.9	15.0
35845	15.0	9.2	11.0	13.6	3.2	0.7	0	0.0	1	0.0	0	0.0	1	7.9	0.002	1401.7	9000	1.7	2.0	1.6	15.0
35725	15.0	10.7	15.0	13.0	3.2	0.7	0	0.0	1	0.0	0	0.0	1	6.5	0.004	1377.9	9000	1.8	2.0	3.0	15.0
35515	18.0	11.5	17.1	12.0	3.2	0.7	0	0.0	1	0.0	0	0.0	1	6.0	0.005	1354.8	9000	1.7	2.0	3.9	18.0
35245	18.0	11.4	17.3	11.3	3.2	0.7	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1328.3	9000	1.5	2.0	4.0	18.0
35040	21.0	12.7	19.6	10.7	3.2	0.7	0	0.0	1	0.0	0	0.0	1	5.5	0.006	1354.8	9000	1.7	2.0	5.2	21.0
34860	21.0	11.6	18.4	10.0	3.2	0.7	0	0.0	1	0.0	0	0.0	1	4.9	0.009	1285.7	9000	1.2	2.0	4.6	21.0
34720	21.0	11.8	18.4	9.2	3.2	0.7	0	0.0	1	0.0	0	0.0	1	4.5	0.009	1411.2	9000	1.4	2.0	4.6	21.0
34495	18.0	10.9	17.4	9.0	3.2	0.7	0	0.0	1	0.0	0	0.0	1	5.2	0.009	1283.9	9000	1.0	2.0	4.1	18.0
34310	18.0	10.8	16.8	9.3	3.2	0.7	0	0.0	1	0.0	0	0.0	1	5.9	0.005	1308.5	9000	1.2	2.0	3.8	18.0
34090	18.0	10.8	17.0	8.6	3.2	0.7	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1295.5	9000	1.0	2.0	3.9	18.0
33880	18.0	10.2	16.6	9.3	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.3	0.007	1318.4	9000	1.2	2.0	3.7	18.0
33710	18.0	9.9	15.4	9.7	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1372.1	9000	1.3	2.0	3.2	18.0
33500	18.0	10.4	16.2	9.3	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.1	0.007	1496.0	9000	1.5	2.0	3.5	18.0
33310	18.0	10.9	15.8	9.0	3.4	0.0	0	0.0	1	0.0	0	0.0	1	4.2	0.006	1770.4	9000	2.1	2.0	3.4	18.0
33115	15.0	9.0	10.4	10.6	3.4	0.0	0	0.0	1	0.0	0	0.0	1	6.1	0.003	1847.3	9000	2.1	2.0	1.4	15.0
32795	15.0	9.9	13.0	10.6	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.2	0.004	1735.6	9000	2.3	2.0	2.3	15.0
32605	15.0	10.5	14.4	11.1	3.4	0.0	0	0.0	1	0.0	0	0.0	1	5.0	0.005	1699.9	9000	2.3	2.0	2.8	15.0
32265	18.0	9.9	15.9	10.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.8	0.006	1853.2	9000	2.5	2.0	3.4	18.0
31875	15.0	9.1	12.4	10.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	4.7	0.006	2409.2	9000	3.0	2.0	2.1	15.0
31585	15.0	8.6	10.9	11.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.9	0.003	2182.2	9000	3.0	2.0	1.6	15.0
31360	15.0	8.3	10.3	13.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.002	1878.7	9000	2.8	2.0	1.4	15.0
31060	12.0	7.5	8.2	15.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.1	0.001	1708.2	9000	2.6	2.0	0.9	12.0
30720	12.0	7.9	6.7	17.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.2	0.001	1888.6	9000	3.3	2.0	0.6	12.0
30445	12.0	7.9	6.3	19.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	12.7	0.000	1779.7	9000	3.3	2.0	0.5	12.0
30095	12.0	8.1	6.7	21.3	2.0	0.0	0	0.0	1	0.0	0	0.0	1	13.4	0.000	1622.7	9000	3.5	2.0	0.6	12.0
29815	12.0	7.7	7.7	21.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	13.5	0.000	1433.2	9000	2.9	2.0	0.8	12.0
29565	12.0	7.1	7.4	22.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	14.8	0.000	1323.8	9000	2.4	2.0	0.7	12.0
29385	12.0	7.0	8.3	23.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	14.4	0.000	1237.4	9000	2.1	2.0	0.9	12.0
29140	12.0	10.4	9.2	24.1	4.4	1.6	0	0.0	1	0.0	0	0.0	1	14.1	0.001	1087.2	9000	1.2	2.0	1.1	12.0
28895	21.0	13.5	18.8	22.5	4.4	1.6	0	0.0	1	0.0	0	0.0	1	9.9	0.002	972.1	9000	0.8	2.0	4.8	21.0
28695	15.0	15.0	28.9	14.0	4.4	1.6	0	0.0	1	0.0	0	0.0	1	5.4	0.025	899.4	9000	0.0	2.0	7.0	14.0
28500	14.7	14.7	22.4	16.1	4.4	1.6	0	0.0	1	0.0	0	0.0	1	11.4	0.006	552.2	9000	0.0	2.0	6.8	14.0
28280	21.0	13.6	29.6	10.8	4.4	1.6	0	0.0	1	0.0	0	0.0	1	5.8	0.013	944.5	9000	0.3	2.0	5.4	21.0
28080	15.0	9.9	11.3	19.1	4.4	1.6	0	0.0	1	0.0	0	0.0	1	14.7	0.001	926.4	9000	0.2	2.0	1.7	15.0
27925	10.3	10.3	13.1	19.3	4.4	1.6	0	0.0	1	0.0	0	0.0	1	13.8	0.001	866.6	9000	0.0	2.0	2.3	10.0
27725	14.0	12.9	19.0	16.7	4.4	1.6	0	0.0	1	0.0	0	0.0	1	10.4	0.003	786.6	9000	0.0	2.0	4.9	14.0
27545	15.0	15.0	22.9	14.1	4.4	1.6	0	0.0	1	0.0	0	0.0	1	9.9	0.005	643.2	9000	0.0	2.0	7.0	14.0
27335	14.1	14.1	24.6	12.3	4.4	1.6	0	0.0	1	0.0	0	0.0	1	8.3	0.008	703.5	9000	0.0	2.0	6.2	14.0
27155	14.0	12.9	19.1	14.8	4.4	1.6	0	0.0	1	0.0	0	0.0	1	9.2	0.003	888.4	9000	0.0	2.0	4.9	14.0
26990	21.0	11.2	22.6	11.5	2.0	1.3	0	0.0	1	0.0	0	0.0	1	6.8	0.011	922.3	9000	0.1	2.0	5.7	21.0
26780	21.0	11.6	23.1	11.3	2.0	1.3	0	0.0	1	0.0	0	0.0	1	6.2	0.009	1043.3	9000	0.6	2.0	5.6	21.0
26575	21.0	16.0	20.7	11.1	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.7	0.012	1187.3	3000	5.2	2.0	5.6	21.0
26355	18.0	15.4	15.9	13.4	2.0	1.3	0	0.0	1	0.0	0	0.0	1	7.5	0.004	1260.4	3000	6.7	2.0	3.4	18.0
26170	18.0	16.6	17.0	13.5	2.0	1.3	0	0.0	1	0.0	0	0.0	1	7.6	0.003	1269.0	3000	7.4	2.0	3.9	18.0
25965	21.0	17.1	18.2	12.9	2.0	1.3	0	0.0	1	0.0	0	0.0	1	6.9	0.004	1281.3	3000	7.3	2.0	4.5	21.0
25785	21.0	16.7	18.9	12.1	2.0	1.3	0	0.0	1	0.0	0	0.0	1	6.9	0.005	1219.7	3000	6.5	2.0	4.8	21.0
25600	21.0	15.9	18.5	12.4	2.0	1.3	0	0.0	1	0.0	0	0.0	1	7.6	0.005	1109.4	3000	6.0	2.0	4.6	21.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET FROM SAM
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_t+	H/2	Z_{DM}=
25425	21.0	15.1	18.3	12.5	2.0	1.3	0	0.0	1	0.0	0	0.0	1	7.1	0.007	1082.2	3000	5.3	2.0	4.5	21.0
25215	15.0	14.0	14.3	14.7	2.0	1.3	0	0.0	1	0.0	0	0.0	1	9.0	0.003	1097.3	3000	6.0	2.0	2.7	15.0
25000	15.0	13.7	13.2	15.5	2.0	1.3	0	0.0	1	0.0	0	0.0	1	10.1	0.002	1062.4	3000	6.0	2.0	2.3	15.0
24795	15.0	12.3	14.1	15.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.5	0.002	957.4	3000	5.6	2.0	2.7	15.0
24550	18.0	12.4	15.1	16.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.0	0.003	856.1	3000	5.4	2.0	3.1	18.0
24335	21.0	13.0	18.2	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.1	0.004	764.8	3000	4.5	2.0	4.5	21.0
24115	21.0	13.5	20.0	13.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.4	0.006	754.2	3000	4.1	2.0	5.4	21.0
23975	21.0	13.9	20.8	12.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.7	0.007	783.2	3000	4.1	2.0	5.8	21.0
23755	21.0	13.2	18.1	14.7	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.7	0.004	815.7	3000	4.8	2.0	4.4	21.0
23565	21.0	14.5	20.2	14.3	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.2	0.007	850.9	3000	4.9	2.0	5.5	21.0
23365	21.0	14.3	18.4	14.3	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.7	0.004	939.0	3000	5.7	2.0	4.6	21.0
23180	21.0	15.8	21.9	12.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.0	0.005	916.6	3000	5.5	2.0	6.3	21.0
23000	21.0	13.0	22.0	11.3	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.2	0.010	784.0	3000	3.4	2.0	5.6	21.0
22790	26.8	26.8	17.9	13.0	2.0	0.0	0.9	2.0	1	0.0	0	14.7	1	10.0	0.005	784.0	3000	3.7	2.0	4.3	18.0
22600	21.0	14.8	19.8	12.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.6	0.006	999.0	3000	5.5	2.0	5.3	21.0
22415	21.0	14.0	21.3	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.6	0.010	1039.1	3000	4.6	2.0	5.4	21.0
22195	15.0	13.3	13.6	14.0	2.0	0.2	0	0.0	1	0.0	0	0.0	1	8.7	0.003	1309.6	3000	6.6	2.0	2.5	15.0
22010	18.0	15.3	16.1	14.3	2.0	0.2	0	0.0	1	0.0	0	0.0	1	7.6	0.003	1254.1	3000	7.6	2.0	3.5	18.0
21790	21.0	15.3	19.7	11.6	2.0	0.2	0	0.0	1	0.0	0	0.0	1	6.5	0.006	1144.5	3000	5.9	2.0	5.2	21.0
21615	21.0	12.5	21.3	8.5	2.0	0.2	0	0.0	1	0.0	0	0.0	1	5.8	0.011	1163.0	3000	4.1	2.0	4.3	21.0
21440	18.0	14.1	17.5	11.0	2.0	0.2	0	0.0	1	0.0	0	0.0	1	6.9	0.005	1286.1	3000	5.8	2.0	4.1	18.0
21225	21.0	16.3	18.1	11.7	2.0	0.2	0	0.0	1	0.0	0	0.0	1	5.6	0.005	1559.0	3000	7.7	2.0	4.4	21.0
21020	21.0	12.6	20.3	9.7	2.0	0.2	0	0.0	1	0.0	0	0.0	1	7.8	0.007	903.0	3000	3.6	2.0	4.9	21.0
20845	18.0	15.2	15.1	12.7	2.0	0.2	0	0.0	1	0.0	0	0.0	1	6.7	0.003	1563.7	3000	7.9	2.0	3.1	18.0
20595	15.0	14.1	12.4	13.4	2.0	0.2	0	0.0	1	0.0	0	0.0	1	8.3	0.002	1548.8	3000	7.8	2.0	2.1	15.0
20435	15.0	14.4	12.1	14.3	2.0	0.2	0	0.0	1	0.0	0	0.0	1	8.8	0.001	1528.3	3000	8.3	2.0	2.0	15.0
20280	18.0	15.4	15.6	12.8	2.0	0.2	0	0.0	1	0.0	0	0.0	1	6.8	0.003	1531.3	3000	8.0	2.0	3.3	18.0
20070	21.0	16.8	19.3	11.1	2.0	0.2	0	0.0	1	0.0	0	0.0	1	5.2	0.006	1526.6	3000	7.5	2.0	5.0	21.0
19855	21.0	14.5	20.6	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.0	0.008	1205.4	3000	5.4	2.0	5.1	21.0
19630	21.0	12.3	20.6	8.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.6	0.009	1060.3	3000	3.8	2.0	4.4	21.0
19440	15.0	12.2	13.1	13.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.2	0.002	1194.5	3000	5.9	2.0	2.3	15.0
19240	18.0	13.0	15.9	11.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.004	1216.9	3000	5.6	2.0	3.4	18.0
19050	21.0	14.1	18.8	10.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	5.8	0.009	1321.4	3000	5.4	2.0	4.8	21.0
18830	15.0	14.5	13.3	14.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.4	0.003	1531.5	3000	8.1	2.0	2.4	15.0
18650	15.0	14.7	12.1	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.0	0.002	1604.5	3000	8.8	2.0	2.0	15.0
18475	13.6	13.6	8.9	16.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.9	0.001	1621.5	3000	8.5	2.0	1.1	12.0
18290	14.1	14.1	9.8	16.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.4	0.001	1594.2	3000	8.9	2.0	1.3	12.0
18025	8.0	4.8	7.9	18.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	11.9	0.001	1520.2	17000	0.0	2.0	0.8	8.0
17785	8.0	5.0	8.5	20.2	2.0	0.0	0	0.0	1	0.0	0	0.0	1	12.0	0.001	1398.1	17000	0.0	2.0	1.0	8.0
17510	10.0	6.9	11.0	19.2	2.0	1.3	0	0.0	1	0.0	0	0.0	1	10.2	0.001	1350.7	17000	0.0	2.0	1.6	10.0
17360	12.5	9.2	17.1	15.9	2.0	1.3	0	0.0	1	0.0	0	0.0	1	8.8	0.004	943.2	17000	0.0	2.0	3.9	12.5
17110	14.0	12.0	22.3	15.2	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.8	0.007	1175.4	17000	0.0	2.0	6.7	14.0
16970	14.0	12.1	23.1	13.6	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.9	0.010	1067.0	17000	0.0	2.0	6.8	14.0
16720	14.0	9.9	24.4	9.2	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.2	0.019	1122.9	17000	0.0	2.0	4.6	14.0
16515	14.0	10.4	19.4	10.4	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.8	0.010	1249.9	17000	0.0	2.0	5.1	14.0
16305	10.0	7.1	11.6	14.6	2.0	1.3	0	0.0	1	0.0	0	0.0	1	9.4	0.002	1360.5	17000	0.0	2.0	1.8	10.0
16130	12.5	8.6	15.7	12.3	2.0	1.3	0	0.0	1	0.0	0	0.0	1	7.1	0.005	1326.5	17000	0.0	2.0	3.3	12.5
15960	12.5	9.5	17.7	11.0	2.0	1.3	0	0.0	1	0.0	0	0.0	1	5.9	0.008	1386.0	17000	0.0	2.0	4.2	12.5
15745	10.0	7.3	12.3	13.3	2.0	1.3	0	0.0	1	0.0	0	0.0	1	8.4	0.003	1363.9	17000	0.0	2.0	2.0	10.0
15540	10.0	6.8	10.6	13.7	2.0	1.3	0	0.0	1	0.0	0	0.0	1	9.4	0.002	1426.6	17000	0.0	2.0	1.5	10.0
15335	12.5	8.8	16.2	12.1	2.0	1.3	0	0.0	1	0.0	0	0.0	1	8.2	0.006	1064.1	17000	0.0	2.0	3.5	12.5
15125	26.1	26.1	17.9	11.6	2.0	0.4	0.9	4.0	1	0.0	0	17.4	1	8.0	0.007	1000.5	17000	0.0	2.0	4.3	12.5
14900	14.0	9.3	19.3	9.8	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.3	0.009	1626.5	17000	0.0	2.0	4.9	14.0
14720	21.0	8.9	18.1	9.8	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.0	0.008	1722.3	17000	0.1	2.0	4.4	21.0
14480	21.0	8.9	19.0	8.9	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.2	0.010	1726.7	17000	0.1	2.0	4.4	21.0
14315	15.0	7.4	14.0	9.9	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.8	0.005	1881.0	17000	0.3	2.0	2.6	15.0
14090	15.0	7.3	14.3	8.5	2.0	0.4	0	0.0	1	0.0	0	0.0	1	5.6	0.006	1772.8	17000	0.1	2.0	2.8	15.0
13850	15.0	6.7	12.6	9.7	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.5	0.004	1741.6	17000	0.1	2.0	2.2	15.0
13635	18.0	7.7	15.5	10.3	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.3	0.004	1705.8	17000	0.1	2.0	3.2	18.0
13425	21.0	8.6	18.0	7.8	2.0	0.4	0	0.0	1	0.0	0	0.0	1	4.3	0.011	1850.7	17000	0.2	2.0	3.9	21.0
13190	15.0	6.7	12.2	9.5	2.0	0.4	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1847.4	17000	0.3	2.0	2.0	15.0
13030	15.0	6.9	14.2	9.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	6.5	0.003	1763.0	17000	0.2	2.0	2.7	15.0
12835	10.0	6.4	13.3	10.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	6.1	12.5	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1470.8	17000	0.0	2.0	2.1	10.0
12395	10.0	6.0	12.3	11.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.0	0.002	1438.1	17000	0.0	2.0	2.0	10.0
12195	10.0	5.5	10.6	12.5	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.3	0.001	1383.7	17000	0.0	2.0	1.5	10.0
11995	10.0	6.2	12.8	13.6	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.7	0.002	1280.5	17000	0.0	2.0	2.2	10.0
11780	10.0	6.1	12.6	14.4	2.0	0.0	0	0.0	1	0.0	0	0.0	1	9.3	0.001	1422.2	17000	0.0	2.0	2.1	10.0
11605	10.0	6.6	13.9	13.8	2.0	0.0	0	0.0	1	0.0	0	0.0	1	8.6	0.002	1325.5	17000	0.0	2.0	2.6	10.0
11405	10.0	6.3	13.2	15.1	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.3	0.002	1114.6	17000	0.0	2.0	2.3	10.0
11180	12.5	7.7	16.6	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	1	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.0	10.4	19.1	13.3	2.0	1.5	0	0.0	1	0.0	0	0.0	1	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	14.0	10.9	21.9	10.9	2.0	1.5	0	0.0	1	0.0	0	0.0	1	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	14.0	9.2	24.1	7.5	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	14.0	9.9	22.7	8.8	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.8	0.008	1247.0	17000	0.0	2.0	4.4	14.0
10225	12.5	9.8	17.8	9.5	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.9	0.007	1374.1	17000	0.0	2.0	4.3	12.5
10000	10.0	8.5	14.9	11.1	2.0	1.5	0	0.0	1	0.0	0	0.0	1	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.0	10.2	18.6	10.0	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.7	0.008	1402.3	17000	0.0	2.0	4.7	14.0
9595	10.0	8.4	14.6	10.3	2.0	1.5	0	0.0	1	0.0	0	0.0	1	6.6	0.005	1619.5	17000	0.0	2.0	2.9	10.0
9385	18.0	9.0	15.8	9.5	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.3	0.006	1770.4	17000	0.2	2.0	3.4	18.0
9220	18.0	9.3	16.4	8.9	2.0	1.5	0	0.0	1	0.0	0	0.0	1	4.9	0.008	1771.4	17000	0.1	2.0	3.6	18.0
9025	18.0	9.0	15.9	8.9	2.0	1.5	0	0.0	1	0.0	0	0.0	1	5.5	0.005	1736.9	17000	0.1	2.0	3.4	18.0
MAX=	26.8	26.8			8.1	1.6					0.0	17.4					17000.0	8.9	2.0	8.3	21.0
MIN=	8.0	4.8			2.0	0.0					0.0	0.0					3000.0	0.0	2.0	0.5	8.0

CALCULATIONS FOR TOTAL TOE-DOWN BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM W/ SAM -- SANTA CLARA RIVER PROPOSED CONDITIONS STRAIGHT-INSIDE CURVED REACH, Q_b n=0.025

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_I+	H/2	Z_{DM}=
46195	14.0	11.1	21.7	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	11.7	0.005	453.0	9000	0.0	2.0	6.3	14.0
46020	14.0	12.7	24.1	18.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.2	0.009	520.9	9000	0.0	2.0	7.9	14.0
45545	14.0	10.4	20.3	19.2	2.8	0.0	0	0.0	1	0.0	0	0.0	0	12.7	0.004	446.7	9000	0.0	2.0	5.6	14.0
45030	14.0	13.1	26.1	16.5	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.0	0.011	492.5	9000	0.0	2.0	8.3	14.0
44585	14.0	9.8	19.2	21.1	2.8	0.0	0	0.0	1	0.0	0	0.0	0	11.3	0.004	531.9	9000	0.0	2.0	5.0	14.0
44210	14.0	12.5	26.2	15.4	2.8	0.0	0	0.0	1	0.0	0	0.0	0	9.7	0.009	452.6	9000	0.0	2.0	7.7	14.0
43820	15.4	15.4	19.9	19.5	8.1	0.0	0	0.0	1	0.0	0	0.0	0	12.1	0.004	476.5	9000	0.0	2.0	5.3	14.0
43610	17.0	17.0	26.7	13.8	8.1	0.0	0	0.0	1	0.0	0	0.0	0	9.6	0.010	450.6	9000	0.0	2.0	6.9	14.0
43410	15.8	15.8	28.8	11.3	8.1	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.011	583.4	9000	0.0	2.0	5.7	14.0
43200	16.3	16.3	26.1	12.4	8.1	0.0	0	0.0	1	0.0	0	0.0	0	6.7	0.011	689.2	9000	0.0	2.0	6.2	14.0
42975	15.5	15.5	26.6	10.8	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.9	0.016	735.1	9000	0.0	2.0	5.4	14.0
42815	15.5	15.5	23.9	10.7	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.6	0.016	864.3	9000	0.0	2.0	5.4	14.0
42590	14.7	14.7	22.4	9.2	8.1	0.0	0	0.0	1	0.0	0	0.0	0	5.2	0.014	1013.1	9000	0.0	2.0	4.6	14.0
42430	15.3	15.3	19.6	10.7	8.1	0.0	0	0.0	1	0.0	0	0.0	0	6.4	0.009	915.8	9000	0.0	2.0	5.2	14.0
42215	14.7	14.7	18.5	11.2	8.1	0.0	0	0.0	1	0.0	0	0.0	0	6.1	0.009	1019.0	9000	0.0	2.0	4.6	14.0
41940	11.9	11.9	11.6	14.3	8.1	0.0	0	0.0	1	0.0	0	0.0	0	7.7	0.002	1284.2	9000	0.0	2.0	1.8	10.0
41730	12.0	12.0	11.8	14.7	8.1	0.0	0	0.0	1	0.0	0	0.0	0	8.2	0.002	1190.9	9000	0.0	2.0	1.9	10.0
41460	11.9	11.9	11.6	16.2	8.1	0.0	0	0.0	1	0.0	0	0.0	0	9.1	0.002	1093.5	9000	0.0	2.0	1.8	10.0
41280	12.5	10.9	16.4	14.4	5.2	0.1	0	0.0	1	0.0	0	0.0	0	8.3	0.004	852.3	9000	0.0	2.0	3.6	12.5
41080	14.0	12.7	19.9	12.1	5.2	0.1	0	0.0	1	0.0	0	0.0	0	6.7	0.008	874.1	9000	0.0	2.0	5.4	14.0
40825	14.0	11.7	18.0	11.5	5.2	0.1	0	0.0	1	0.0	0	0.0	0	6.2	0.007	1040.4	9000	0.0	2.0	4.4	14.0
40585	12.5	11.2	17.0	11.7	5.2	0.1	0	0.0	1	0.0	0	0.0	0	6.8	0.006	1005.8	9000	0.0	2.0	3.9	12.5
40335	10.0	8.8	10.5	15.1	5.2	0.1	0	0.0	1	0.0	0	0.0	0	8.8	0.002	1249.6	9000	0.0	2.0	1.5	10.0
40130	10.0	9.0	11.3	15.5	5.2	0.1	0	0.0	1	0.0	0	0.0	0	8.8	0.002	1195.6	9000	0.0	2.0	1.7	10.0
39945	10.0	8.9	11.0	16.3	5.2	0.1	0	0.0	1	0.0	0	0.0	0	9.3	0.002	1173.3	9000	0.0	2.0	1.6	10.0
39755	12.5	11.0	16.5	13.3	5.2	0.1	0	0.0	1	0.0	0	0.0	0	8.1	0.004	894.5	9000	0.0	2.0	3.7	12.5
39605	14.0	12.5	19.7	11.5	5.2	0.1	0	0.0	1	0.0	0	0.0	0	7.1	0.007	849.7	9000	0.0	2.0	5.2	14.0
39310	12.5	11.0	16.5	12.7	5.2	0.1	0	0.0	1	0.0	0	0.0	0	8.1	0.004	931.1	9000	0.0	2.0	3.7	12.5
39100	14.0	12.5	20.9	10.4	5.2	0.1	0	0.0	1	0.0	0	0.0	0	7.2	0.009	761.1	9000	0.0	2.0	5.2	14.0
38925	10.0	9.5	12.8	14.3	5.2	0.1	0	0.0	1	0.0	0	0.0	0	10.3	0.002	873.5	9000	0.0	2.0	2.2	10.0
38710	10.0	6.7	12.0	15.6	2.7	0.0	0	0.0	1	0.0	0	0.0	0	11.7	0.002	820.3	9000	0.0	2.0	2.0	10.0
38475	12.5	9.0	17.9	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	0	9.8	0.004	659.7	9000	0.0	2.0	4.3	12.5
38300	14.0	9.8	22.5	10.3	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.7	0.010	666.3	9000	0.0	2.0	5.1	14.0
38065	10.0	7.6	14.5	14.0	2.7	0.0	0	0.0	1	0.0	0	0.0	0	12.0	0.002	658.4	9000	0.0	2.0	2.9	10.0
37810	14.0	9.2	18.2	12.2	2.7	0.0	0	0.0	1	0.0	0	0.0	0	10.2	0.004	618.2	9000	0.0	2.0	4.5	14.0
37655	14.0	10.0	20.9	10.5	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.8	0.008	706.7	9000	0.0	2.0	5.3	14.0
37390	14.0	8.0	23.7	6.5	2.7	0.0	0	0.0	1	0.0	0	0.0	0	5.9	0.015	823.8	9000	0.0	2.0	3.3	14.0
37135	12.5	8.4	16.6	9.3	2.7	0.0	0	0.0	1	0.0	0	0.0	0	8.5	0.005	821.4	9000	0.0	2.0	3.7	12.5
36930	14.0	8.8	19.8	8.1	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.2	0.008	812.4	9000	0.0	2.0	4.1	14.0
36735	12.5	8.2	16.1	9.8	2.7	0.0	0	0.0	1	0.0	0	0.0	0	8.0	0.005	896.9	9000	0.0	2.0	3.5	12.5
36515	10.0	6.9	12.9	12.0	2.7	0.0	0	0.0	1	0.0	0	0.0	0	9.0	0.002	994.7	9000	0.0	2.0	2.2	10.0
36265	10.0	6.8	12.3	12.5	2.7	0.0	0	0.0	1	0.0	0	0.0	0	7.9	0.003	1176.0	9000	0.0	2.0	2.1	10.0
36080	22.0	22.0	14.7	11.6	3.2	0.7	0.9	2.0	1	0.0	0	13.3	0	6.7	0.006	1176.0	9000	0.0	2.0	2.9	10.0
35845	10.0	7.5	11.0	13.6	3.2	0.7	0	0.0	1	0.0	0	0.0	0	7.9	0.002	1401.7	9000	0.0	2.0	1.6	10.0
35725	10.0	8.9	15.0	13.0	3.2	0.7	0	0.0	1	0.0	0	0.0	0	6.5	0.004	1377.9	9000	0.0	2.0	3.0	10.0
35515	12.5	9.8	17.1	12.0	3.2	0.7	0	0.0	1	0.0	0	0.0	0	6.0	0.005	1354.8	9000	0.0	2.0	3.9	12.5
35245	12.5	9.9	17.3	11.3	3.2	0.7	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1328.3	9000	0.0	2.0	4.0	12.5
35040	14.0	11.0	19.6	10.7	3.2	0.7	0	0.0	1	0.0	0	0.0	0	5.5	0.006	1354.8	9000	0.0	2.0	5.2	14.0
34860	14.0	10.4	18.4	10.0	3.2	0.7	0	0.0	1	0.0	0	0.0	0	4.9	0.009	1285.7	9000	0.0	2.0	4.6	14.0
34720	14.0	10.4	18.4	9.2	3.2	0.7	0	0.0	1	0.0	0	0.0	0	4.5	0.009	1411.2	9000	0.0	2.0	4.6	14.0
34495	12.5	10.0	17.4	9.0	3.2	0.7	0	0.0	1	0.0	0	0.0	0	5.2	0.009	1283.9	9000	0.0	2.0	4.1	12.5
34310	12.5	9.6	16.8	9.3	3.2	0.7	0	0.0	1	0.0	0	0.0	0	5.9	0.005	1308.5	9000	0.0	2.0	3.8	12.5
34090	12.5	9.7	17.0	8.6	3.2	0.7	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1295.5	9000	0.0	2.0	3.9	12.5
33880	12.5	9.1	16.6	9.3	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.3	0.007	1318.4	9000	0.0	2.0	3.7	12.5
33710	12.5	8.6	15.4	9.7	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1372.1	9000	0.0	2.0	3.2	12.5
33500	12.5	8.9	16.2	9.3	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.1	0.007	1496.0	9000	0.0	2.0	3.5	12.5
33310	12.5	8.7	15.8	9.0	3.4	0.0	0	0.0	1	0.0	0	0.0	0	4.2	0.006	1770.4	9000	0.0	2.0	3.4	12.5
33115	10.0	6.8	10.4	10.6	3.4	0.0	0	0.0	1	0.0	0	0.0	0	6.1	0.003	1847.3	9000	0.0	2.0	1.4	10.0
32795	10.0	7.7	13.0	10.6	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.2	0.004	1735.6	9000	0.0	2.0	2.3	10.0
32605	10.0	8.2	14.4	11.1	3.4	0.0	0	0.0	1	0.0	0	0.0	0	5.0	0.005	1699.9	9000	0.0	2.0	2.8	10.0
32265	12.5	7.4	15.9	10.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.8	0.006	1853.2	9000	0.0	2.0	3.4	12.5
31875	10.0	6.1	12.4	10.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	4.7	0.006	2409.2	9000	0.0	2.0	2.1	10.0
31585	10.0	5.6	10.9	11.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.9	0.003	2182.2	9000	0.0	2.0	1.6	10.0
31360	10.0	5.4	10.3	13.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.002	1878.7	9000	0.0	2.0	1.4	10.0
31060	8.0	4.9	8.2	15.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.1	0.001	1708.2	9000	0.0	2.0	0.9	8.0
30720	8.0	4.6	6.7	17.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.2	0.001	1888.6	9000	0.0	2.0	0.6	8.0
30445	8.0	4.5	6.3	19.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	12.7	0.000	1779.7	9000	0.0	2.0	0.5	8.0
30095	8.0	4.6	6.7	21.3	2.0	0.0	0	0.0	1	0.0	0	0.0	0	13.4	0.000	1622.7	9000	0.0	2.0	0.6	8.0
29815	8.0	4.8	7.7	21.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	13.5	0.000	1433.2	9000	0.0	2.0	0.8	8.0
29565	8.0	4.7	7.4	22.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	14.8	0.000	1323.8	9000	0.0	2.0	0.7	8.0
29385	8.0	4.9	8.3	23.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	14.4	0.000	1237.4	9000	0.0	2.0	0.9	8.0
29140	9.1	9.1	9.2	24.1	4.4	1.6	0	0.0	1	0.0	0	0.0	0	14.1	0.001	1087.2	9000	0.0	2.0	1.1	8.0
28895	14.0	12.7	18.8	22.5	4.4	1.6	0	0.0	1	0.0	0	0.0	0	9.9	0.002	972.1	9000	0.0	2.0	4.8	14.0
28695	15.0	15.0	28.9	14.0	4.4	1.6	0	0.0	1	0.0	0	0.0	0	5.4	0.025	899.4	9000	0.0	2.0	7.0	14.0
28500	14.7	14.7	22.4	16.1	4.4	1.6	0	0.0	1	0.0	0	0.0	0	11.4	0.006	552.2	9000	0.0	2.0	6.8	14.0
28280	14.0	13.4	29.6	10.8	4.4	1.6	0	0.0	1	0.0	0	0.0	0	5.8	0.013	944.5	9000	0.0	2.0	5.4	14.0
28080	10.0	9.7	11.3	19.1	4.4	1.6	0	0.0	1	0.0	0	0.0	0	14.7	0.001	926.4	9000	0.0	2.0	1.7	10.0
27925	10.3	10.3	13.1	19.3	4.4	1.6	0	0.0	1	0.0	0	0.0	0	13.8	0.001	866.6	9000	0.0	2.0	2.3	10.0
27725	14.0	12.9	19.0	16.7	4.4	1.6	0	0.0	1	0.0	0	0.0	0	10.4	0.003	786.6	9000	0.0	2.0	4.9	14.0
27545	15.0	15.0	22.9	14.1	4.4	1.6	0	0.0	1	0.0	0	0.0	0	9.9	0.005	643.2	9000	0.0	2.0	7.0	14.0
27335	14.1	14.1	24.6	12.3	4.4	1.6	0	0.0	1	0.0	0	0.0	0	8.3	0.008	703.5	9000	0.0	2.0	6.2	14.0
27155	14.0	12.9	19.1	14.8	4.4	1.6	0	0.0	1	0.0	0	0.0	0	9.2	0.003	888.4	9000	0.0	2.0	4.9	14.0
26990	14.0	11.0	22.6	11.5	2.0	1.3	0	0.0	1	0.0	0	0.0	0	6.8	0.011	922.3	9000	0.0	2.0	5.7	14.0
26780	14.0	10.9	23.1	11.3	2.0	1.3	0	0.0	1	0.0	0	0.0	0	6.2	0.009	1043.3	9000	0.0	2.0	5.6	14.0
26575	14.0	10.9	20.7	11.1	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.7	0.012	1187.3	3000	0.0	2.0	5.6	14.0
26355	12.5	8.7	15.9	13.4	2.0	1.3	0	0.0	1	0.0	0	0.0	0	7.5	0.004	1260.4	3000	0.0	2.0	3.4	12.5
26170	12.5	9.2	17.0	13.5	2.0	1.3	0	0.0	1	0.0	0	0.0	0	7.6	0.003	1269.0	3000	0.0	2.0	3.9	12.5
25965	14.0	9.8	18.2	12.9	2.0	1.3	0	0.0	1	0.0	0	0.0	0	6.9	0.004	1281.3	3000	0.0	2.0	4.5	14.0

DEFINITIONS

V(FPS) =VELOCITY IN FEET PER SECOND
Z_{TOT}=TOTAL POTENTIAL VERTICAL ADJUSTMENT IN FEET
Z_{DEG}=LONG TERM DEGRADATION IN FEET
Z_{GS}=GENERAL SCOUR IN FEET FROM SAM
Z_{LS}=LOCAL SCOUR IN FEET
PIER TYPE=PIER SHAPE FACTOR; IF NO PIERS=**0**
1.0=SQUARE NOSE; **0.9** ROUND NOSE; **0.9** CYLINDER;
0.8 SHARP NOSE; **0.9** GROUP OF CYLINDERS
FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET
B=WIDTH OF PIERS IN FEET; NO PIER=0
ABUT TYPE=VERT WALL FACTOR; IF VERT=**2**; NON VERT=**1**
A=ABUTMENT PROTRUSION INTO FLOW PATH IN FEET
SOFT = SOFT BOTTOM AT A BRIDGE OR AN ABUTMENT
0 = HARD BOTTOM; **1** = SOFT BOTTOM
Z_{BS}=BEND SCOUR IN FEET
BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1
HYD DEPTH=HYDRAULIC DEPTH IN FEET
E SLOPE=ENERGY SLOPE, UNITLESS
TOP WIDTH=CHANNEL TOP WIDTH IN FEET
RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET
Z_I=LOW-FLOW INCISEMENT IN FEET, MEASURED OR 2'; VALUE **NOT LESS THAN 2'**
H=BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963)
Z_{DM}=CUT OFF DEPTH REQUIRED BY LACFCDDM

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE SCOUR PROTECTION (TOE DOWN) BASED ON LADPW COUNTY HYDROLOGY MANUAL (1991) PAGES 5.2-5.8 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH A MAXIMUM VALUE LIMITED BY THE EQUATION. THE PRESENT VERSION (10/04) WILL CALCULATE UP TO 50 VELOCITIES AT ONE TIME. LONG TERM DEGRADATION IS USER SUPPLIED. GENERAL SCOUR IS TAKEN FROM APPENDIX Q3, INTERPOLATED. LOCAL SCOUR AT BENDS AND ABUTMENTS ARE BASED ON LADWP EQUATIONS FOUND IN APP Q12. BEND SCOUR IS BASED ON EQUATIONS IN APPENDIX Q12. A LONGITUDINAL EXTENT BASED ON SECONDARY CURRENTS IS NOT INCLUDED. BEDFORM HEIGHT IS BASED ON EQUATIONS IN APPENDIX Q13. JULY 2005 REVISION INCLUDES CALCULATION FOR CUT OFF DEPTH BASED ON LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL. THE CALCULATION DOES NOT CONSIDER ADJUSTMENTS TO CUT OFF DEPTH BASED ON TABLE F-06 THE OCTOBER 2005 REVISION INCLUDES ADDITIONAL TOEDOWN AT BRIDGES/ABUTMENTS WITH SOFT BOTTOMS.

COLOR CODES

OUTPUT
DATA FROM HEC-RAS
USER SUPPLIED DATA
INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
OCTOBER, 2004
OCTOBER 2005, REVISED

SECTION	Z_{MAX}=	Z_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Z_{DEG}+	Z_{GS}+	PIER TYPE	B	ABUT TYPE	A	SOFT	Z_{LS}+	BEND COEFF	HYD DEPTH	E SLOPE	TOP WIDTH	RADIUS	Z_{BS}+	Z_L+	H/2	Z_{DM}=
25785	14.0	10.1	18.9	12.1	2.0	1.3	0	0.0	1	0.0	0	0.0	0	6.9	0.005	1219.7	3000	0.0	2.0	4.8	14.0
25600	14.0	9.9	18.5	12.4	2.0	1.3	0	0.0	1	0.0	0	0.0	0	7.6	0.005	1109.4	3000	0.0	2.0	4.6	14.0
25425	14.0	9.8	18.3	12.5	2.0	1.3	0	0.0	1	0.0	0	0.0	0	7.1	0.007	1082.2	3000	0.0	2.0	4.5	14.0
25215	10.0	8.0	14.3	14.7	2.0	1.3	0	0.0	1	0.0	0	0.0	0	9.0	0.003	1097.3	3000	0.0	2.0	2.7	10.0
25000	10.0	7.6	13.2	15.5	2.0	1.3	0	0.0	1	0.0	0	0.0	0	10.1	0.002	1062.4	3000	0.0	2.0	2.3	10.0
24795	10.0	6.7	14.1	15.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.5	0.002	957.4	3000	0.0	2.0	2.7	10.0
24550	12.5	7.1	15.1	16.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.0	0.003	856.1	3000	0.0	2.0	3.1	12.5
24335	14.0	8.5	18.2	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.1	0.004	764.8	3000	0.0	2.0	4.5	14.0
24115	14.0	9.4	20.0	13.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.4	0.006	754.2	3000	0.0	2.0	5.4	14.0
23975	14.0	9.8	20.8	12.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.7	0.007	783.2	3000	0.0	2.0	5.8	14.0
23755	14.0	8.4	18.1	14.7	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.7	0.004	815.7	3000	0.0	2.0	4.4	14.0
23565	14.0	9.5	20.2	14.3	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.2	0.007	850.9	3000	0.0	2.0	5.5	14.0
23365	14.0	8.6	18.4	14.3	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.7	0.004	939.0	3000	0.0	2.0	4.6	14.0
23180	14.0	10.3	21.9	12.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.0	0.005	916.6	3000	0.0	2.0	6.3	14.0
23000	14.0	9.6	22.0	11.3	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.2	0.010	784.0	3000	0.0	2.0	5.6	14.0
22790	23.0	23.0	17.9	13.0	2.0	0.0	0.9	2.0	1	0.0	0	14.7	0	10.0	0.005	784.0	3000	0.0	2.0	4.3	12.5
22600	14.0	9.3	19.8	12.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.6	0.006	999.0	3000	0.0	2.0	5.3	14.0
22415	14.0	9.4	21.3	10.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.6	0.010	1039.1	3000	0.0	2.0	5.4	14.0
22195	10.0	6.7	13.6	14.0	2.0	0.2	0	0.0	1	0.0	0	0.0	0	8.7	0.003	1309.6	3000	0.0	2.0	2.5	10.0
22010	12.5	7.7	16.1	14.3	2.0	0.2	0	0.0	1	0.0	0	0.0	0	7.6	0.003	1254.1	3000	0.0	2.0	3.5	12.5
21790	14.0	9.4	19.7	11.6	2.0	0.2	0	0.0	1	0.0	0	0.0	0	6.5	0.006	1144.5	3000	0.0	2.0	5.2	14.0
21615	14.0	8.5	21.3	8.5	2.0	0.2	0	0.0	1	0.0	0	0.0	0	5.8	0.011	1163.0	3000	0.0	2.0	4.3	14.0
21440	12.5	8.3	17.5	11.0	2.0	0.2	0	0.0	1	0.0	0	0.0	0	6.9	0.005	1286.1	3000	0.0	2.0	4.1	12.5
21225	14.0	8.6	18.1	11.7	2.0	0.2	0	0.0	1	0.0	0	0.0	0	5.6	0.005	1559.0	3000	0.0	2.0	4.4	14.0
21020	14.0	9.1	20.3	9.7	2.0	0.2	0	0.0	1	0.0	0	0.0	0	7.8	0.007	903.0	3000	0.0	2.0	4.9	14.0
20845	12.5	7.3	15.1	12.7	2.0	0.2	0	0.0	1	0.0	0	0.0	0	6.7	0.003	1563.7	3000	0.0	2.0	3.1	12.5
20595	10.0	6.3	12.4	13.4	2.0	0.2	0	0.0	1	0.0	0	0.0	0	8.3	0.002	1548.8	3000	0.0	2.0	2.1	10.0
20435	10.0	6.2	12.1	14.3	2.0	0.2	0	0.0	1	0.0	0	0.0	0	8.8	0.001	1528.3	3000	0.0	2.0	2.0	10.0
20280	12.5	7.5	15.6	12.8	2.0	0.2	0	0.0	1	0.0	0	0.0	0	6.8	0.003	1531.3	3000	0.0	2.0	3.3	12.5
20070	14.0	9.2	19.3	11.1	2.0	0.2	0	0.0	1	0.0	0	0.0	0	5.2	0.006	1526.6	3000	0.0	2.0	5.0	14.0
19855	14.0	9.1	20.6	10.2	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.0	0.008	1205.4	3000	0.0	2.0	5.1	14.0
19630	14.0	8.4	20.6	8.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.6	0.009	1060.3	3000	0.0	2.0	4.4	14.0
19440	10.0	6.3	13.1	13.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.2	0.002	1194.5	3000	0.0	2.0	2.3	10.0
19240	12.5	7.4	15.9	11.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.004	1216.9	3000	0.0	2.0	3.4	12.5
19050	14.0	8.8	18.8	10.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	5.8	0.009	1321.4	3000	0.0	2.0	4.8	14.0
18830	10.0	6.4	13.3	14.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.4	0.003	1531.5	3000	0.0	2.0	2.4	10.0
18650	10.0	6.0	12.1	15.0	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.0	0.002	1604.5	3000	0.0	2.0	2.0	10.0
18475	8.0	5.1	8.9	16.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.9	0.001	1621.5	3000	0.0	2.0	1.1	8.0
18290	8.0	5.3	9.8	16.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.4	0.001	1594.2	3000	0.0	2.0	1.3	8.0
18025	8.0	4.8	7.9	18.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	11.9	0.001	1520.2	17000	0.0	2.0	0.8	8.0
17785	8.0	5.0	8.5	20.2	2.0	0.0	0	0.0	1	0.0	0	0.0	0	12.0	0.001	1398.1	17000	0.0	2.0	1.0	8.0
17510	10.0	6.9	11.0	19.2	2.0	1.3	0	0.0	1	0.0	0	0.0	0	10.2	0.001	1350.7	17000	0.0	2.0	1.6	10.0
17360	12.5	9.2	17.1	15.9	2.0	1.3	0	0.0	1	0.0	0	0.0	0	8.8	0.004	943.2	17000	0.0	2.0	3.9	12.5
17110	14.0	12.0	22.3	15.2	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.8	0.007	1175.4	17000	0.0	2.0	6.7	14.0
16970	14.0	12.1	23.1	13.6	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.9	0.010	1067.0	17000	0.0	2.0	6.8	14.0
16720	14.0	9.9	24.4	9.2	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.2	0.019	1122.9	17000	0.0	2.0	4.6	14.0
16515	14.0	10.4	19.4	10.4	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.8	0.010	1249.9	17000	0.0	2.0	5.1	14.0
16305	10.0	7.1	11.6	14.6	2.0	1.3	0	0.0	1	0.0	0	0.0	0	9.4	0.002	1360.5	17000	0.0	2.0	1.8	10.0
16130	12.5	8.6	15.7	12.3	2.0	1.3	0	0.0	1	0.0	0	0.0	0	7.1	0.005	1326.5	17000	0.0	2.0	3.3	12.5
15960	12.5	9.5	17.7	11.0	2.0	1.3	0	0.0	1	0.0	0	0.0	0	5.9	0.008	1386.0	17000	0.0	2.0	4.2	12.5
15745	10.0	7.3	12.3	13.3	2.0	1.3	0	0.0	1	0.0	0	0.0	0	8.4	0.003	1363.9	17000	0.0	2.0	2.0	10.0
15540	10.0	6.8	10.6	13.7	2.0	1.3	0	0.0	1	0.0	0	0.0	0	9.4	0.002	1426.6	17000	0.0	2.0	1.5	10.0
15335	12.5	8.8	16.2	12.1	2.0	1.3	0	0.0	1	0.0	0	0.0	0	8.2	0.006	1064.1	17000	0.0	2.0	3.5	12.5
15125	26.1	26.1	17.9	11.6	2.0	0.4	0.9	4.0	1	0.0	0	17.4	0	8.0	0.007	1000.5	17000	0.0	2.0	4.3	12.5
14900	14.0	9.3	19.3	9.8	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.3	0.009	1626.5	17000	0.0	2.0	4.9	14.0
14720	14.0	8.8	18.1	9.8	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.0	0.008	1722.3	17000	0.0	2.0	4.4	14.0
14480	14.0	8.8	19.0	8.9	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.2	0.010	1726.7	17000	0.0	2.0	4.4	14.0
14315	10.0	7.0	14.0	9.9	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.8	0.005	1881.0	17000	0.0	2.0	2.6	10.0
14090	10.0	7.2	14.3	8.5	2.0	0.4	0	0.0	1	0.0	0	0.0	0	5.6	0.006	1772.8	17000	0.0	2.0	2.8	10.0
13850	10.0	6.6	12.6	9.7	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.5	0.004	1741.6	17000	0.0	2.0	2.2	10.0
13635	12.5	7.6	15.5	10.3	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.3	0.004	1705.8	17000	0.0	2.0	3.2	12.5
13425	14.0	8.3	18.0	7.8	2.0	0.4	0	0.0	1	0.0	0	0.0	0	4.3	0.011	1850.7	17000	0.0	2.0	3.9	14.0
13190	10.0	6.4	12.2	9.5	2.0	0.4	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1847.4	17000	0.0	2.0	2.0	10.0
13030	10.0	6.7	14.2	9.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	6.5	0.003	1763.0	17000	0.0	2.0	2.7	10.0
12835	10.0	6.4	13.3	10.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	7.3	0.003	1607.5	17000	0.0	2.0	2.4	10.0
12615	10.0	6.1	12.5	10.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1470.8	17000	0.0	2.0	2.1	10.0
12395	10.0	6.0	12.3	11.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.0	0.002	1438.1	17000	0.0	2.0	2.0	10.0
12195	10.0	5.5	10.6	12.5	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.3	0.001	1383.7	17000	0.0	2.0	1.5	10.0
11995	10.0	6.2	12.8	13.6	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.7	0.002	1280.5	17000	0.0	2.0	2.2	10.0
11780	10.0	6.1	12.6	14.4	2.0	0.0	0	0.0	1	0.0	0	0.0	0	9.3	0.001	1422.2	17000	0.0	2.0	2.1	10.0
11605	10.0	6.6	13.9	13.8	2.0	0.0	0	0.0	1	0.0	0	0.0	0	8.6	0.002	1325.5	17000	0.0	2.0	2.6	10.0
11405	10.0	6.3	13.2	15.1	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.3	0.002	1114.6	17000	0.0	2.0	2.3	10.0
11180	12.5	7.7	16.6	13.9	2.0	0.0	0	0.0	1	0.0	0	0.0	0	10.6	0.003	835.7	17000	0.0	2.0	3.7	12.5
11015	14.0	10.4	19.1	13.3	2.0	1.5	0	0.0	1	0.0	0	0.0	0	11.0	0.004	679.4	17000	0.0	2.0	4.9	14.0
10835	14.0	10.9	21.9	10.9	2.0	1.5	0	0.0	1	0.0	0	0.0	0	8.2	0.007	790.4	17000	0.0	2.0	5.4	14.0
10575	14.0	9.2	24.1	7.5	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.3	0.016	1108.8	17000	0.0	2.0	3.7	14.0
10390	14.0	9.9	22.7	8.8	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.8	0.008	1247.0	17000	0.0	2.0	4.4	14.0
10225	12.5	9.8	17.8	9.5	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.9	0.007	1374.1	17000	0.0	2.0	4.3	12.5
10000	10.0	8.5	14.9	11.1	2.0	1.5	0	0.0	1	0.0	0	0.0	0	6.6	0.004	1488.0	17000	0.0	2.0	3.0	10.0
9820	14.0	10.2	18.6	10.0	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.7	0.008	1402.3	17000	0.0	2.0	4.7	14.0
9595	10.0	8.4	14.6	10.3	2.0	1.5	0	0.0	1	0.0	0	0.0	0	6.6	0.005	1619.5	17000	0.0	2.0	2.9	10.0
9385	12.5	8.9	15.8	9.5	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.3	0.006	1770.4	17000	0.0	2.0	3.4	12.5
9220	12.5	9.1	16.4	8.9	2.0	1.5	0	0.0	1	0.0	0	0.0	0	4.9	0.008	1771.4	17000	0.0	2.0	3.6	12.5
9025	12.5	8.9	15.9	8.9	2.0	1.5	0	0.0	1	0.0	0	0.0	0	5.5	0.005	1736.9	17000	0.0	2.0	3.4	12.5
MAX=	26.1	26.1			8.1	1.6					0.0						17000.0		2.0	8.3	14.0
MIN=	8.0	4.5			2.0	0.0					0.0						3000.0		2.0	0.5	8.0

Santa Clara River Fluvial Study

APPENDIX CHAPTER 6.2

LACH&SM Freeboard
Proposed Condition
Curved & Straight Reaches

PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

CALCULATIONS FOR TOTAL FREEBOARD BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM - SANTA CLARA RIVER PROPOSED CONDITIONS OUTSIDE CURVED REACH Q_{CAP} n=0.085

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
46195	**3.1**	3.1	10.7	28.1	1.0	0.6	2	215.7	750.8	0.0	1	1.5	9000	1.5	2.5
46020	**3.0**	3.0	10.2	30.0	1.0	0.6	2	162.7	570.2	0.0	1	1.5	9000	1.4	2.5
45545	**3.4**	3.4	11.6	27.8	1.0	0.6	2	151.3	524.2	0.0	1	1.5	9000	1.8	2.5
45030	**3.0**	3.0	10.3	29.2	1.0	0.6	2	222.6	558.0	0.0	1	1.5	9000	1.4	2.5
44585	**3.2**	3.2	10.7	28.6	1.0	0.6	2	163.7	654.4	0.0	1	1.5	9000	1.6	2.5
44210	**2.9**	2.9	10.0	27.8	1.0	0.6	2	204.3	620.0	0.0	1	1.5	9000	1.3	2.5
43820	**3.9**	3.9	14.2	24.1	1.0	0.2	2	207.8	528.7	0.0	1	1.5	9000	2.7	2.5
43610	**4.0**	4.0	14.4	21.3	1.0	0.2	2	242.1	536.9	0.0	1	1.5	9000	2.8	2.5
43410	**3.6**	3.6	13.3	19.8	1.0	0.2	2	312.8	729.1	0.0	1	1.5	9000	2.4	2.5
43200	**3.5**	3.5	13.0	19.2	1.0	0.2	2	308.4	779.5	0.0	1	1.5	9000	2.3	2.5
42975	**2.9**	2.9	10.7	19.0	1.0	0.2	2	410.5	955.8	0.1	1	1.5	9000	1.5	2.5
42815	**2.5**	2.4	9.1	18.7	1.0	0.2	2	380.4	1120.8	0.1	1	1.5	9000	1.1	2.5
42590	**2.5**	2.0	7.7	18.4	1.0	0.2	2	451.9	1230.7	0.1	1	1.5	9000	0.8	2.5
42430	**2.5**	2.0	7.6	19.5	1.0	0.2	2	445.9	1334.9	0.1	1	1.5	9000	0.8	2.5
42215	**2.5**	1.8	6.6	20.7	1.0	0.2	2	493.2	1374.6	0.0	1	1.5	9000	0.6	2.5
41940	**2.5**	1.8	6.4	20.6	1.0	0.2	2	454.2	1327.0	0.0	1	1.5	9000	0.5	2.5
41730	**2.5**	1.9	6.9	20.6	1.0	0.2	2	404.1	1221.5	0.0	1	1.5	9000	0.6	2.5
41460	**2.5**	2.0	7.4	21.2	1.0	0.2	2	365.7	1121.0	0.0	1	1.5	9000	0.7	2.5
41280	**2.5**	2.1	8.7	20.8	1.0	0.0	2	342.4	1193.2	0.1	1	1.5	9000	1.0	2.5
41080	**2.5**	2.1	8.6	20.5	1.0	0.0	2	429.5	1136.8	0.1	1	1.5	9000	1.0	2.5
40825	**2.5**	1.8	7.3	19.8	1.0	0.0	2	426.6	1213.0	0.1	1	1.5	9000	0.7	2.5
40585	**2.5**	1.7	7.1	20.3	1.0	0.0	2	404.3	1247.2	0.0	1	1.5	9000	0.7	2.5
40335	**2.5**	1.5	6.1	21.4	1.0	0.0	2	397.2	1288.6	0.0	1	1.5	9000	0.5	2.5
40130	**2.5**	1.6	6.6	21.6	1.0	0.0	2	311.3	1264.5	0.0	1	1.5	9000	0.6	2.5
39945	**2.5**	1.7	6.8	21.9	1.0	0.0	2	293.8	1212.3	0.0	1	1.5	9000	0.6	2.5
39755	**2.5**	2.0	8.6	20.6	1.0	0.0	2	296.7	1088.1	0.1	1	1.5	9000	1.0	2.5
39605	**2.5**	2.0	8.5	20.7	1.0	0.0	2	348.8	1074.7	0.1	1	1.5	9000	1.0	2.5
39310	**2.5**	2.0	8.4	20.2	1.0	0.0	2	323.4	977.3	0.1	1	1.5	9000	1.0	2.5
39100	**2.5**	1.9	8.2	21.1	1.0	0.0	2	436.5	831.5	0.0	1	1.5	9000	0.9	2.5
38925	**2.5**	1.9	7.8	20.8	1.0	0.0	2	422.3	906.7	0.1	1	1.5	9000	0.8	2.5
38710	**2.5**	2.0	8.1	21.2	1.0	0.1	2	394.9	844.1	0.0	1	1.5	9000	0.9	2.5
38475	**2.6**	2.6	10.4	21.0	1.0	0.1	2	375.1	695.3	0.0	1	1.5	9000	1.5	2.5
38300	**2.5**	2.3	9.6	20.3	1.0	0.1	2	407.6	716.8	0.0	1	1.5	9000	1.2	2.5
38065	**2.5**	2.3	9.6	20.1	1.0	0.1	2	569.0	691.3	0.0	1	1.5	9000	1.2	2.5
37810	**2.8**	2.8	11.3	18.4	1.0	0.1	2	546.8	648.4	0.0	1	1.5	9000	1.7	2.5
37655	**2.6**	2.6	10.6	17.9	1.0	0.1	2	348.9	738.9	0.0	1	1.5	9000	1.5	2.5
37390	**2.5**	2.0	8.2	17.5	1.0	0.1	2	803.3	869.1	0.0	1	1.5	9000	0.9	2.5
37135	**2.5**	2.1	8.7	16.8	1.0	0.1	2	564.0	863.7	0.0	1	1.5	9000	1.0	2.5
36930	**2.5**	2.1	8.3	17.7	1.0	0.1	2	708.3	923.7	0.1	1	1.5	9000	0.9	2.5
36735	**2.5**	2.1	8.1	17.6	1.0	0.1	2	633.8	963.2	0.1	1	1.5	9000	0.9	2.5
36515	**2.5**	1.9	7.4	18.6	1.0	0.1	2	532.1	1032.7	0.1	1	1.5	9000	0.7	2.5
36265	**2.5**	1.8	7.1	18.3	1.0	0.1	2	359.0	1176.0	0.0	1	1.5	9000	0.7	2.5
36080	**2.5**	1.9	7.8	17.6	1.0	0.0	2	326.3	1176.0	0.0	1	1.5	9000	0.8	2.5
35845	**2.5**	1.7	7.0	18.1	1.0	0.0	2	376.2	1512.8	0.0	1	1.5	9000	0.7	2.5
35725	**2.5**	1.9	8.0	18.3	1.0	0.0	2	378.2	1488.9	0.1	1	1.5	9000	0.9	2.5
35515	**2.5**	2.0	8.5	17.9	1.0	0.0	2	379.3	1501.0	0.1	1	1.5	9000	1.0	2.5
35245	**2.5**	2.0	8.3	17.0	1.0	0.0	2	414.3	1580.3	0.1	1	1.5	9000	0.9	2.5
35040	**2.5**	2.1	8.8	16.6	1.0	0.0	2	440.9	1491.6	0.1	1	1.5	9000	1.0	2.5
34860	**2.5**	1.9	7.7	16.3	1.0	0.0	2	432.9	1431.5	0.1	1	1.5	9000	0.8	2.5
34720	**2.5**	1.8	7.4	15.8	1.0	0.0	2	545.6	1449.9	0.1	1	1.5	9000	0.7	2.5
34495	**2.5**	1.8	7.2	15.7	1.0	0.0	2	504.6	1461.5	0.1	1	1.5	9000	0.7	2.5
34310	**2.5**	2.0	8.1	15.4	1.0	0.0	2	684.5	1384.9	0.1	1	1.5	9000	0.9	2.5
34090	**2.5**	1.9	7.5	15.0	1.0	0.0	2	787.5	1371.0	0.1	1	1.5	9000	0.8	2.5
33880	**2.5**	2.0	7.3	15.7	1.0	0.2	2	761.0	1482.9	0.1	1	1.5	9000	0.7	2.5
33710	**2.5**	1.9	7.0	15.6	1.0	0.2	2	719.2	1637.9	0.1	1	1.5	9000	0.7	2.5
33500	**2.5**	1.9	7.0	15.3	1.0	0.2	2	666.4	1755.5	0.1	1	1.5	9000	0.7	2.5
33310	**2.5**	1.8	6.2	15.3	1.0	0.2	2	609.9	1828.2	0.1	1	1.5	9000	0.5	2.5
33115	**2.5**	1.7	5.8	15.4	1.0	0.2	2	667.8	1927.1	0.0	1	1.5	9000	0.4	2.5
32795	**2.5**	1.8	6.3	15.7	1.0	0.2	2	697.6	1920.8	0.1	1	1.5	9000	0.5	2.5

DEFINITIONS

Y_{MAX} = GREATER OF THE DM AND S&H HEIGHTS

Y_{TOT}=TOTAL EMBANKMENT PROTECTION IN FEET BASED ON THE H&S

V(FPS) =VELOCITY IN FEET PER SECOND

FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET

Y_{AGG}=LONG TERM AGGRADATION IN FEET

Y_{GA}=GENERAL AGGRADATION IN FEET FROM SAM

CHANNEL TYPE=CHANNEL SHAPE/FLOW FACTOR:
IF Fr<1, RECTANGULAR = 0; IF Fr>1, RECTANGULAR = 1;
IF Fr<1, TRAPEZOIDAL = 2; IF Fr>1, TRAPEZOIDAL = 3.

Y_{SE}=SUPER ELEVATION IN FEET

BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1

SIDE SLOPE=CHANNEL SIDE SLOPE (H:V), UNITLESS

BOTTOM WIDTH=CHANNEL BOTTOM WIDTH IN FEET, $Q_{2\text{-}YEAR}$ TOP WIDTH

RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET

H/2=HALF BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH, AFTER KENNEDY (1963)

Y_{DM} = EMBANKMENT PROTECTION REQUIRED BY THE LACFCDDM IN FEET

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE TOP PROTECTION (FREE BOARD) BASED ON LACDWP COUNTY HYDROLOGY MANUAL (1991) PAGES 5.8-5.9 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH NO MAXIMUM VALUE. THE USER SHOULD CONSIDER A PRACTICAL MAXIMUM OF APPROXIMATELY 20-30 FPS. THE PRESENT VERSION (8/05) WILL CALCULATE UP TO 100 VELOCITIES AT ONE TIME. LONG TERM AGGRADATION IS USER SUPPLIED. GENERAL AGGRADATION IS ALSO USER SUPPLIED. SUPER ELEVATION AT BENDS IS BASED ON LACFCDDM EQUATIONS FOUND IN C-3.1. BEDFORM HEIGHT, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963), IS BASED ON EQUATIONS IN APPENDIX Q13. IF FLOW IS SUPERCRITICAL SPREADSHEET REPORTS LACFCDDM TOTAL WALL HEIGHT INSTEAD OF FREEBOARD. LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL (LACFCDDM) VALUES ARE PRESENTED AS A PART OF LACH&SM CALCULATIONS. THE SPREADSHEET CALCULATES THE GREATER OF THE TWO METHODOLOGIES. BOTTOM WIDTH IS BASED ON THE 2-YEAR WATER SURFACE AFTER ACOE PROCEDURES.

COLOR CODES

OUTPUT

DATA FROM HEC-RAS

USER SUPPLIED DATA

INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
AUGUST, 2005

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
32605	2.5	1.7	6.1	16.7	1.0	0.2	2	652.8	2407.4	0.1	1	1.5	9000	0.5	2.5
32265	2.5	2.2	5.5	17.2	1.0	0.8	2	651.0	2840.2	0.0	1	1.5	9000	0.4	2.5
31875	2.5	2.2	5.3	16.6	1.0	0.8	2	562.0	2593.1	0.0	1	1.5	9000	0.4	2.5
31585	2.5	2.2	5.0	18.7	1.0	0.8	2	619.5	2377.5	0.0	1	1.5	9000	0.3	2.5
31360	2.5	2.2	5.5	19.9	1.0	0.8	2	672.2	1959.5	0.0	1	1.5	9000	0.4	2.5
31060	2.5	2.2	5.1	21.2	1.0	0.8	2	955.0	1975.9	0.1	1	1.5	9000	0.3	2.5
30720	2.5	2.1	4.6	22.5	1.0	0.8	2	772.7	1911.5	0.0	1	1.5	9000	0.3	2.5
30445	2.5	2.1	4.6	24.1	1.0	0.8	2	700.9	1841.8	0.0	1	1.5	9000	0.3	2.5
30095	2.5	2.2	5.2	25.5	1.0	0.8	2	617.1	1637.3	0.0	1	1.5	9000	0.4	2.5
29815	2.5	2.3	6.1	25.8	1.0	0.8	2	551.1	1445.2	0.0	1	1.5	9000	0.5	2.5
29565	2.5	2.3	6.0	26.3	1.0	0.8	2	461.8	1334.9	0.0	1	1.5	9000	0.5	2.5
29385	2.5	2.5	6.8	26.6	1.0	0.8	2	381.5	1249.1	0.0	1	1.5	9000	0.6	2.5
29140	2.5	1.9	7.9	26.4	1.0	0.0	2	217.2	1095.0	0.0	1	1.5	9000	0.8	2.5
28895	4.8	4.8	16.5	23.8	1.0	0.0	2	201.9	978.0	0.1	1	1.5	9000	3.7	2.5
28695	2.5	2.3	9.4	24.9	1.0	0.0	2	269.6	951.6	0.1	1	1.5	9000	1.2	2.5
28500	3.1	3.1	12.0	23.0	1.0	0.0	2	326.0	1039.5	0.1	1	1.5	9000	1.9	2.5
28280	2.5	2.1	8.7	23.8	1.0	0.0	2	379.1	1003.9	0.1	1	1.5	9000	1.0	2.5
28080	2.5	2.0	8.3	24.1	1.0	0.0	2	416.6	945.4	0.1	1	1.5	9000	0.9	2.5
27925	2.5	2.2	9.6	24.1	1.0	0.0	2	402.0	884.9	0.0	1	1.5	9000	1.2	2.5
27725	2.9	2.9	11.9	23.1	1.0	0.0	2	386.2	811.8	0.0	1	1.5	9000	1.9	2.5
27545	3.1	3.1	12.4	22.3	1.0	0.0	2	409.6	852.5	0.0	1	1.5	9000	2.1	2.5
27335	2.7	2.7	10.9	22.0	1.0	0.0	2	422.5	937.2	0.1	1	1.5	9000	1.6	2.5
27155	2.9	2.9	11.4	21.0	1.0	0.0	2	452.4	978.1	0.1	1	1.5	9000	1.8	2.5
26990	2.5	2.3	9.4	20.4	1.0	0.0	2	440.9	1020.9	0.1	1	1.5	9000	1.2	2.5
26780	2.5	2.1	8.8	21.3	1.0	0.0	2	527.5	1106.5	0.1	1	1.5	9000	1.0	2.5
26575	2.5	1.9	7.3	21.5	1.0	0.0	2	513.5	1243.6	0.2	1	1.5	3000	0.7	2.5
26355	2.5	2.0	7.4	21.6	1.0	0.0	2	601.4	1294.5	0.2	1	1.5	3000	0.9	2.5
26170	2.5	2.3	7.7	21.9	1.0	0.0	2	457.8	1301.2	0.2	1	1.5	3000	1.1	2.5
25965	2.6	2.6	7.5	22.2	1.0	0.0	2	568.4	1313.2	0.2	1	1.5	3000	1.3	2.5
25785	2.7	2.7	7.5	22.0	1.0	0.0	2	550.9	1256.9	0.3	1	1.5	3000	1.4	2.5
25600	2.5	2.5	7.8	22.3	1.0	0.0	2	478.1	1149.9	0.2	1	1.5	3000	1.3	2.5
25425	2.5	2.5	7.3	23.1	1.0	0.0	2	399.8	1138.3	0.2	1	1.5	3000	1.3	2.5
25215	2.5	2.4	7.3	23.3	1.0	0.0	2	444.6	1133.6	0.2	1	1.5	3000	1.2	2.5
25000	2.5	2.5	7.3	23.5	1.0	0.0	2	453.1	1093.8	0.2	1	1.5	3000	1.3	2.5
24795	3.7	3.7	8.0	23.5	1.9	0.2	2	391.4	986.5	0.3	1	1.5	3000	1.3	2.5
24550	3.6	3.6	8.9	24.1	1.9	0.2	2	334.0	887.1	0.3	1	1.5	3000	1.2	2.5
24335	3.9	3.9	9.9	23.5	1.9	0.2	2	337.2	800.3	0.3	1	1.5	3000	1.5	2.5
24115	3.8	3.8	10.0	23.0	1.9	0.2	2	422.7	793.2	0.3	1	1.5	3000	1.4	2.5
23975	3.5	3.5	9.7	22.6	1.9	0.2	2	354.1	828.2	0.2	1	1.5	3000	1.2	2.5
23755	3.2	3.2	9.9	22.7	1.9	0.2	2	333.9	939.2	0.2	1	1.5	3000	1.0	2.5
23565	3.7	3.7	9.4	23.6	1.9	0.2	2	322.2	941.5	0.3	1	1.5	3000	1.3	2.5
23365	3.5	3.5	9.4	22.4	1.9	0.2	2	329.4	987.4	0.3	1	1.5	3000	1.1	2.5
23180	3.2	3.2	9.6	22.5	1.9	0.2	2	400.7	975.5	0.2	1	1.5	3000	0.9	2.5
23000	3.3	3.3	9.5	22.0	1.9	0.2	2	407.6	784.0	0.3	1	1.5	3000	0.9	2.5
22790	3.1	3.1	10.6	20.0	1.9	0.2	2	425.5	784.0	0.2	1	1.5	3000	0.9	2.5
22600	3.2	3.2	10.2	19.8	1.9	0.2	2	386.7	1050.2	0.3	1	1.5	3000	0.8	2.5
22415	3.2	3.2	9.3	18.9	1.9	0.2	2	422.3	1091.6	0.2	1	1.5	3000	0.8	2.5
22195	2.5	2.4	8.4	19.1	1.4	0.0	2	371.3	1464.0	0.3	1	1.5	3000	0.8	2.5
22010	2.5	2.5	9.8	19.4	1.4	0.0	2	471.8	1735.1	0.3	1	1.5	3000	0.8	2.5
21790	2.6	2.6	9.0	18.4	1.4	0.0	2	549.9	1778.4	0.2	1	1.5	3000	1.0	2.5
21615	2.6	2.6	8.0	16.9	1.4	0.0	2	563.1	1687.7	0.3	1	1.5	3000	0.9	2.5
21440	2.5	2.4	8.2	17.8	1.4	0.0	2	638.9	1653.0	0.2	1	1.5	3000	0.8	2.5
21225	2.5	2.4	8.0	18.7	1.4	0.0	2	352.4	1600.8	0.2	1	1.5	3000	0.7	2.5
21020	2.5	2.3	7.8	18.6	1.4	0.0	2	675.0	1607.4	0.2	1	1.5	3000	0.7	2.5
20845	2.5	2.3	7.9	18.7	1.4	0.0	2	613.7	1605.1	0.2	1	1.5	3000	0.8	2.5
20595	2.5	2.1	7.5	18.6	1.4	0.0	2	744.5	1600.4	0.1	1	1.5	3000	0.6	2.5
20435	2.5	2.1	7.9	18.8	1.4	0.0	2	765.2	1613.5	0.1	1	1.5	3000	0.6	2.5
20280	2.5	2.1	8.7	18.1	1.4	0.0	2	439.6	1636.3	0.1	1	1.5	3000	0.6	2.5
20070	2.5	1.9	8.3	18.6	1.4	0.0	2	602.4	1797.8	0.1	1	1.5	3000	0.5	2.5
19855	3.0	3.0	7.7	19.1	1.0	1.4	2	585.9	1809.6	0.1	1	1.5	3000	0.5	2.5
19630	2.9	2.9	7.4	18.6	1.0	1.4	2	634.2	1833.7	0.0	1	1.5	3000	0.5	2.5
19440	3.0	3.0	7.2	19.9	1.0	1.4	2	536.3	1986.1	0.0	1	1.5	3000	0.6	2.5

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
19240	**3.4**	3.4	7.6	19.4	1.0	1.4	2	445.4	1738.0	0.0	1	1.5	3000	1.0	2.5
19050	**4.1**	4.1	6.7	20.2	1.0	1.4	2	418.1	1753.4	0.0	1	1.5	3000	1.7	2.5
18830	**4.1**	4.1	6.8	21.4	1.0	1.4	2	338.9	1684.0	0.0	1	1.5	3000	1.6	2.5
18650	**4.0**	4.0	6.7	21.2	1.0	1.4	2	339.7	1686.2	0.0	1	1.5	3000	1.6	2.5
18475	**3.4**	3.4	5.8	22.3	1.0	1.4	2	336.6	1665.9	0.0	1	1.5	3000	1.0	2.5
18290	**3.2**	3.2	6.3	22.1	1.0	1.4	2	365.1	1631.9	0.0	1	1.5	3000	0.8	2.5
18025	**3.1**	3.1	5.8	22.9	1.0	1.4	2	380.4	1557.4	0.0	1	1.5	17000	0.7	2.5
17785	**3.2**	3.2	6.4	24.0	1.0	1.4	2	389.3	1444.1	0.0	1	1.5	17000	0.8	2.5
17510	**2.5**	1.7	8.4	22.4	1.0	0.0	2	326.3	1398.9	0.0	1	1.5	17000	0.7	2.5
17360	**2.5**	1.7	11.1	20.3	1.0	0.0	2	223.6	1303.3	0.0	1	1.5	17000	0.7	2.5
17110	**2.5**	1.6	11.0	21.5	1.0	0.0	2	228.7	1229.6	0.0	1	1.5	17000	0.6	2.5
16970	**2.5**	2.1	10.7	20.3	1.0	0.0	2	235.7	1196.0	0.0	1	1.5	17000	1.1	2.5
16720	**2.5**	2.3	8.5	18.8	1.0	0.0	2	260.0	1182.0	0.0	1	1.5	17000	1.3	2.5
16515	**2.5**	2.1	7.7	19.2	1.0	0.0	2	296.5	1303.8	0.0	1	1.5	17000	1.1	2.5
16305	**2.5**	2.0	7.1	20.4	1.0	0.0	2	304.6	1395.5	0.0	1	1.5	17000	1.0	2.5
16130	**2.5**	1.7	7.7	19.4	1.0	0.0	2	323.4	1368.9	0.0	1	1.5	17000	0.7	2.5
15960	**2.5**	1.6	7.1	19.6	1.0	0.0	2	294.6	1437.6	0.0	1	1.5	17000	0.6	2.5
15745	**2.5**	1.6	7.0	19.6	1.0	0.0	2	295.8	1401.3	0.0	1	1.5	17000	0.6	2.5
15540	**2.5**	1.6	6.6	19.2	1.0	0.0	2	344.9	2361.2	0.0	1	1.5	17000	0.6	2.5
15335	**2.5**	1.7	8.9	18.8	1.0	0.0	2	348.6	1064.1	0.0	1	1.5	17000	0.7	2.5
15125	**2.5**	1.4	9.8	18.0	1.0	0.0	2	437.3	1053.5	0.0	1	1.5	17000	0.4	2.5
14900	**2.5**	1.4	8.8	16.7	1.0	0.0	2	584.1	2233.1	0.0	1	1.5	17000	0.4	2.5
14720	**2.5**	1.5	8.5	16.4	1.0	0.0	2	532.9	2020.9	0.0	1	1.5	17000	0.5	2.5
14480	**2.5**	1.5	7.4	16.4	1.0	0.0	2	819.8	1851.8	0.0	1	1.5	17000	0.5	2.5
14315	**2.5**	1.6	6.8	16.0	1.0	0.0	2	1014.4	1944.1	0.0	1	1.5	17000	0.6	2.5
14090	**2.5**	1.6	6.7	14.8	1.0	0.0	2	787.4	1816.2	0.0	1	1.5	17000	0.6	2.5
13850	**2.5**	1.6	6.6	15.6	1.0	0.0	2	582.7	1774.9	0.0	1	1.5	17000	0.6	2.5
13635	**2.5**	1.8	7.3	16.5	1.0	0.0	2	631.2	1818.0	0.0	1	1.5	17000	0.7	2.5
13425	**2.5**	1.8	5.7	16.8	1.0	0.0	2	576.3	1936.1	0.0	1	1.5	17000	0.7	2.5
13190	**2.5**	1.9	5.6	17.1	1.0	0.0	2	713.9	1911.1	0.0	1	1.5	17000	0.8	2.5
13030	**4.2**	4.2	6.0	17.6	1.0	2.1	2	712.9	1863.7	0.1	1	1.5	17000	1.0	2.5
12835	**4.7**	4.7	6.2	18.0	1.0	2.1	2	799.4	1775.1	0.1	1	1.5	17000	1.5	2.5
12615	**5.2**	5.2	6.5	18.3	1.0	2.1	2	741.8	1566.5	0.0	1	1.5	17000	2.1	2.5
12395	**5.1**	5.1	6.7	18.7	1.0	2.1	2	738.1	1543.0	0.0	1	1.5	17000	2.0	2.5
12195	**4.2**	4.2	6.5	19.1	1.0	2.1	2	990.8	1463.7	0.0	1	1.5	17000	1.1	2.5
11995	**4.1**	4.1	7.4	20.3	1.0	2.1	2	589.4	1448.5	0.0	1	1.5	17000	1.0	2.5
11780	**4.0**	4.0	7.3	20.6	1.0	2.1	2	590.4	1460.8	0.0	1	1.5	17000	0.9	2.5
11605	**4.0**	4.0	7.9	20.3	1.0	2.1	2	587.6	1417.5	0.0	1	1.5	17000	0.9	2.5
11405	**3.9**	3.9	8.7	20.6	1.0	2.1	2	579.7	1144.9	0.0	1	1.5	17000	0.8	2.5
11180	**3.9**	3.9	10.7	19.7	1.0	2.1	2	580.2	1009.2	0.0	1	1.5	17000	0.8	2.5
11015	**3.8**	3.8	12.6	18.7	3.1	0.0	2	519.8	851.0	0.0	1	1.5	17000	0.7	2.5
10835	**3.7**	3.7	12.2	17.1	3.1	0.0	2	510.4	1073.0	0.0	1	1.5	17000	0.6	2.5
10575	**3.8**	3.8	9.1	16.1	3.1	0.0	2	534.5	1322.2	0.0	1	1.5	17000	0.7	2.5
10390	**3.1**	3.1	8.6	17.1	3.1	0.0	2	598.1	1517.0	0.0	1	1.5	17000	0.0	2.5
10225	**3.1**	3.1	8.0	16.6	3.1	0.0	2	606.9	1543.4	0.0	1	1.5	17000	0.0	2.5
10000	**3.1**	3.1	8.1	16.6	3.1	0.0	2	685.3	1626.0	0.0	1	1.5	17000	0.0	2.5
9820	**3.1**	3.1	7.9	17.4	3.1	0.0	2	773.4	1648.8	0.0	1	1.5	17000	0.0	2.5
9595	**3.1**	3.1	7.8	16.1	3.1	0.0	2	698.1	1719.6	0.0	1	1.5	17000	0.0	2.5
9385	**3.1**	3.1	7.2	15.6	3.1	0.0	2	694.0	1799.3	0.0	1	1.5	17000	0.0	2.5
9220	**3.1**	3.1	6.8	15.6	3.1	0.0	2	645.1	1853.4	0.0	1	1.5	17000	0.0	2.5
9025	**3.1**	3.1	7.0	15.6	3.1	0.0	2	537.6	1822.9	0.0	1	1.5	17000	0.0	2.5
MAX=	**5.2**	5.2			3.1					0.3				3.7	2.5
MIN=	**2.5**	1.4			1.0					0.0				0.0	2.5

CALCULATIONS FOR TOTAL FREEBOARD BY INDIVIDUAL ADJUSTMENT COMPONENT BASED ON LACH&SM - SANTA CLARA RIVER PROPOSED CONDITIONS STRAIGHT-INSIDE CURVED REACH Q_{CAP} n=0.085

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
46195	**3.1**	3.1	10.7	28.1	1.0	0.6	2	215.7	750.8	0.0	0	1.5	9000	1.5	2.5
46020	**3.0**	3.0	10.2	30.0	1.0	0.6	2	162.7	570.2	0.0	0	1.5	9000	1.4	2.5
45545	**3.4**	3.4	11.6	27.8	1.0	0.6	2	151.3	524.2	0.0	0	1.5	9000	1.8	2.5
45030	**3.0**	3.0	10.3	29.2	1.0	0.6	2	222.6	558.0	0.0	0	1.5	9000	1.4	2.5
44585	**3.2**	3.2	10.7	28.6	1.0	0.6	2	163.7	654.4	0.0	0	1.5	9000	1.6	2.5
44210	**2.9**	2.9	10.0	27.8	1.0	0.6	2	204.3	620.0	0.0	0	1.5	9000	1.3	2.5
43820	**3.9**	3.9	14.2	24.1	1.0	0.2	2	207.8	528.7	0.0	0	1.5	9000	2.7	2.5
43610	**4.0**	4.0	14.4	21.3	1.0	0.2	2	242.1	536.9	0.0	0	1.5	9000	2.8	2.5
43410	**3.6**	3.6	13.3	19.8	1.0	0.2	2	312.8	729.1	0.0	0	1.5	9000	2.4	2.5
43200	**3.5**	3.5	13.0	19.2	1.0	0.2	2	308.4	779.5	0.0	0	1.5	9000	2.3	2.5
42975	**2.7**	2.7	10.7	19.0	1.0	0.2	2	410.5	955.8	0.0	0	1.5	9000	1.5	2.5
42815	**2.5**	2.3	9.1	18.7	1.0	0.2	2	380.4	1120.8	0.0	0	1.5	9000	1.1	2.5
42590	**2.5**	2.0	7.7	18.4	1.0	0.2	2	451.9	1230.7	0.0	0	1.5	9000	0.8	2.5
42430	**2.5**	2.0	7.6	19.5	1.0	0.2	2	445.9	1334.9	0.0	0	1.5	9000	0.8	2.5
42215	**2.5**	1.8	6.6	20.7	1.0	0.2	2	493.2	1374.6	0.0	0	1.5	9000	0.6	2.5
41940	**2.5**	1.7	6.4	20.6	1.0	0.2	2	454.2	1327.0	0.0	0	1.5	9000	0.5	2.5
41730	**2.5**	1.8	6.9	20.6	1.0	0.2	2	404.1	1221.5	0.0	0	1.5	9000	0.6	2.5
41460	**2.5**	1.9	7.4	21.2	1.0	0.2	2	365.7	1121.0	0.0	0	1.5	9000	0.7	2.5
41280	**2.5**	2.0	8.7	20.8	1.0	0.0	2	342.4	1193.2	0.0	0	1.5	9000	1.0	2.5
41080	**2.5**	2.0	8.6	20.5	1.0	0.0	2	429.5	1136.8	0.0	0	1.5	9000	1.0	2.5
40825	**2.5**	1.7	7.3	19.8	1.0	0.0	2	426.6	1213.0	0.0	0	1.5	9000	0.7	2.5
40585	**2.5**	1.7	7.1	20.3	1.0	0.0	2	404.3	1247.2	0.0	0	1.5	9000	0.7	2.5
40335	**2.5**	1.5	6.1	21.4	1.0	0.0	2	397.2	1288.6	0.0	0	1.5	9000	0.5	2.5
40130	**2.5**	1.6	6.6	21.6	1.0	0.0	2	311.3	1264.5	0.0	0	1.5	9000	0.6	2.5
39945	**2.5**	1.6	6.8	21.9	1.0	0.0	2	293.8	1212.3	0.0	0	1.5	9000	0.6	2.5
39755	**2.5**	2.0	8.6	20.6	1.0	0.0	2	296.7	1088.1	0.0	0	1.5	9000	1.0	2.5
39605	**2.5**	2.0	8.5	20.7	1.0	0.0	2	348.8	1074.7	0.0	0	1.5	9000	1.0	2.5
39310	**2.5**	2.0	8.4	20.2	1.0	0.0	2	323.4	977.3	0.0	0	1.5	9000	1.0	2.5
39100	**2.5**	1.9	8.2	21.1	1.0	0.0	2	436.5	831.5	0.0	0	1.5	9000	0.9	2.5
38925	**2.5**	1.8	7.8	20.8	1.0	0.0	2	422.3	906.7	0.0	0	1.5	9000	0.8	2.5
38710	**2.5**	2.0	8.1	21.2	1.0	0.1	2	394.9	844.1	0.0	0	1.5	9000	0.9	2.5
38475	**2.6**	2.6	10.4	21.0	1.0	0.1	2	375.1	695.3	0.0	0	1.5	9000	1.5	2.5
38300	**2.5**	2.3	9.6	20.3	1.0	0.1	2	407.6	716.8	0.0	0	1.5	9000	1.2	2.5
38065	**2.5**	2.3	9.6	20.1	1.0	0.1	2	569.0	691.3	0.0	0	1.5	9000	1.2	2.5
37810	**2.8**	2.8	11.3	18.4	1.0	0.1	2	546.8	648.4	0.0	0	1.5	9000	1.7	2.5
37655	**2.6**	2.6	10.6	17.9	1.0	0.1	2	348.9	738.9	0.0	0	1.5	9000	1.5	2.5
37390	**2.5**	2.0	8.2	17.5	1.0	0.1	2	803.3	869.1	0.0	0	1.5	9000	0.9	2.5
37135	**2.5**	2.1	8.7	16.8	1.0	0.1	2	564.0	863.7	0.0	0	1.5	9000	1.0	2.5
36930	**2.5**	2.0	8.3	17.7	1.0	0.1	2	708.3	923.7	0.0	0	1.5	9000	0.9	2.5
36735	**2.5**	2.0	8.1	17.6	1.0	0.1	2	633.8	963.2	0.0	0	1.5	9000	0.9	2.5
36515	**2.5**	1.8	7.4	18.6	1.0	0.1	2	532.1	1032.7	0.0	0	1.5	9000	0.7	2.5
36265	**2.5**	1.8	7.1	18.3	1.0	0.1	2	359.0	1176.0	0.0	0	1.5	9000	0.7	2.5
36080	**2.5**	1.8	7.8	17.6	1.0	0.0	2	326.3	1176.0	0.0	0	1.5	9000	0.8	2.5
35845	**2.5**	1.7	7.0	18.1	1.0	0.0	2	376.2	1512.8	0.0	0	1.5	9000	0.7	2.5
35725	**2.5**	1.9	8.0	18.3	1.0	0.0	2	378.2	1488.9	0.0	0	1.5	9000	0.9	2.5
35515	**2.5**	2.0	8.5	17.9	1.0	0.0	2	379.3	1501.0	0.0	0	1.5	9000	1.0	2.5
35245	**2.5**	1.9	8.3	17.0	1.0	0.0	2	414.3	1580.3	0.0	0	1.5	9000	0.9	2.5
35040	**2.5**	2.0	8.8	16.6	1.0	0.0	2	440.9	1491.6	0.0	0	1.5	9000	1.0	2.5
34860	**2.5**	1.8	7.7	16.3	1.0	0.0	2	432.9	1431.5	0.0	0	1.5	9000	0.8	2.5
34720	**2.5**	1.7	7.4	15.8	1.0	0.0	2	545.6	1449.9	0.0	0	1.5	9000	0.7	2.5
34495	**2.5**	1.7	7.2	15.7	1.0	0.0	2	504.6	1461.5	0.0	0	1.5	9000	0.7	2.5
34310	**2.5**	1.9	8.1	15.4	1.0	0.0	2	684.5	1384.9	0.0	0	1.5	9000	0.9	2.5
34090	**2.5**	1.8	7.5	15.0	1.0	0.0	2	787.5	1371.0	0.0	0	1.5	9000	0.8	2.5
33880	**2.5**	1.9	7.3	15.7	1.0	0.2	2	761.0	1482.9	0.0	0	1.5	9000	0.7	2.5
33710	**2.5**	1.9	7.0	15.6	1.0	0.2	2	719.2	1637.9	0.0	0	1.5	9000	0.7	2.5
33500	**2.5**	1.9	7.0	15.3	1.0	0.2	2	666.4	1755.5	0.0	0	1.5	9000	0.7	2.5
33310	**2.5**	1.7	6.2	15.3	1.0	0.2	2	609.9	1828.2	0.0	0	1.5	9000	0.5	2.5
33115	**2.5**	1.6	5.8	15.4	1.0	0.2	2	667.8	1927.1	0.0	0	1.5	9000	0.4	2.5
32795	**2.5**	1.7	6.3	15.7	1.0	0.2	2	697.6	1920.8	0.0	0	1.5	9000	0.5	2.5

DEFINITIONS

Y_{MAX} = GREATER OF THE DM AND S&H HEIGHTS

Y_{TOT}=TOTAL EMBANKMENT PROTECTION IN FEET BASED ON THE H&S

V(FPS) =VELOCITY IN FEET PER SECOND

FLOW DEPTH=WATER DEPTH IN CHANNEL IN FEET

Y_{AGG}=LONG TERM AGGRADATION IN FEET

Y_{GA}=GENERAL AGGRADATION IN FEET FROM SAM

CHANNEL TYPE=CHANNEL SHAPE/FLOW FACTOR:
IF Fr<1, RECTANGULAR = 0; IF Fr>1, RECTANGULAR = 1;
IF Fr<1, TRAPEZOIDAL = 2; IF Fr>1, TRAPEZOIDAL = 3.

Y_{SE}=SUPER ELEVATION IN FEET

BEND COEFF=BEND COEFFICIENT; IF NO BEND=0, BEND=1

SIDE SLOPE=CHANNEL SIDE SLOPE (H:V), UNITLESS

BOTTOM WIDTH=CHANNEL BOTTOM WIDTH IN FEET, $Q_{2\text{-}YEAR}$ TOP WIDTH

RADIUS=RADIUS OF CURVATURE TO CENTERLINE IN FEET

H/2=HALF BEDFORM HEIGHT IN FEET, LIMITED TO FLOW DEPTH, AFTER KENNEDY (1963)

Y_{DM} = EMBANKMENT PROTECTION REQUIRED BY THE LACFCDDM IN FEET

GENERAL

THIS SPREADSHEET IS DESIGNED TO CALCULATE TOP PROTECTION (FREE BOARD) BASED ON LACDWP COUNTY HYDROLOGY MANUAL (1991) PAGES 5.8-5.9 AND ASSOCIATED APPENDICES (SEDIMENTATION MANUAL). ALL VELOCITIES ARE IN FPS, WITH NO MAXIMUM VALUE. THE USER SHOULD CONSIDER A PRACTICAL MAXIMUM OF APPROXIMATELY 20-30 FPS. THE PRESENT VERSION (8/05) WILL CALCULATE UP TO 100 VELOCITIES AT ONE TIME. LONG TERM AGGRADATION IS USER SUPPLIED. GENERAL AGGRADATION IS ALSO USER SUPPLIED. SUPER ELEVATION AT BENDS IS BASED ON LACFCDDM EQUATIONS FOUND IN C-3.1. BEDFORM HEIGHT, LIMITED TO FLOW DEPTH AFTER KENNEDY (1963), IS BASED ON EQUATIONS IN APPENDIX Q13. IF FLOW IS SUPERCRITICAL SPREADSHEET REPORTS LACFCDDM TOTAL WALL HEIGHT INSTEAD OF FREEBOARD. LOS ANGELES COUNTY FLOOD CONTROL DISTRICT DESIGN MANUAL (LACFCDDM) VALUES ARE PRESENTED AS A PART OF LACH&SM CALCULATIONS. THE SPREADSHEET CALCULATES THE GREATER OF THE TWO METHODOLOGIES. BOTTOM WIDTH IS BASED ON THE 2-YEAR WATER SURFACE AFTER ACOE PROCEDURES.

COLOR CODES

OUTPUT

DATA FROM HEC-RAS

USER SUPPLIED DATA

INTERMEDIATE CALCULATIONS (INDIVIDUAL SHEETS ONLY)

DESIGNED BY DAVID A JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC
AUGUST, 2005

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
32605	2.5	1.7	6.1	16.7	1.0	0.2	2	652.8	2407.4	0.0	0	1.5	9000	0.5	2.5
32265	2.5	2.2	5.5	17.2	1.0	0.8	2	651.0	2840.2	0.0	0	1.5	9000	0.4	2.5
31875	2.5	2.2	5.3	16.6	1.0	0.8	2	562.0	2593.1	0.0	0	1.5	9000	0.4	2.5
31585	2.5	2.1	5.0	18.7	1.0	0.8	2	619.5	2377.5	0.0	0	1.5	9000	0.3	2.5
31360	2.5	2.2	5.5	19.9	1.0	0.8	2	672.2	1959.5	0.0	0	1.5	9000	0.4	2.5
31060	2.5	2.1	5.1	21.2	1.0	0.8	2	955.0	1975.9	0.0	0	1.5	9000	0.3	2.5
30720	2.5	2.1	4.6	22.5	1.0	0.8	2	772.7	1911.5	0.0	0	1.5	9000	0.3	2.5
30445	2.5	2.1	4.6	24.1	1.0	0.8	2	700.9	1841.8	0.0	0	1.5	9000	0.3	2.5
30095	2.5	2.2	5.2	25.5	1.0	0.8	2	617.1	1637.3	0.0	0	1.5	9000	0.4	2.5
29815	2.5	2.3	6.1	25.8	1.0	0.8	2	551.1	1445.2	0.0	0	1.5	9000	0.5	2.5
29565	2.5	2.3	6.0	26.3	1.0	0.8	2	461.8	1334.9	0.0	0	1.5	9000	0.5	2.5
29385	2.5	2.4	6.8	26.6	1.0	0.8	2	381.5	1249.1	0.0	0	1.5	9000	0.6	2.5
29140	2.5	1.8	7.9	26.4	1.0	0.0	2	217.2	1095.0	0.0	0	1.5	9000	0.8	2.5
28895	4.7	4.7	16.5	23.8	1.0	0.0	2	201.9	978.0	0.0	0	1.5	9000	3.7	2.5
28695	2.5	2.2	9.4	24.9	1.0	0.0	2	269.6	951.6	0.0	0	1.5	9000	1.2	2.5
28500	2.9	2.9	12.0	23.0	1.0	0.0	2	326.0	1039.5	0.0	0	1.5	9000	1.9	2.5
28280	2.5	2.0	8.7	23.8	1.0	0.0	2	379.1	1003.9	0.0	0	1.5	9000	1.0	2.5
28080	2.5	1.9	8.3	24.1	1.0	0.0	2	416.6	945.4	0.0	0	1.5	9000	0.9	2.5
27925	2.5	2.2	9.6	24.1	1.0	0.0	2	402.0	884.9	0.0	0	1.5	9000	1.2	2.5
27725	2.9	2.9	11.9	23.1	1.0	0.0	2	386.2	811.8	0.0	0	1.5	9000	1.9	2.5
27545	3.1	3.1	12.4	22.3	1.0	0.0	2	409.6	852.5	0.0	0	1.5	9000	2.1	2.5
27335	2.6	2.6	10.9	22.0	1.0	0.0	2	422.5	937.2	0.0	0	1.5	9000	1.6	2.5
27155	2.8	2.8	11.4	21.0	1.0	0.0	2	452.4	978.1	0.0	0	1.5	9000	1.8	2.5
26990	2.5	2.2	9.4	20.4	1.0	0.0	2	440.9	1020.9	0.0	0	1.5	9000	1.2	2.5
26780	2.5	2.0	8.8	21.3	1.0	0.0	2	527.5	1106.5	0.0	0	1.5	9000	1.0	2.5
26575	2.5	1.7	7.3	21.5	1.0	0.0	2	513.5	1243.6	0.0	0	1.5	3000	0.7	2.5
26355	2.5	1.9	7.4	21.6	1.0	0.0	2	601.4	1294.5	0.0	0	1.5	3000	0.9	2.5
26170	2.5	2.1	7.7	21.9	1.0	0.0	2	457.8	1301.2	0.0	0	1.5	3000	1.1	2.5
25965	2.5	2.3	7.5	22.2	1.0	0.0	2	568.4	1313.2	0.0	0	1.5	3000	1.3	2.5
25785	2.5	2.4	7.5	22.0	1.0	0.0	2	550.9	1256.9	0.0	0	1.5	3000	1.4	2.5
25600	2.5	2.3	7.8	22.3	1.0	0.0	2	478.1	1149.9	0.0	0	1.5	3000	1.3	2.5
25425	2.5	2.3	7.3	23.1	1.0	0.0	2	399.8	1138.3	0.0	0	1.5	3000	1.3	2.5
25215	2.5	2.2	7.3	23.3	1.0	0.0	2	444.6	1133.6	0.0	0	1.5	3000	1.2	2.5
25000	2.5	2.3	7.3	23.5	1.0	0.0	2	453.1	1093.8	0.0	0	1.5	3000	1.3	2.5
24795	3.4	3.4	8.0	23.5	1.9	0.2	2	391.4	986.5	0.0	0	1.5	3000	1.3	2.5
24550	3.3	3.3	8.9	24.1	1.9	0.2	2	334.0	887.1	0.0	0	1.5	3000	1.2	2.5
24335	3.6	3.6	9.9	23.5	1.9	0.2	2	337.2	800.3	0.0	0	1.5	3000	1.5	2.5
24115	3.5	3.5	10.0	23.0	1.9	0.2	2	422.7	793.2	0.0	0	1.5	3000	1.4	2.5
23975	3.3	3.3	9.7	22.6	1.9	0.2	2	354.1	828.2	0.0	0	1.5	3000	1.2	2.5
23755	3.1	3.1	9.9	22.7	1.9	0.2	2	333.9	939.2	0.0	0	1.5	3000	1.0	2.5
23565	3.4	3.4	9.4	23.6	1.9	0.2	2	322.2	941.5	0.0	0	1.5	3000	1.3	2.5
23365	3.2	3.2	9.4	22.4	1.9	0.2	2	329.4	987.4	0.0	0	1.5	3000	1.1	2.5
23180	3.0	3.0	9.6	22.5	1.9	0.2	2	400.7	975.5	0.0	0	1.5	3000	0.9	2.5
23000	3.0	3.0	9.5	22.0	1.9	0.2	2	407.6	784.0	0.0	0	1.5	3000	0.9	2.5
22790	3.0	3.0	10.6	20.0	1.9	0.2	2	425.5	784.0	0.0	0	1.5	3000	0.9	2.5
22600	2.9	2.9	10.2	19.8	1.9	0.2	2	386.7	1050.2	0.0	0	1.5	3000	0.8	2.5
22415	2.9	2.9	9.3	18.9	1.9	0.2	2	422.3	1091.6	0.0	0	1.5	3000	0.8	2.5
22195	2.5	2.2	8.4	19.1	1.4	0.0	2	371.3	1464.0	0.0	0	1.5	3000	0.8	2.5
22010	2.5	2.2	9.8	19.4	1.4	0.0	2	471.8	1735.1	0.0	0	1.5	3000	0.8	2.5
21790	2.5	2.4	9.0	18.4	1.4	0.0	2	549.9	1778.4	0.0	0	1.5	3000	1.0	2.5
21615	2.5	2.3	8.0	16.9	1.4	0.0	2	563.1	1687.7	0.0	0	1.5	3000	0.9	2.5
21440	2.5	2.2	8.2	17.8	1.4	0.0	2	638.9	1653.0	0.0	0	1.5	3000	0.8	2.5
21225	2.5	2.1	8.0	18.7	1.4	0.0	2	352.4	1600.8	0.0	0	1.5	3000	0.7	2.5
21020	2.5	2.1	7.8	18.6	1.4	0.0	2	675.0	1607.4	0.0	0	1.5	3000	0.7	2.5
20845	2.5	2.2	7.9	18.7	1.4	0.0	2	613.7	1605.1	0.0	0	1.5	3000	0.8	2.5
20595	2.5	2.0	7.5	18.6	1.4	0.0	2	744.5	1600.4	0.0	0	1.5	3000	0.6	2.5
20435	2.5	2.0	7.9	18.8	1.4	0.0	2	765.2	1613.5	0.0	0	1.5	3000	0.6	2.5
20280	2.5	2.0	8.7	18.1	1.4	0.0	2	439.6	1636.3	0.0	0	1.5	3000	0.6	2.5
20070	2.5	1.9	8.3	18.6	1.4	0.0	2	602.4	1797.8	0.0	0	1.5	3000	0.5	2.5
19855	2.9	2.9	7.7	19.1	1.0	1.4	2	585.9	1809.6	0.0	0	1.5	3000	0.5	2.5
19630	2.9	2.9	7.4	18.6	1.0	1.4	2	634.2	1833.7	0.0	0	1.5	3000	0.5	2.5
19440	3.0	3.0	7.2	19.9	1.0	1.4	2	536.3	1986.1	0.0	0	1.5	3000	0.6	2.5

SECTION	Y_{MAX}	Y_{TOT}=	V (FPS)	FLOW DEPTH (FT)	Y_{AGG}+	Y_{GA}+	CHANNEL TYPE	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	Y_{SE}+	BEND COEFF	SIDE SLOPE	RADIUS	H/2	Y_{DM}
19240	**3.4**	3.4	7.6	19.4	1.0	1.4	2	445.4	1738.0	0.0	0	1.5	3000	1.0	2.5
19050	**4.1**	4.1	6.7	20.2	1.0	1.4	2	418.1	1753.4	0.0	0	1.5	3000	1.7	2.5
18830	**4.0**	4.0	6.8	21.4	1.0	1.4	2	338.9	1684.0	0.0	0	1.5	3000	1.6	2.5
18650	**4.0**	4.0	6.7	21.2	1.0	1.4	2	339.7	1686.2	0.0	0	1.5	3000	1.6	2.5
18475	**3.4**	3.4	5.8	22.3	1.0	1.4	2	336.6	1665.9	0.0	0	1.5	3000	1.0	2.5
18290	**3.2**	3.2	6.3	22.1	1.0	1.4	2	365.1	1631.9	0.0	0	1.5	3000	0.8	2.5
18025	**3.1**	3.1	5.8	22.9	1.0	1.4	2	380.4	1557.4	0.0	0	1.5	17000	0.7	2.5
17785	**3.2**	3.2	6.4	24.0	1.0	1.4	2	389.3	1444.1	0.0	0	1.5	17000	0.8	2.5
17510	**2.5**	1.7	8.4	22.4	1.0	0.0	2	326.3	1398.9	0.0	0	1.5	17000	0.7	2.5
17360	**2.5**	1.7	11.1	20.3	1.0	0.0	2	223.6	1303.3	0.0	0	1.5	17000	0.7	2.5
17110	**2.5**	1.6	11.0	21.5	1.0	0.0	2	228.7	1229.6	0.0	0	1.5	17000	0.6	2.5
16970	**2.5**	2.1	10.7	20.3	1.0	0.0	2	235.7	1196.0	0.0	0	1.5	17000	1.1	2.5
16720	**2.5**	2.3	8.5	18.8	1.0	0.0	2	260.0	1182.0	0.0	0	1.5	17000	1.3	2.5
16515	**2.5**	2.1	7.7	19.2	1.0	0.0	2	296.5	1303.8	0.0	0	1.5	17000	1.1	2.5
16305	**2.5**	2.0	7.1	20.4	1.0	0.0	2	304.6	1395.5	0.0	0	1.5	17000	1.0	2.5
16130	**2.5**	1.7	7.7	19.4	1.0	0.0	2	323.4	1368.9	0.0	0	1.5	17000	0.7	2.5
15960	**2.5**	1.6	7.1	19.6	1.0	0.0	2	294.6	1437.6	0.0	0	1.5	17000	0.6	2.5
15745	**2.5**	1.6	7.0	19.6	1.0	0.0	2	295.8	1401.3	0.0	0	1.5	17000	0.6	2.5
15540	**2.5**	1.6	6.6	19.2	1.0	0.0	2	344.9	2361.2	0.0	0	1.5	17000	0.6	2.5
15335	**2.5**	1.7	8.9	18.8	1.0	0.0	2	348.6	1064.1	0.0	0	1.5	17000	0.7	2.5
15125	**2.5**	1.4	9.8	18.0	1.0	0.0	2	437.3	1053.5	0.0	0	1.5	17000	0.4	2.5
14900	**2.5**	1.4	8.8	16.7	1.0	0.0	2	584.1	2233.1	0.0	0	1.5	17000	0.4	2.5
14720	**2.5**	1.5	8.5	16.4	1.0	0.0	2	532.9	2020.9	0.0	0	1.5	17000	0.5	2.5
14480	**2.5**	1.5	7.4	16.4	1.0	0.0	2	819.8	1851.8	0.0	0	1.5	17000	0.5	2.5
14315	**2.5**	1.6	6.8	16.0	1.0	0.0	2	1014.4	1944.1	0.0	0	1.5	17000	0.6	2.5
14090	**2.5**	1.6	6.7	14.8	1.0	0.0	2	787.4	1816.2	0.0	0	1.5	17000	0.6	2.5
13850	**2.5**	1.6	6.6	15.6	1.0	0.0	2	582.7	1774.9	0.0	0	1.5	17000	0.6	2.5
13635	**2.5**	1.7	7.3	16.5	1.0	0.0	2	631.2	1818.0	0.0	0	1.5	17000	0.7	2.5
13425	**2.5**	1.7	5.7	16.8	1.0	0.0	2	576.3	1936.1	0.0	0	1.5	17000	0.7	2.5
13190	**2.5**	1.8	5.6	17.1	1.0	0.0	2	713.9	1911.1	0.0	0	1.5	17000	0.8	2.5
13030	**4.1**	4.1	6.0	17.6	1.0	2.1	2	712.9	1863.7	0.0	0	1.5	17000	1.0	2.5
12835	**4.6**	4.6	6.2	18.0	1.0	2.1	2	799.4	1775.1	0.0	0	1.5	17000	1.5	2.5
12615	**5.2**	5.2	6.5	18.3	1.0	2.1	2	741.8	1566.5	0.0	0	1.5	17000	2.1	2.5
12395	**5.1**	5.1	6.7	18.7	1.0	2.1	2	738.1	1543.0	0.0	0	1.5	17000	2.0	2.5
12195	**4.2**	4.2	6.5	19.1	1.0	2.1	2	990.8	1463.7	0.0	0	1.5	17000	1.1	2.5
11995	**4.1**	4.1	7.4	20.3	1.0	2.1	2	589.4	1448.5	0.0	0	1.5	17000	1.0	2.5
11780	**4.0**	4.0	7.3	20.6	1.0	2.1	2	590.4	1460.8	0.0	0	1.5	17000	0.9	2.5
11605	**4.0**	4.0	7.9	20.3	1.0	2.1	2	587.6	1417.5	0.0	0	1.5	17000	0.9	2.5
11405	**3.9**	3.9	8.7	20.6	1.0	2.1	2	579.7	1144.9	0.0	0	1.5	17000	0.8	2.5
11180	**3.9**	3.9	10.7	19.7	1.0	2.1	2	580.2	1009.2	0.0	0	1.5	17000	0.8	2.5
11015	**3.8**	3.8	12.6	18.7	3.1	0.0	2	519.8	851.0	0.0	0	1.5	17000	0.7	2.5
10835	**3.7**	3.7	12.2	17.1	3.1	0.0	2	510.4	1073.0	0.0	0	1.5	17000	0.6	2.5
10575	**3.8**	3.8	9.1	16.1	3.1	0.0	2	534.5	1322.2	0.0	0	1.5	17000	0.7	2.5
10390	**3.1**	3.1	8.6	17.1	3.1	0.0	2	598.1	1517.0	0.0	0	1.5	17000	0.0	2.5
10225	**3.1**	3.1	8.0	16.6	3.1	0.0	2	606.9	1543.4	0.0	0	1.5	17000	0.0	2.5
10000	**3.1**	3.1	8.1	16.6	3.1	0.0	2	685.3	1626.0	0.0	0	1.5	17000	0.0	2.5
9820	**3.1**	3.1	7.9	17.4	3.1	0.0	2	773.4	1648.8	0.0	0	1.5	17000	0.0	2.5
9595	**3.1**	3.1	7.8	16.1	3.1	0.0	2	698.1	1719.6	0.0	0	1.5	17000	0.0	2.5
9385	**3.1**	3.1	7.2	15.6	3.1	0.0	2	694.0	1799.3	0.0	0	1.5	17000	0.0	2.5
9220	**3.1**	3.1	6.8	15.6	3.1	0.0	2	645.1	1853.4	0.0	0	1.5	17000	0.0	2.5
9025	**3.1**	3.1	7.0	15.6	3.1	0.0	2	537.6	1822.9	0.0	0	1.5	17000	0.0	2.5
MAX=	**5.2**	5.2			3.1					0.0				3.7	2.5
MIN=	**2.5**	1.4			1.0					0.0				0.0	2.5

Santa Clara River Fluvial Study

APPENDIX CHAPTER 6.3

Summary of Appendix 6
Toedown & Freeboard
Proposed Condition
Curved & Straight Reaches

PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

Table A6.3: Santa Clara River Appendix 6 Summary of Proposed Toe-down & Freeboard (ft)											
			Outside Curved Reach		Straight-Inside Curved Reach			Outside Curved Reach		Straight-Inside Curved Reach	
Subreach	HEC-RAS Station	Z_{99} [2]	Total Degradation (H&S w/ SAM) [3]	Proposed Toe-down Elevation [1,4]	Total Degradation (H&S w/ SAM) [3]	Proposed Toe-down Elevation [1,4]	WSE	Total Freeboard (H&S w/ SAM) [3]	Proposed Top of Levee Elevation [2]	Total Freeboard (H&S w/ SAM) [4]	Proposed Top of Levee Elevation [1]
SRA1	46195	1035.0	11.1	1023.9	11.1	1023.9	1063.1	3.1	1066.3	3.1	1066.3
	46020	1032.0	12.7	1019.3	12.7	1019.3	1062.0	3.0	1065.0	3.0	1065.0
	45545	1030.0	10.4	1019.6	10.4	1019.6	1057.9	3.4	1061.3	3.4	1061.3
	45030	1025.0	13.1	1011.9	13.1	1011.9	1054.2	3.0	1057.3	3.0	1057.3
	44585	1022.0	9.8	1012.2	9.8	1012.2	1050.6	3.2	1053.8	3.2	1053.8
	44210	1020.0	12.5	1007.5	12.5	1007.5	1047.8	2.9	1050.8	2.9	1050.8
SRA2	43820	1018.0	15.4	1002.6	15.4	1002.6	1042.1	3.9	1046.0	3.9	1046.0
	43610	1017.0	17.0	1000.0	17.0	1000.0	1038.3	4.0	1042.2	4.0	1042.2
	43410	1016.0	15.8	1000.2	15.8	1000.2	1035.8	3.6	1039.4	3.6	1039.4
	43200	1014.0	16.3	997.7	16.3	997.7	1033.2	3.5	1036.7	3.5	1036.7
	42975	1012.0	15.5	996.5	15.5	996.5	1031.0	2.9	1033.8	2.7	1033.7
	42815	1011.0	15.5	995.5	15.5	995.5	1029.7	2.5	1032.2	2.5	1032.2
	42590	1010.0	15.1	994.9	14.7	995.3	1028.4	2.5	1030.9	2.5	1030.9
	42430	1008.0	15.4	992.6	15.3	992.7	1027.5	2.5	1030.0	2.5	1030.0
	42215	1006.0	15.2	990.8	14.7	991.3	1026.7	2.5	1029.2	2.5	1029.2
	41940	1005.0	13.4	991.6	11.9	993.1	1025.6	2.5	1028.1	2.5	1028.1
	41730	1004.0	13.2	990.8	12.0	992.0	1024.6	2.5	1027.1	2.5	1027.1
	41460	1002.0	12.8	989.2	11.9	990.1	1023.2	2.5	1025.7	2.5	1025.7
SRA3	41280	1001.0	10.9	990.1	10.9	990.1	1021.8	2.5	1024.3	2.5	1024.3
	41080	1000.0	12.7	987.3	12.7	987.3	1020.5	2.5	1023.0	2.5	1023.0
	40825	999.5	12.2	987.3	11.7	987.8	1019.3	2.5	1021.8	2.5	1021.8
	40585	998.0	11.6	986.4	11.2	986.8	1018.3	2.5	1020.8	2.5	1020.8
	40335	996.0	10.2	985.8	8.8	987.2	1017.4	2.5	1019.9	2.5	1019.9
	40130	995.0	10.3	984.7	9.0	986.0	1016.6	2.5	1019.1	2.5	1019.1
	39945	994.0	10.2	983.8	8.9	985.1	1015.9	2.5	1018.4	2.5	1018.4
	39755	994.0	11.0	983.0	11.0	983.0	1014.6	2.5	1017.1	2.5	1017.1
	39605	993.0	12.5	980.5	12.5	980.5	1013.7	2.5	1016.2	2.5	1016.2
	39310	992.0	11.2	980.8	11.0	981.0	1012.2	2.5	1014.7	2.5	1014.7
	39100	990.0	12.5	977.5	12.5	977.5	1011.1	2.5	1013.6	2.5	1013.6
	38925	989.5	9.5	980.0	9.5	980.0	1010.3	2.5	1012.8	2.5	1012.8
SRA4	38710	988.0	6.7	981.3	6.7	981.3	1009.2	2.5	1011.7	2.5	1011.7
	38475	986.0	9.0	977.0	9.0	977.0	1007.0	2.6	1009.5	2.6	1009.5
	38300	985.5	9.8	975.7	9.8	975.7	1005.8	2.5	1008.3	2.5	1008.3
	38065	984.0	7.6	976.4	7.6	976.4	1004.1	2.5	1006.6	2.5	1006.6
	37810	983.0	9.2	973.8	9.2	973.8	1001.4	2.8	1004.2	2.8	1004.2
	37655	982.0	10.0	972.0	10.0	972.0	999.9	2.6	1002.5	2.6	1002.5
	37390	981.0	8.0	973.0	8.0	973.0	998.5	2.5	1001.0	2.5	1001.0
	37135	980.0	8.4	971.6	8.4	971.6	996.8	2.5	999.3	2.5	999.3
	36930	978.0	8.8	969.3	8.8	969.3	995.7	2.5	998.2	2.5	998.2
	36735	977.0	8.2	968.8	8.2	968.8	994.6	2.5	997.1	2.5	997.1
	36515	975.0	7.3	967.7	6.9	968.1	993.6	2.5	996.1	2.5	996.1
	36265	974.0	7.7	966.3	6.8	967.2	992.3	2.5	994.8	2.5	994.8
SRB1	36080	973.0	22.9	950.1	22.0	951.0	990.6	2.5	993.1	2.5	993.1
	35845	971.0	9.2	961.8	7.5	963.5	989.1	2.5	991.6	2.5	991.6
	35725	970.0	10.7	959.3	8.9	961.1	988.3	2.5	990.8	2.5	990.8
	35515	969.0	11.5	957.5	9.8	959.2	986.9	2.5	989.4	2.5	989.4
	35245	968.0	11.4	956.6	9.9	958.1	985.0	2.5	987.5	2.5	987.5
	35040	967.0	12.7	954.3	11.0	956.0	983.6	2.5	986.1	2.5	986.1
	34860	966.0	11.6	954.4	10.4	955.6	982.3	2.5	984.8	2.5	984.8
	34720	965.5	11.8	953.7	10.4	955.1	981.3	2.5	983.8	2.5	983.8
	34495	964.0	10.9	953.1	10.0	954.0	979.7	2.5	982.2	2.5	982.2
	34310	963.0	10.8	952.2	9.6	953.4	978.4	2.5	980.9	2.5	980.9
	34090	962.0	10.8	951.2	9.7	952.3	977.0	2.5	979.5	2.5	979.5
SRB2	33880	960.0	10.2	949.8	9.1	950.9	975.7	2.5	978.2	2.5	978.2
	33710	959.0	9.9	949.1	8.6	950.4	974.6	2.5	977.1	2.5	977.1
	33500	958.0	10.4	947.6	8.9	949.1	973.3	2.5	975.8	2.5	975.8
	33310	957.0	10.9	946.1	8.7	948.3	972.3	2.5	974.8	2.5	974.8
	33115	956.0	9.0	947.0	6.8	949.2	971.4	2.5	973.9	2.5	973.9
	32795	954.0	9.9	944.1	7.7	946.3	969.7	2.5	972.2	2.5	972.2
	32605	952.0	10.5	941.5	8.2	943.8	968.7	2.5	971.2	2.5	971.2
SRC1	32265	950.0	9.9	940.1	7.4	942.6	967.2	2.5	969.7	2.5	969.7
	31875	949.0	9.1	939.9	6.1	942.9	965.6	2.5	968.1	2.5	968.1
	31585	946.0	8.6	937.4	5.6	940.4	964.7	2.5	967.2	2.5	967.2
	31360	944.0	8.3	935.7	5.4	938.6	963.9	2.5	966.4	2.5	966.4
	31060	942.0	7.5	934.5	4.9	937.1	963.2	2.5	965.7	2.5	965.7
	30720	940.0	7.9	932.1	4.6	935.4	962.5	2.5	965.0	2.5	965.0
	30445	938.0	7.9	930.1	4.5	933.5	962.1	2.5	964.6	2.5	964.6
	30095	936.0	8.1	927.9	4.6	931.4	961.5	2.5	964.0	2.5	964.0
	29815	935.0	7.7	927.3	4.8	930.2	960.8	2.5	963.3	2.5	963.3
	29565	934.0	7.1	926.9	4.7	929.3	960.3	2.5	962.8	2.5	962.8
	29385	933.0	7.0	926.0	4.9	928.1	959.6	2.5	962.1	2.5	962.1
SRC2	29140	932.0	10.4	921.6	9.1	922.9	958.4	2.5	960.9	2.5	960.9
	28895	930.0	13.5	916.5	12.7	917.3	953.8	4.8	958.6	4.7	958.5
	28695	928.0	15.0	913.0	15.0	913.0	952.9	2.5	955.4	2.5	955.4
	28500	927.5	14.7	912.8	14.7	912.8	950.5	3.1	953.5	2.9	953.4
	28280	926.0	13.6	912.4	13.4	912.6	949.8	2.5	952.3	2.5	952.3
	28080	925.0	9.9	915.1	9.7	915.3	949.1	2.5	951.6	2.5	951.6
	27925	924.0	10.3	913.7	10.3	913.7	948.1	2.5	950.6	2.5	950.6
	27725	923.0	12.9	910.1	12.9	910.1	946.1	2.9	949.0	2.9	949.0
	27545	922.0	15.0	907.0	15.0	907.0	944.3	3.1	947.4	3.1	947.4
	27335	921.0	14.1	906.9	14.1	906.9	943.0	2.7	945.7	2.6	945.6
	27155	920.5	12.9	907.6	12.9	907.6	941.5	2.9	944.4	2.8	944.2
SRC3	26990	920.0	11.2	908.8	11.0	909.0	940.4	2.5	942.9	2.5	942.9
	26780	918.0	11.6	906.4	10.9	907.1	939.3	2.5	941.8	2.5	941.8
	26575	917.0	16.0	901.0	10.9	906.1	938.5	2.5	941.0	2.5	941.0
	26355	916.0	15.4	900.6	8.7	907.3	937.6	2.5	940.1	2.5	940.1
	26170	915.0	16.6	898.4	9.2	905.8	936.9	2.5	939.4	2.5	939.4
	25965	914.0	17.1	896.9	9.8	904.2	936.2	2.6	938.8	2.5	938.7
	25785	913.5	16.7	896.8	10.1	903.4	935.5	2.7	938.2	2.5	938.0
	25600	912.5	15.9	896.6	9.9	902.6	934.8	2.5	937.3	2.5	937.3
	25425	911.0	15.1	895.9	9.8	901.2	934.1	2.5	936.7	2.5	936.6
	25215	910.0	14.0	896.0	8.0	902.0	933.3	2.5	935.8	2.5	935.8
	25000	909.0	13.7	895.3	7.6	901.4	932.5	2.5	935.0	2.5	935.0
SRC4	24795	908.0	12.3	895.7	6.7	901.3	931.5	3.7	935.2	3.4	934.9
	24550	906.0	12.4	893.6	7.1	898.9	930.1	3.6	933.6	3.3	933.4
	24335	905.0	13.0	892.0	8.5	896.5	928.5	3.9	932.4	3.6	932.1
	24115	904.0	13.5	890.5	9.4	894.6	927.0	3.8	930.8	3.5	930.5
	23975	903.5	13.9	889.6	9.8	893.7	926.1	3.5	929.7	3.3	929.4
	23755	902.0	13.2	888.8	8.4	893.6	924.7	3.2	927.9	3.1	927.8
	23565	900.0	14.5	885.5	9.5	890.5	923.6	3.7	927.3	3.4	927.0
	23365	900.0	14.3	885.7	8.6	891.4	922.4	3.5	925.9	3.2	925.6
	23180	899.0	15.8	883.2	10.3	888.7	921.5	3.2	924.6	3.0	924.4
	23000	898.0	13.0	885.0	9.6	888.4	920.0	3.3	923.3	3.0	923.0
	22790	897.5	26.8	870.7	23.0	874.5	917.5	3.1	920.6	3.0	920.5
	22600	896.0	14.8	881.2	9.3	886.7	915.8	3.2	919.0	2.9	918.7
	22415	895.5	14.0	881.5	9.4	886.1	914.4	3.2	917.6	2.9	917.4

1 - Phase 1 Analysis

2 - Minimum 1999 Bed Elevation

3 - Toe-down based on LA County Hydrology & Sedimentation Manual; Freeboard based on max of LA County Hydrology & Sedimentation Manual and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Final design of levee will include detailed bridge analysis

Table A6.3: Santa Clara River Summary of Proposed Toe-down & Freeboard (ft) continued

Subreach	HEC-RAS Station	Z_{99} [2]	Outside Curved Reach		Straight-Inside Curved Reach		WSE	Outside Curved Reach		Straight-Inside Curved Reach	
			Total Degradation (H&S w/ SAM) [3]	Proposed Toe-down Elevation [1,4]	Total Degradation (H&S w/ SAM) [3]	Proposed Toe-down Elevation [1,4]		Total Freeboard (H&S w/ SAM) [3]	Proposed Top of Levee Elevation [2]	Total Freeboard (H&S w/ SAM) [4]	Proposed Top of Levee Elevation [1]
SRD1	22195	894.0	13.3	880.7	6.7	887.3	913.1	2.5	915.6	2.5	915.6
	22010	892.0	15.3	876.7	7.7	884.3	911.4	2.5	913.9	2.5	913.9
	21790	891.5	15.3	876.2	9.4	882.1	909.9	2.6	912.6	2.5	912.4
	21615	892.0	12.5	879.5	8.5	883.5	908.9	2.6	911.5	2.5	911.4
	21440	890.0	14.1	875.9	8.3	881.7	907.8	2.5	910.3	2.5	910.3
	21225	888.0	16.3	871.7	8.6	879.4	906.7	2.5	909.2	2.5	909.2
	21020	887.0	12.6	874.4	9.1	877.9	905.6	2.5	908.1	2.5	908.1
	20845	886.0	15.2	870.8	7.3	878.7	904.7	2.5	907.2	2.5	907.2
	20595	885.0	14.1	870.9	6.3	878.7	903.6	2.5	906.1	2.5	906.1
	20435	884.0	14.4	869.6	6.2	877.8	902.8	2.5	905.3	2.5	905.3
	20280	883.7	15.4	868.3	7.5	876.2	901.8	2.5	904.3	2.5	904.3
	20070	882.0	16.8	865.2	9.2	872.8	900.6	2.5	903.1	2.5	903.1
SRD2	19855	880.5	14.5	866.0	9.1	871.4	899.6	3.0	902.6	2.9	902.5
	19630	880.0	12.3	867.7	8.4	871.6	898.6	2.9	901.5	2.9	901.5
	19440	878.0	12.2	865.8	6.3	871.7	897.9	3.0	900.8	3.0	900.8
	19240	877.5	13.0	864.5	7.4	870.1	896.9	3.4	900.3	3.4	900.2
	19050	876.0	14.1	861.9	8.8	867.2	896.2	4.1	900.3	4.1	900.3
	18830	874.0	14.5	859.5	6.4	867.6	895.4	4.1	899.4	4.0	899.4
	18650	873.5	14.7	858.8	6.0	867.5	894.7	4.0	898.7	4.0	898.7
	18475	872.0	13.6	858.4	5.1	866.9	894.3	3.4	897.6	3.4	897.6
	18290	871.5	14.1	857.4	5.3	866.2	893.6	3.2	896.8	3.2	896.8
	18025	870.0	4.8	865.2	4.8	865.2	892.9	3.1	895.9	3.1	895.9
	17785	868.0	5.0	863.0	5.0	863.0	892.0	3.2	895.2	3.2	895.2
SRD3	17510	868.0	6.9	861.1	6.9	861.1	890.4	2.5	892.9	2.5	892.9
	17360	868.0	9.2	858.8	9.2	858.8	888.3	2.5	890.8	2.5	890.8
	17110	864.0	12.0	852.0	12.0	852.0	885.5	2.5	888.0	2.5	888.0
	16970	863.7	12.1	851.6	12.1	851.6	884.0	2.5	886.5	2.5	886.5
	16720	863.5	9.9	853.6	9.9	853.6	882.3	2.5	884.8	2.5	884.8
	16515	862.0	10.4	851.6	10.4	851.6	881.2	2.5	883.7	2.5	883.7
	16305	860.0	7.1	852.9	7.1	852.9	880.4	2.5	882.9	2.5	882.9
	16130	860.0	8.6	851.4	8.6	851.4	879.4	2.5	881.9	2.5	881.9
	15960	859.0	9.5	849.5	9.5	849.5	878.6	2.5	881.1	2.5	881.1
	15745	858.0	7.3	850.7	7.3	850.7	877.6	2.5	880.1	2.5	880.1
	15540	857.5	6.8	850.7	6.8	850.7	876.7	2.5	879.2	2.5	879.2
	15335	856.0	8.8	847.2	8.8	847.2	874.8	2.5	877.3	2.5	877.3
SRE1	15125	854.0	26.1	827.9	26.1	827.9	872.0	2.5	874.5	2.5	874.5
	14900	853.0	9.3	843.7	9.3	843.7	869.7	2.5	872.2	2.5	872.2
	14720	852.0	8.9	843.1	8.8	843.2	868.4	2.5	870.9	2.5	870.9
	14480	850.5	8.9	841.6	8.8	841.7	866.9	2.5	869.4	2.5	869.4
	14315	850.0	7.4	842.6	7.0	843.0	866.0	2.5	868.5	2.5	868.5
	14090	850.0	7.3	842.7	7.2	842.8	864.8	2.5	867.3	2.5	867.3
	13850	848.0	6.7	841.3	6.6	841.4	863.6	2.5	866.1	2.5	866.1
	13635	846.0	7.7	838.3	7.6	838.4	862.5	2.5	865.0	2.5	865.0
	13425	845.0	8.6	836.4	8.3	836.7	861.8	2.5	864.3	2.5	864.3
	13190	844.0	6.7	837.3	6.4	837.6	861.1	2.5	863.6	2.5	863.6
SRE2	13030	843.0	6.9	836.1	6.7	836.3	860.6	4.2	864.8	4.1	864.8
	12835	842.0	6.4	835.6	6.4	835.6	860.0	4.7	864.7	4.6	864.7
	12615	841.0	6.1	834.9	6.1	834.9	859.3	5.2	864.6	5.2	864.6
	12395	840.0	6.0	834.0	6.0	834.0	858.7	5.1	863.8	5.1	863.8
	12195	839.0	5.5	833.5	5.5	833.5	858.1	4.2	862.3	4.2	862.3
	11995	837.0	6.2	830.8	6.2	830.8	857.3	4.1	861.4	4.1	861.4
	11780	836.0	6.1	829.9	6.1	829.9	856.6	4.0	860.5	4.0	860.5
	11605	835.5	6.6	828.9	6.6	828.9	855.8	4.0	859.8	4.0	859.8
	11405	834.0	6.3	827.7	6.3	827.7	854.6	3.9	858.6	3.9	858.6
	11180	833.0	7.7	825.3	7.7	825.3	852.7	3.9	856.6	3.9	856.6
SRE3	11015	831.5	10.4	821.1	10.4	821.1	850.2	3.8	854.0	3.8	854.0
	10835	831.0	10.9	820.1	10.9	820.1	848.1	3.7	851.8	3.7	851.8
	10575	830.0	9.2	820.8	9.2	820.8	846.1	3.8	849.9	3.8	849.9
	10390	828.0	9.9	818.1	9.9	818.1	845.1	3.1	848.2	3.1	848.2
	10225	827.5	9.8	817.7	9.8	817.7	844.1	3.1	847.2	3.1	847.2
	10000	826.0	8.5	817.5	8.5	817.5	842.6	3.1	845.7	3.1	845.7
	9820	824.0	10.2	813.8	10.2	813.8	841.4	3.1	844.5	3.1	844.5
	9595	823.8	8.4	815.4	8.4	815.4	839.9	3.1	843.0	3.1	843.0
	9385	823.0	9.0	814.0	8.9	814.1	838.6	3.1	841.7	3.1	841.7
	9220	822.0	9.3	812.7	9.1	812.9	837.6	3.1	840.7	3.1	840.7
	9025	821.0	9.0	812.0	8.9	812.1	836.6	3.1	839.7	3.1	839.7

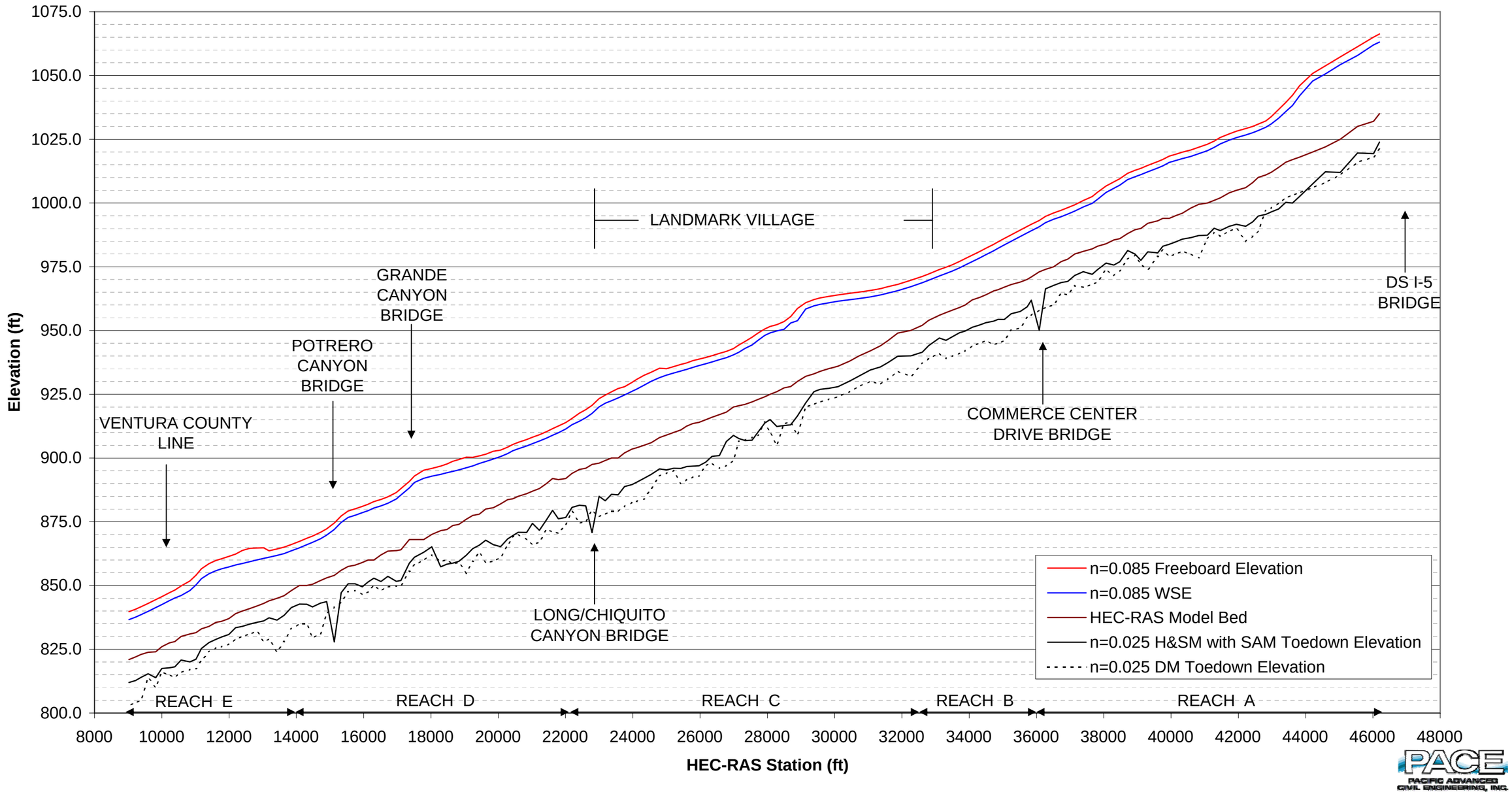
1 - Phase 1 Analysis

2 - Minimum 1999 Bed Elevation

3 - Toe-down based on LA County Hydrology & Sedimentation Manual; Freeboard based on max of LA County Hydrology & Sedimentation Manual and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Final design of levee will include detailed bridge analysis

Figure A6.3: Santa Clara River Appendix 6 Summary of Proposed Conditions Outside Curved Reach Toedown & Freeboard



P:\8197E\5-Administrative\Reports\Fluvial Report\Fluvial Spreadsheets\Appendix 6 Summary Proposed Toe & Top (old Tbl 8) 02-22-06

PACE
PACIFIC ADVANCED
CIVIL ENGINEERING, INC.
17520 Newhope Street, Suite 200
Fountain Valley, California 92708
714.481.7300

Pacific Advanced Civil Engineering, Inc., "Newhall Ranch River Fluvial Study Phase 2" (January 2008)

Newhall Ranch

River Fluvial Study

PHASE 2

SANTA CLARA RIVER

Prepared for:

NEWHALL LAND
A LENNAR/LNR COMPANY

Prepared by:

PACE
Advanced Water Engineering

JANUARY 2008
(August 2007) - Revised
(July 2006) - Revised
Job #8197E

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

17520 Newhope Street, Suite 200 ▪ Fountain Valley, California 92708 ▪ 714.481.7300 ▪ fax: 714.481.7299

August 24, 2007

Ben Willardson
Water Resources Division
Los Angeles County Department of Public Works
900 S. Freemont Ave.
Alhambra, CA 91803
(626) 458-6117

Re: Responses to the Newhall Ranch Santa Clara River Study – Phase 2A Review of Tributary Sediment Yield Impact to River **#8197E**

Dear Mr. Willardson:

Pacific Advanced Civil Engineering, Inc. (PACE) is pleased to provide the following responses to the LADPW review comments regarding the above referenced project. The responses from PACE are as follows:

General Comments

1. *The models for existing hydrology appear to be developed properly. The hydrology models for the proposed condition are sectioned into pieces and do not appear to provide flow data at the outlet where sediment transport is being modeled. The hydrologic models for the proposed condition must be revised to provide flow data and hydrographs at the downstream outlet. Flows for existing and proposed conditions must be calculated and used in SAM.*

PACE RESPONSE:
The hydrology modeling has been revised and hydrologic modeling in the present draft is conducted using only Los Angeles County Flood Control District Modified Rational Method.

2. *All of the sections in the report describe 100-yr floodplains. Were these calculated using HEC-1 and HEC-RAS models? Why are different hydrologic models being used, MODRAT vs. HEC-1? Please use consistent models for all watersheds for both the existing and proposed conditions.*

PACE RESPONSE:
Please see response to Comment 1.

3. *Flow rates in the SAM models are inconsistent with the hydrology studies. The flow rates used for the existing conditions SAM models should match the single event output from the existing conditions hydrologic models. The flow in the proposed condition SAM models should match proposed condition hydrologic model flows. SAM should be used to calculate sediment transport for the peak flow, the mean flow, 0.5 times the mean flow, and a flow between the mean and the peak. This requires analyzing the hydrographs from the hydrologic models.*

PACE RESPONSE:
The hydrographs used in SAM numerical modeling in the present draft employ output from the MODRAT hydrology simulations as discussed in Comment 1, above. The hydrographs for the respective models are entered into the SAM.YLD component of the sediment transport model.

4. *There are two processes being termed "yield" in the report. Watersheds produce sediment through erosion processes. Sediment yield describes how much sediment a watershed produces. The second process, the change in transport potential within a stream, is not "yield". The stream will carry what is provided to it, up to the stream transport potential. If the characteristics of the stream change, the stream will have a different transport potential. Changes between proposed and existing conditions only dictate how much sediment can be transported. If the supply is sufficient, the difference indicates changes to the downstream river system sediment supply. If the supply is insufficient, the channel will try to make up the difference by eroding channel bed and banks.*

   For example, the sediment yield for the Potrero watershed is estimated at 237,473 and 104,506 tons/event for the existing and proposed conditions respectively. Based on the submitted SAM models, the channel transport potential changes from 17,484 to 49,792 tons/day for the existing and proposed conditions, respectively. In this case, the yield to the river appears to increase by 32,308 tons/day since the watershed yield is still sufficient to meet the transport capacity. However, if a debris basin is involved, it may be possible that only the smaller fraction of the sediment may stay in the system. This would result in degradation of the stream system and a much smaller sediment delivery to the river system. This type of discussion and analysis needs to be provided in order to quantify changes to the river system supply. More information is needed on why yields are changing and how it will affect the sediment delivery to the river. How much of the watershed will be developed? Is a debris basin being proposed? Do water quality basins capture sediment? Is the transport potential higher or lower than the yield? All of these things impact sediment delivery to the river system, which is what this report needs to evaluate.

PACE RESPONSE:
There are two types of yield addressed in this report; watershed yield and stream yield. Watershed yield is calculated using procedures such as MUSLE, ACOE (Tatum) and LAC method, and is an estimate of sediment production of a watershed during a hypothetical design storm. Stream yield is an estimate of the sediment transported through a section of channel during a hypothetical design event, and is the sum of the area under the sediment hydrograph. Stream yield is measured in the present study using SAM.YLD, which applies a hydrograph from MODRAT to the SAM.SED model output. The wording in the text has been updated to clarify the type of yield being discussed in a given section.

5. *Maps showing general regions of development within each watershed, along with proposed debris basins and water quality ponds, would help to understand the changes for proposed conditions. These maps can be integrated into the sections on the watersheds.*

PACE RESPONSE:
The figures have been updated to show proposed conditions.

6. *More information and detail is needed in the yield calculations. The electronic versions of the spreadsheets must be provided, or equations and step-by-step calculations must be shown. Subareas and delineations used for developed areas and debris control areas must be named the same as the information provided in the maps requested in comment #5.*

PACE RESPONSE:
The electronic versions of the MUSLE and ACOE (TATUM) spreadsheets are included in Appendix Chapter 3. The MODRAT models are also included in the appendix.

7. *Why is only the LS factor in the MUSLE method changed? This only accounts for length and slope differences, which in most cases should be minor. What about changes to the cropping factor (C) and erosion control (P)? Please provide a description of each variable and how it is modified to reflect development of the watershed.*

PACE RESPONSE:
The MUSLE method was originally intended to estimate sediment production of a watershed, or watershed yield, where agricultural activities are presently in practice. Cropping and erosion control factors specifically refer to types of agricultural practices related to harvesting of crops. Cropping does not appear to have an analog in land development. In the present draft, the erosion control factor to represent the change in imperviousness between the existing and proposed conditions is used. The application of the revised methodology is discussed in Chapter 4.

8. *Do the proposed hydraulic conditions in the SAM model reflect the "restoration" techniques discussed in the last presentation by Newhall and PACE?*

PACE RESPONSE:
The present study addresses issues associated with the establishment of the top and toe of soil cement bank protection for Santa Clara River below the Landmark Project site. The restoration techniques used in the tributary channels will be discussed in future Drainage Concept Reports. The conditions modeled in the SAM models represent a starting point for the future reports.

9. *The flow rates used in the ACOE method appear to be incorrect for the existing conditions. Taking the flow rate from the hydrologic model, divided by the area, provides flows of approximately 1 cfs/acre. This translates to 640 cfs/sq. mi. These values are not reflected in the calculations. Numbers for the proposed condition were not compared since the hydrologic models for the proposed conditions do not appear to be complete.*

PACE RESPONSE:
The hydrologic modeling in the present draft has been revised; please see response to Comment 1. The values of discharge are taken directly from the MODRAT models, divided by the watershed area, and entered into the ACOE (Tatum) calculation spreadsheets. Please see Chapter 4 and Appendix Chapter 4.

10. *The ACOE method indicates that for use of the method outside of the San Gabriel Mountains, rates should be modified using the A-T method. The current study uses the same A-T factor for all subareas. Based on the LADPW debris production zones, the erosion rate is not the same in the 4 tributaries. More detailed calculations and documentation for the development of the A-T factor are needed.*

    Four methods are suggested in the ACOE manual. Method 1 is most preferable and Method 4 is the least preferable. The current study appears to use the tables from Method 4 to develop an A-T factor. However, there is not enough supporting documentation to show that a thorough field investigation and comparison were made between the Newhall Land areas and the San Gabriel Mountains. It is felt that this method should only be used as a check since other methods can be used in the Newhall Land area.

    Method 3 allows use of nearby debris basins to calculate yields and appropriate A-T values. Method 3 could be developed for the Newhall Ranch area. Method 2 requires periodic on-site debris measurements. However, the LADPW Sedimentation Manual has curves that relate erosion rates in the Santa Clara River watershed to erosion rates in the San Gabriel Mountains. These curves could be used as substitutes for actual debris measurements in a method very similar to Method 2.

More detailed documentation and calculations for proposed and existing conditions need to be provided for the ACOE sediment yield method. In order to make the results truly comparable with the LADPW methodology, a fire factor related to watershed recovery of 5 years with a probability of exceedence of 0.02 should also be used for the existing condition. The current study uses a fire factor of approximately 3 for both proposed and existing conditions. Unless a detailed study can be shown for this area, LADPW feels that this fire factor value is much too low for the area for existing conditions. Based on Figures A-1 and A-2 in the ACOE manual, this value should be between 4.0 and 4.5.

PACE RESPONSE:
As discussed with LAC personnel (B. Willardson, July 7, 2007) the method used in the present draft provides more conservative results than changing the A-T factor based on methods one through three. Because the present method is more conservative, another method was not used.

11. *The data in the tables for sediment yield and tributary yield potential should all be in the same units. Tons/day and tons/event should be fairly comparable terms for the LADPW and ACOE methods. The final delivery to the river should also be expressed in tons/day for comparison to SAM models of the Santa Clara River.*

PACE RESPONSE:
The units have been adjusted in the text and tables to be consistent between methodologies.

Page Specific Concerns to be Addressed

12. *Page iii, paragraph 1, the MUSLE method is based on agricultural erosion of topsoil and is not a "yield" based method. Yield based methods are more appropriate for sediment transport since they usually deal with the heavier portion of the sediment which is trapped by debris control structures. It is good for comparison purposes, but was not developed specifically for use within the Southern California environment.*

PACE RESPONSE:
MULSE is included as a basis of comparison of values for watershed yield. It is also included because it is a well known technique, carefully considered in the literature.

13. *Page iii, paragraph 1, the LADPW method was developed based on "yields" to debris basins and dams using much of the same data used for the Army Corps of Engineers method.*

PACE RESPONSE:
The text has been updated to reflect this comment.

14. *Page v, paragraph 2, more discussion is needed on the differences between the Length-Slope factor (LS) used in the current report versus the Simons, Li, and Associates report.*

PACE RESPONSE:
The length-slope factor is a function of slope length and bed slope and is computed using the Wischmeier and Smith (1965) equation. The SLA study uses super-watersheds that are comprised of several of the watersheds considered in the present report. For example, in the present study Grande (~3.4 mi^2) and Chiquito (~4.8 mi^2) watersheds are studied separately, where as in the SLA study the individual watersheds are parts of a larger watershed (~19.0 mi^2) and studied as a whole. Because of the dissimilarity in watersheds studied, differences in the slopes and slope length are observed, changing the LS values. The report has been updated to reflect this response.

15. *Page v, paragraph 2, the differences in the soil erodibility factor (K), cropping factor (C), and erosion control factor (P) used in the current report versus the Simons, Li, and Associates report need to be explained further.*

PACE RESPONSE:
In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values. SLA also used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4. The text of the report has been updated to reflect this comment.

16. *Page vi, paragraph 2, the "yield' from SAM is actually transport potential. See general comment 3. The transport potential will increase based on channel design. However, the yield from the watershed only changes when land use changes.*

PACE RESPONSE:
As noted in response to Comment 3, there are two types of yield discussed in this report. SAM models produce estimates of transport potential from the SAM.SED module and values of stream yield from the SAM.YLD module. Hydrographs from the tributaries for the SAM.YLD module are taken from MODRAT models of the tributary watersheds. Please see response to Comment 3.

17. *Page vi, paragraph 3, the largest flow measured at the Old Road Bridge over the Santa Clara River was 31,800 cfs. The largest flow at the County Line gage just below the project area was 68,000 cfs based on USGS data. This information is also found in the draft Newhall Ranch Specific Plan in the Hydromodification section.*

PACE RESPONSE:
The report has been revised to reflect these values.

18. *Page 1, paragraph 1, discussion in this paragraph indicates that the purpose of this report is to evaluate impacts to the river from single storm events, long-term fluvial operations, and to determine the top and toe of levees on the Santa Clara River. The Phase 2A study only evaluates changes for a single hypothetical event. If yields and delivery to the river change significantly for this event, more analysis on the long-term effects of changes may be necessary to assess the changes to effective sediment transport flows and effects on the river.*

PACE RESPONSE:
The present study considers watershed yield and stream yield differences for the four main tributaries to Santa Clara River within Newhall Ranch below the Landmark Project site. The study also considers the changes to yield based on the complete removal of sediment from tributary discharges during the CAP and peak observed (31,800 cfs) events. Please see Chapter 7.

19. *Page 3, paragraph 2, this paragraph discusses the Santa Clara River within the Newhall Ranch property boundaries. The construction of Castaic Dam should be included in this discussion, along with the effects it had on sediment delivery, changes to flow in the river, etc…*

PACE RESPONSE:
The text has been updated to reflect this comment.

20. *Figure 2.1, The figure shows gaps in watershed delineations between neighboring watersheds. The watersheds should share a boundary.*

    PACE RESPONSE:
    Figure 2.1 has been revised to eliminate the gaps between watershed boundaries.

21. *Page 7, paragraph 1, this paragraph indicates that the average slope of San Martinez Grande Canyon watercourse is 0.059. The slope of the watercourse within the Newhall Ranch property boundary is 0.022. Does this indicate a depositional area and how will this be addressed? How will changes to the depositional area effect sediment delivery to the river?*

    PACE RESPONSE:
    The fact that the upper watershed is steeper than the lower watershed does not necessarily indicate that the upper watershed is erosional, while the lower watershed is depositional. This concept is supported by the fact that both the upper and lower slopes are hydraulically steep. It is likely that the lower watershed is observing less degradation than the upper portions, as would be expected in similar watershed settings. The present study examines the impact on the River by the limiting, lower reaches of the tributaries with SAM modeling in Chapter 6. Design issues associated with sediment control on the tributary will be addressed in a separate, future drainage concept report.

22. *Page 8, paragraph 2, This paragraph indicates that there is a wide section in the middle of Long Canyon watershed that will result in delivering more runoff in a shorter time frame. However, the watershed appears to be fairly uniform in width for the entire length of the watercourse. Please revise or add more discussion.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

23. *Page 9, paragraph 1, this paragraph references a 500 ft upstream area of the watershed with a less defined active channel and much wider canyon floor, reflecting a depositional area. Please indicate this area and how it affects the sediment yield.*

    PACE RESPONSE:
    As noted in response to Comment 21, it is likely that the lower watershed is observing less degradation than the upper portions, as would be expected in similar watershed settings. The present study examines the impact on the River by the limiting, lower reaches of the tributaries with SAM modeling in Chapter 6. Design issues associated with sediment control on the tributary will be addressed in a separate, future drainage concept report.

24. *Page 12, paragraph 2, this paragraph references the 1991 manual, not the 2006 Hydrology Manual.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

25. *Page 13, paragraph 2, this paragraph references MORA runs using a fire factor of 1. Based on the 2006 Hydrology Manual, a fire factor should be 0.34 used.*

    PACE RESPONSE:
    The present draft no longer employs MORA, instead using MODRAT. Please see response to Comment 1

26. *Page 13, paragraph 3, MORA does not accept soil values above 199.*

    PACE RESPONSE:
    Please see response to Comment #25.

27. *Page 13, paragraph 9, indicates that debris basins were used to reduce burned and bulked flow rates for proposed conditions. The burned flow rate should still be applied, but not the bulked. The idea is that the sediment settles, but due to reduced vegetation, and hydrophobic soil conditions, the amount of runoff increases over the unburned condition.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

28. *Page 13, paragraph 9, debris basins indicated in this paragraph should be shown on the maps along with the assumed debris capacities.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

29. *Page 14, paragraph 2, there is a statement that the HEC-1 program includes procedures that are more physically based and representative of actual surface runoff processes. However, the sentence does not complete the thought about what HEC-1 is more representative than in determining runoff processes.*

    PACE RESPONSE:
    Please see response to Comment #25.

30. *Page 14, paragraph 5, the synthetic storm used for the analysis was based on sources other than Los Angeles County's design storm. Please indicate how this will influence runoff calculated by the HEC-1 program. HEC-1 was only used for one of the existing and proposed hydrologic models. Consistent methods should be used for all subareas.*

    PACE RESPONSE:
    Please see response to Comment #25.

31. *Page 15, paragraph 3, discussion is provided about averaging overland flow lengths from the headwaters of each watershed. Please provide the details of the averaging procedure for each watershed in an appendix. This should include the number of overland flow paths that were averaged, the lengths, and the average overland flow length for the watershed. However, this is again related to the HEC-1 model, which was only used for Potrero Canyon.*

    PACE RESPONSE:
    Please see response to Comment #25.

32. *Page 16 and 17, paragraphs 1 and 2, respectively suggest that a summary table of kinematic wave parameters for the subareas within Potrero Canyon will be provided. The table is not in the report.*

    PACE RESPONSE:
    Please see response to Comment #25.

33. *Page 19, paragraph 4, this paragraph indicates that the A-T table from the ACOE (Tatum) method will be provided in the Appendix Chapter 4. The table is not in the appendix. See comment 10 for more discussion on the information needed for the A-T factor.*

    PACE RESPONSE:
    Please see response to comment #10.

34. *Page 20, paragraph 2, the results section discusses a slight increase in yield for the Grande watershed, indicating that more sediment is being produced after development. This normally only occurs when land uses change from natural conditions to less environmentally friendly practices. Conversion of farmland to residential and commercial uses should reduce sediment yield since pavement and grass cover sediments that were previously more exposed to surface runoff and erosion processes. Please explain how the yield will increase when the production area is decreasing.*

    PACE RESPONSE:
    In the present draft, no increases in watershed yield are expected. Please see Chapter 4.

35. *Page 21, Table 4.1 shows negative changes in yield. See comment 34.*

    PACE RESPONSE:
    Please see response to Comment 34.

36. *Page 22, paragraph 2, reference to the SLA sub-watershed size uses acres instead of square miles.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

37. *Page 23, paragraph 1, the references to the Los Angeles County methods should be updated to reference the 2006 Hydrology Manual and the reformatted Sedimentation Manual, which have now been separated into two different manuals.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

38. *Page 23, paragraph 2, the discussion on differences between the SLA and PACE study indicate that changes were made to the LADPW burning and bulking methodologies after the SLA study. This is not true. The methodologies were not changed and this should not be a factor in the differences.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

39. *Page 24, paragraph 3, the existing and proposed cropping (C) and erosion control factor (P) should be altered for existing and proposed conditions in the MUSLE method. More discussion of these factors for each subarea should be added for the existing and proposed conditions in each subarea. The spreadsheets in Appendix 5 should include information similar to the ACOE spreadsheet calculations regarding factors, ranges, limitations, etc.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

40. *Page 24, paragraph 4, comparison of flow volumes on a cfs/acre or cfs/square mile should be provided for a true comparison of differences.*

    PACE RESPONSE:
    SLA did not comment on the acreage used to determine these values. It can be assumed that the full 19 to 20 mi^2 was used, but that is not clear from the SLA text. Because no clarity exists on this issue, the values have not been updated.

41. *Page 24, paragraph 4, the LADPW burning and bulking methodologies were not modified after the SLA study.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

42. *Page 29, paragraph 2, this paragraph uses yield versus transport potential. See comment 4.*

    PACE RESPONSE:
    Please see response to Comment 4.

43. *Page 30, Table 6.2, the existing and proposed sediment yield does not match information from the SAM models based on existing or proposed hydraulics and the design event. Please investigate the differences. The results provided in the table are misleading and incomplete. Changes in transport potential do not indicate changes to yield to the river. They work in conjunction with changes to yield to impact sediment delivery. The full analysis should provide final information on the changes to sediment delivery. See comment 4.*

    PACE RESPONSE:
    Table 6.2 was revised to match information from the revised SAM models. Please see response to Comment 4.

44. *Page 32, Table 6.4, the Q_s provided in the third column appears to be approximately the flow value in cubic feet per second, not changes to delivery in tons/event.*

    PACE RESPONSE:
    The third column of table 6.4 corresponds to changes to delivery in tons/event. Please see revise table headings.

45. Page 33, paragraph 1, Why are different hydrology models used? See comment 2.

PACE RESPONSE:
Please see response to Comment 1.

46. Page 33, paragraph 4, this paragraph uses yield in place of transport potential. See comment 4.

PACE RESPONSE:
Please see response to Comment 4.

47. Page 34, paragraph 3, this paragraph needs to be rephrased. Using different study areas does not change the physical parameters used, but results in a refinement of input for modeling purposes.

PACE RESPONSE:
The text has been updated to reflect this comment.

If you have any questions regarding the above responses, please do not hesitate to contact us at (714) 481-7300.

Sincerely,

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

David A. Jaffe, PhD, PE
Project Manager

DAJ/mr

C:\Documents and Settings\sharris\Desktop\Willardson, Ben Response Letter 8-23-07.doc

River Fluvial Study – Phase 2

Newhall Ranch
Santa Clara River

January 2008

Prepared For Submittal to:

LADPW
900 South Fremont Ave.
Alhambra, CA 91803-8197

On Behalf of:

Newhall Land/Lennar
23823 Valencia Blvd
Valencia, CA 91355

Prepared By:

Pacific Advanced Civil Engineering, Inc.
17520 Newhope Street, Suite 200
Fountain Valley, CA 92708

Contact Person:
Mark Krebs, P.E.
David Jaffe, Ph.D., P.E.

#8197E

Table of Contents

Executive Summary ..... **ii**

1 Introduction **1**
1.1 Study Objectives 1

2 River and Tributary Descriptions **3**
2.1 Santa Clara River 3
2.2 Chiquito Canyon Creek 4
2.3 Potrero Canyon Creek 4
2.4 San Martinez Grande Canyon Creek 5
2.5 Long Canyon Creek 6

3 River and Tributary Hydrology **8**
3.1 Methodology 8
3.1.1 Link Node Hydrology Models 8
3.2 Watershed Parameters 8
3.2.1 Watershed and Subarea Delineation 8
3.2.2 Hydrometeorlogic Characteristics 9
3.2.3 Geology 9
3.2.4 Landuse/Vegetation 9
3.2.5 MORA Routing 9
3.2.6 MORA Burning and Bulking 10
3.2.7 Time of Concentration Calculator 10
3.2.8 Debris Volume Calculations 10
3.3 General Discussion of Results 10

4 Watershed Sediment Production **12**
4.1 Methods 12
4.2 MUSLE 12
4.3 ACOE (TATUM) 12
4.4 Los Angeles County 13
4.5 Results 13

5 Comparison with Previous Work **15**
5.1 SLA's Fluvial Study of the Santa Clara River and Its Tributaries Interim Report 15
5.2 PACE's Newhall Ranch River Fluvial Study Phase 1 Final Draft 15
5.3 Results 16
5.3.1 Differences in ACOE(Tatum) method results 16
5.3.2 Differences in MUSLE method results 16
5.3.3 Differences in Los Angeles County method results 17

6 Sediment Transport and Delivery **18**
6.1 Methods 18
6.1.1 SAM Transport Potential 19
6.1.2 SAM Yield 19
6.1.3 SAM Model Assembly 19
6.2 Results 20

7 Summary and Recommendations **24**
7.1 Summary 24
7.2 Recommendations 25
7.3 A Note Concerning Differences Between Calculated Tributary and Stream Yields 29

8 References **30**

Executive Summary

This technical investigation provides a detailed and focused evaluation of the fluvial characteristics and long-term stability of the Santa Clara River for the reach including all of Newhall Land's proposed Newhall Ranch and Phase 2 development below the proposed Landmark Village. The River study reach is located from upstream of Chiquito and Long Canyon Creeks on the east and to a point directly downstream of the Ventura County/Los Angeles County line. This reach includes the Newhall Ranch Specific Plan and the proposed Entrada project. The first phase of the Newhall Ranch Specific Plan (Landmark Village) is bounded by the River on the south, State Highway 126 on the north, Castaic Creek on the east, and Grande Canyon on the west. The primary objective of this report is to develop the technical engineering analysis to assess river bed impacts from potential modifications of fluvial operation from proposed development west of and including the Long and Chiquito Canyon Creek confluences, including the Newhall Ranch Specific Plan.

The 1,634 square mile Santa Clara River watershed contains Newhall Ranch. **Approximately 12,000 acres of Santa Clara River or only one percent of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite.** The 4.8 square mile (3,053 acre) Chiquito Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 490 acres of Chiquito Canyon or only 16% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The 1.5 square mile (982 acre) Long Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 450 acres of Long Canyon or 50% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The 3.3 square mile (2,111 acre) San Martinez Grande Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 200 acres of San Martinez Grande Canyon, or only 10% of the watershed area, is located within the Newhall Ranch property boundary, with the majority being upstream or offsite.

The LA County approved WMS/MODRAT hydrology model is utilized to perform all rainfall-runoff analysis and transformation of rainfall excess into surface runoff. The WMS/MODRAT hydrology model calculates the 50-year frequency design storm, which is based on rainfall with a 2% probability of being equaled or exceeded in any given year. The 50-year frequency design storm occurs over a period of four days, with the maximum rainfall falling on the fourth day. This hydrology model was adopted for this study to provide the precipitation-runoff modeling since this is the accepted method and approved for use by Los Angeles County. The program's hydrologic procedures transform the physical characteristics of the watershed into a "link-node" model in which the hydrologic process occurs at a calculation node and these processes within the watershed are linked together by hydraulic connections.

Three different methods were used to calculate watershed sediment production: MUSLE, ACOE(Tatum), and MODRAT. The different methods were chosen for their use of data in, near, or within an environment similar to that found within the present Santa Clara River study reach. The MUSLE method is a modification of the Universal Loss Equation developed to predict watershed sediment yields for single storm events in a given watershed. The modification entails a runoff factor instead of a rainfall energy factor. The MUSLE equation is applicable to ephemeral stream of the desert southwest since the equation uses runoff from individual storms, which is the primary mode of sediment delivery in the region. The Los Angeles District of the Army Corps of Engineers developed the ACOE(Tatum) method to estimate the quantity of debris caught by some structure at some location within a watershed during a single discrete event. The method is intended to be used in coastal-draining, mountainous watersheds in southern California between 0.1 and 200 square miles in area and for storms with return periods greater than 5-year return periods. The data for the ACOE method was originally collected in southern California from both ACOE and other sources. The MODRAT hydrology model uses Los Angeles County Department of Public Works Sedimentation Manual methodology to estimate sediment production based

on debris production areas. A debris production area (DPA) is defined as a zone that yields similar volumes of sediment under similar conditions. The LADPW method was developed based on "yields" to debris basins and dams using much of the same data used for the Army Corps of Engineers method.

Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. The proposed conditions utilize the most recent plans at the time of writing, and any revisions to the proposed condition are not expected to alter debris production. The results of the calculations based on the Capital rainfall for each tributary by each method for both the existing and proposed condition are presented in Table 4.1. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. On the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. **The primary limiting factor to the change in north bank watersheds debris production is the relatively small size of the proposed development on each of the northern watersheds. For the tributaries on the River's south bank of Long and Potrero, the larger change in debris production is a function of the extent of development of the south bank watersheds.** For tributaries on the south bank of the River the average change in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum is 67.0% and 63.6% decrease (MUSLE method), respectively. **These results are summarized in Table 4.1.**

Table 4.1: Existing and Proposed Conditions Debris Production Yield by Watershed for the Capital Event [1]

Tributary	Debris Yield (tons/event) Existing	Debris Yield (tons/event) Proposed	Δ (tons/event)	Δ (%)
MUSLE				
Chiquito	6,047	5,801	-246	-4.1
Long	17,704	5,836	-11,868	-67.0
Grande	32,191	28,791	-3,400	-10.6
Potrero	15,725	5,720	-10,005	-63.6
ACOE(Tatum)				
Chiquito	84,128	82,494	-1,634	-1.9
Long	35,136	31,850	-3,286	-9.4
Grande	104,408	103,131	-1,277	-1.2
Potrero	91,204	81,116	-10,088	-11.1
LA County				
Chiquito	282,342	262,197	-20,145	-7.1
Long	79,417	63,105	-16,312	-20.5
Grande	209,251	201,348	-7,903	-3.8
Potrero	360,951	282,229	-78,722	-21.8
Average				
Chiquito	124,172	116,831	-7,342	-4.4
Long	44,086	33,597	-10,489	-32.3
Grande	115,283	111,090	-4,193	-5.2
Potrero	155,960	123,022	-32,938	-32.2

1: All calculations have been converted to tons/event.

2: Average of percentage change from all three methods

In May of 1998, Simons, Li & Associates (SLA) submitted to Los Angeles County Department of Public Works (LACDPW) the *Quantitative Analysis and Mathematical modeling of the Existing Condition of the Santa Clara River Basin, Third Interim Report*. The report covered several areas including hydrologic analysis, hydraulic analysis, sediment watershed yield analysis, and bed sediment analysis. The most relevant to this study is the watershed sediment yield analysis which included the LA County method, the MUSLE method, and the ACOE(Tatum) method. Of the three methods discussed in the report, the authors found that the most representative equation for determining the production of sediment was the LA County equation. **The SLA study has two sub-watersheds that overlap with the watersheds in the present study: the Hasley Canyon group covering the north bank watersheds of Chiquito and Grande watersheds, plus additional area; and the Potrero Canyon group cover the south bank watersheds of Long and Potrero, plus additional area. The SLA sub-watersheds cover an area of 20.0 and 19.0 mi^2, respectively for the Hasley and Potrero groups.**

PACE prepared the approved *Newhall Ranch River Fluvial Study Phase 1 Final Draft* (March 2006). The technical study provides an evaluation of the existing and proposed fluvial characteristics and long-term stability of Santa Clara River between Interstate 5 and an area generally west of the Los Angeles/Ventura County line near the Newhall Ranch Specific Plan. The study was conducted because proposed development along the River within the study area has the potential to modify the fluvial mechanics of the River. The proposed buried soil cement bank protection on both the north and south banks of the River is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. The analysis of the Phase 1 study evaluates impacts from build-out of Newhall Ranch from (1) fluvial modifications of the river bed from single hypothetical storm events, and (2) changes in the floodplain fluvial operation over the long-term.
Several differences exist between the present and SLA values used to calculate watershed sediment yield using the ACOE (Tatum) method. First, the SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. In the SLA study, slopes are generally higher than in the present study: 264 to 349 ft/mi and 163 to 312 ft/mi, respectively. This difference is due primarily to the difference in area whereby the larger slopes occur in the larger watershed groups. Based on SLA Table 4.7 it appears that the study based runoff on rainfall while the present study utilizes peak runoff. Peak runoff was chosen in the present because the ACOE manual indicates that runoff should be used for watersheds greater than 1920 Ac.

Several differences exist between the PACE and SLA values used to calculate watershed sediment yield. As noted above, the SLA and present studies use different study areas. The studies also use differing soil erodibility factor, K, values. The SLA study uses a K value of K=0.43 while the present study uses a value of 0.10. The SLA value was based on estimation of the soils present in the watershed using soil survey data, and the present study based the K value on soil samples presented in Phase 1. The reason for the difference between the two values likely arises from the extent of data considered. In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values. The SLA study considers more upland area possessing a higher percentage of fine particles with the present study focused on single watersheds adjacent to a river valley with more coarse particles. Different methods were used in the respective studies to calculate the slope length factor, LS. SLA also used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4. The values of runoff volume presented in the present study, taken from the hydrologic analysis, described above, are 399 and 370 ac-ft for the north-bank watersheds and 145 and 586 ac-ft for the south bank watersheds. Values in the SLA study for the 50-year peak discharge are approximately 18,625 and 15,825 cfs for the north and south watershed groups, respectively, while values in the present study are approximately 3,195 and 3,080 cfs and 1,135 and 3,340 cfs for the north- and south-bank watersheds. The difference in the two studies can be attributed to the differences in watershed size.

The primary difference in debris production using the LAC method between the SLA and present studies is a function of the areas used in the calculations. In the SLA study the debris production rate (DPR) is calculated, while in the present study the DPR is read from tables in within GIS layers stored in the MODRAT model. This difference leads to very small differences in DPR between the two studies. There is also some difference in debris production area (DPA) acreages. In the SLA study one hundred percent of both the north- and south-bank watershed groups are DPA 5. In the present study, all of the north-bank watersheds are DPA 5 and DPA 9, and the south-bank watersheds are a combination of DPA 3, 5, 8 and 9. The resultant debris production in cubic yards per square mile is 23,000 and 24,000 cubic yards per square mile for SLA north- and south-bank watershed groups, respectively, and approximately 27,246 and 32,949 cubic yards per square mile for the present study north- and south-bank watersheds, respectively. **The differences between the SLA and the present study are show in Table 5.1.**

Table 5.1: Comparison of SLA and Present Study Debris Production (existing condition)

Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE	ACOE(Tatum)	LAC
Hasley	19.9	**11,469**	**36,750**	**23,000**
Potrero	19.0	**51,919**	**32,250**	**24,000**
Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE*	ACOE(Tatum)	LAC
Chiquito	4.8	566	7,868	26,407
Grande	3.3	4,379	14,204	28,467
Combined	8.1	**2,119**	**10,449**	**27,246**
Long	1.5	5,299	10,516	23,769
Potrero	4.5	1,569	9,099	36,010
Combined	6.0	**2,501**	**9,453**	**32,949**

*Assumes soil densiity of 165 lb/ft^3

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River. The SAM Sediment Hydraulic Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity and stream yield in a given channel or floodplain hydraulic cross-section for a given discharge at a single point in time. A number of sediment transport functions are available for this analysis and SAM has the ability to assist in selecting the most appropriate sediment transport equation. For each tributary sediment potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. For SAM modeling sediment data was provided by Seward Engineering Geology, hydraulic data was taken from HEC-RAS models of the tributaries, and the hydrographs used were taken from the hydrologic modeling presented in Chapter 2. Modeling shows that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases stream sediment yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

A comparison of the stream sediment yield in the River with the change in sediment yield from the tributaries for the tributary Capitol event and either the Capitol or the Peak Observed event on the River (31,800 cfs, winter 1968-1969, Old Road Bridge) was made. (The largest flow at the County Line gage just below the project area was 68,000 cfs based on USGS data. This data is not utilized in the study because County Line is significantly downstream of the project reach.) The Peak Observed event was chosen as a basis for comparison since there is a lower probability of the Capitol event on both the

tributaries and River simultaneously than a Capitol event on the tributaries coincident with a sub-Capitol extreme event on the River. **The results show that for coincident Capitol events the tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the transport of one River subreach, depending on tributary. In addition, during the Peak Observed event the tributary stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, again depending on tributary.**

A comparison of modeling results illustrate that the total sediment stream yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River sediment stream yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of the River. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the River represents between approximately 4.1 and 5.9 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the sediment yielded by the tributary delivered to the River. **These results are show in Tables 6.3 and 6.4.**

Table 6.3: Comparison of River Stream Yield with Change in Tributary Stream Yield Resulting from Watershed Development During a Tributary Capitol Event (Tons/Event)

Capital Event			
Subreach	Q_s - River	ΔQ_s - Creek	Δ%
Chiquito Confluence	174,434	202	**0.12**
Long Confluence	174,434	282	**0.16**
Grande Confluence	183,265	536	**0.29**
Potrero Confluence	207,302	370	**0.18**
Peak Observed Event (31,800 cfs)			
Subreach	Q_s - River	ΔQ_s - Creek	Δ%
Chiquito Confluence	36,804	202	**0.55**
Long Confluence	36,804	282	**0.77**
Grande Confluence	49,933	536	**1.07**
Potrero Confluence	51,371	370	**0.72**

1. Positive means there is an increase from existing to proposed

Table 6.4: Comparisonof River Yield with No Tributary Yield Resulting from Watershed Development (Tons/Event)			
Tributary with No Delivery - Capitol in River			
Subreach	Q_s - River	Q_s - Creek	Δ%
Chiquito Confluence	174,434	2,182	**1.25**
Long Confluence	174,434	1,517	**0.87**
Grande Confluence	183,265	1,623	**0.89**
Potrero Confluence	207,302	2,364	**1.14**
Tributary w/ No Delivery - Peak Observed in River (31,800 cfs)			
Subreach	Q_s - River	Q_s - Creek	Δ%
Chiquito Confluence	36,804	2,182	**5.93**
Long Confluence	36,804	1,517	**4.12**
Grande Confluence	49,933	1,623	**3.25**
Potrero Confluence	51,371	2,364	**4.60**

1. Positive means there is an increase from existing to proposed

In Phase 1 of this study, SAM numerical modeling was used to estimate the change in bed elevation. Bed change was determined by calculating the difference between subreach upstream and downstream sediment potential transport for the Q_{CAP} discharge. The difference in transport potential, ΔTP, between subreach inflow and outflow was converted to general adjustment, GA. To estimate how the proposed changes in sediment delivery from the tributaries impact the fluvial mechanics of the River the general adjustment equation was modified to consider the change in tributary sediment delivery given that none of the sediment produced on the watershed reaches the River confluence. The results for the proposed condition potential where both the tributaries and the River are flowing at the Q_{CAP} discharge show that the grade change ranges from -1.5 to 2.1 feet where the highest degradation occurs in Subreach SRE3 and the greatest aggradation occurs in Subreach SRE2. **A comparison between the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.**

A comparison of the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) finds that the potential grade change ranges from -0.3 to 0.4 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. It is important to note that the potential general adjustment in this scenario is very small relative to the potential general adjustment that occurs during the Q_{CAP} scenario. **Comparing the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability for the Q_{CAP}-Q_{31800} scenario shows that influence of the tributary's sediment delivery considered is**

minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

The same comparison was made with tributary stream yield replacing potential transport in the calculations. The results show that the sediment yield grade change ranges from -0.3 to 0.5 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. The results show that influence of the tributary's sediment delivery considered is minimal relative to local river bed yield grade change. The results also show that the yield grade change ranges from -0.1 to 0.1 feet. It is important to note that the yield general adjustment in this scenario is very small relative to the yield general adjustment that occurs during the QCAP scenario. The yield results show that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. **The results of the yield-based analysis are similar to those for the potential-based analysis: that influence of the tributary's sediment delivery considered is minimal relative to local river bed yield grade change. These results are shown in tables 7.2, 7.4, 7.6 and 7.8.**

Table 7.2: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{CAP}

Subreach	US Sta	Phase 1 Proposed Conditions Grade Change (ft)	Phase 2 Proposed Conditions Grade Change (ft)	Phase 1/Phase 2 Delta (ft)	Result
SRC4	24795	0.2	0.2	**0.0**	**NO CHANGE**
SRD1	22195	-0.2	-0.2	**0.0**	**NO CHANGE**
SRD2	19855	1.4	1.4	**0.0**	**NO CHANGE**
SRD3	17510	-1.3	-1.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.4	-0.4	**0.0**	**NO CHANGE**
SRE2	13030	2.1	2.1	**0.0**	**NO CHANGE**
SRE3	11015	-1.5	-1.5	**0.0**	**NO CHANGE**

Table 7.4: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{31800}

Subreach	US Sta	Phase 1 Proposed Conditions Grade Change (ft)	Phase 2 Proposed Conditions Grade Change (ft)	Phase 1/Phase 2 Delta (ft)	Result
SRC4	24795	0.0	0.0	**0.0**	**NO CHANGE**
SRD1	22195	0.1	0.1	**0.0**	**NO CHANGE**
SRD2	19855	0.1	0.1	**0.0**	**NO CHANGE**
SRD3	17510	-0.3	-0.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.4	0.4	**0.0**	**NO CHANGE**
SRE3	11015	-0.2	-0.2	**0.0**	**NO CHANGE**

Table 7.6: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{Burn}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.1	**0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	0.1	0.3	**0.2**	**CHANGE**
SRD3	17510	-0.2	-0.3	**-0.1**	**CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.3	0.5	**0.2**	**CHANGE**
SRE3	11015	-0.1	-0.3	**-0.2**	**CHANGE**

Table 7.8: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.1	0.0	**-0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	-0.1	0.0	**0.1**	**CHANGE**
SRD3	17510	0.1	0.0	**-0.1**	**CHANGE**
SRE1	15125	-0.1	0.0	**0.1**	**CHANGE**
SRE2	13030	0.0	0.0	**0.0**	**NO CHANGE**
SRE3	11015	0.1	0.0	**-0.1**	**CHANGE**

Because the findings of the present study suggest that the impacts of development on the four watersheds considered within will be insignificant with respect to the fluvial mechanics of Santa Clara River, PACE recommends that the top and toe elevations calculated in Phase 1 of this study be approved for final design. These values are presented here in Table 7.1.

Several possible reasons exist to explain the discrepancy between the SAM stream yield and MORA watershed yield calculations. It could be expected that aggradation would occur when watershed yield exceeded stream yield, or conversely, that degradation would occur when stream yield exceeded watershed yield. In the case of Newhall Ranch Canyons fans or delta-type features are present at the confluence with Santa Clara River. To some extent, as yet uncharacterized, the shape and extent of the fan is mediated by large discharges within the River. The Creek as a whole, however, is not aggrading as suggested by the difference in watershed and stream yields presented above. **Two of the explanations are the lack of fines in the SAM model and location of debris basin data within the watershed.**

Additional discussion of the nature of the study watershed's stream and watershed yield is included in a memorandum by Phillip Williams & Associates, included in Appendix Chapter 7.

1 Introduction

The following technical investigation provides a detailed and focused evaluation of the fluvial characteristics and long-term stability of the Santa Clara River for the reach including all of Newhall Land's proposed Newhall Ranch and Phase 2 development below the proposed Landmark Village. The River study reach is located from upstream of Chiquito and Long Canyon Creeks on the east and to a point directly downstream of the Ventura County/Los Angeles County line (Figure 1.1). This reach includes the Newhall Ranch Specific Plan and the proposed Entrada project. The first phase of the Newhall Ranch Specific Plan (Landmark Village) is bounded by the River on the south, State Highway 126 on the north, Castaic Creek on the east, and Grande Canyon on the west (Figure 1.1). The Santa Clara River fluvial system extends from Acton, California in the east to the Pacific Ocean, the River's natural terminus, in the west. Adjacent development along the River within the study reach has the potential to modify the fluvial response of the watershed through changes in the runoff and reduction in the sediment supply from the developed areas. The proposed buried soil cement bank protection on both the north and south banks of the River within the study reach is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. These modifications to the river system have the potential to modify the fluvial operation of the floodplain and cause changes to the stream mechanics. The intent of this analysis is to evaluate these impacts from (1) fluvial modifications of the river bed from single hypothetical storm events, (2) changes in the floodplain fluvial operation over the long-term; and, (3) to determine the top and toe of the proposed bank protection.

1.1 Study Objectives

The primary objective of this report is to develop the technical engineering analysis to assess river bed impacts from potential modifications of fluvial operation from proposed development west of and including the Long and Chiquito Canyon Creek confluences, including the Newhall Ranch Specific Plan. The intent is to provide a comprehensive assessment of hydro-modification-related bed adjustment. This report provides technical analysis for (1) tributary hydrology, (2) watershed sediment production, (3) sediment transport and delivery, (4) total soil cement bank protection toe-down design. The objectives of the fluvial assessment for the proposed development project include the following:

1. Quantify the volume of sediment runoff from each of the tributary watersheds.

2. Estimate the limiting (downstream) transport potential and stream yield for each of the tributary watersheds.

3. Compare the quantity of sediment produced to that delivered to the River from each tributary watershed.

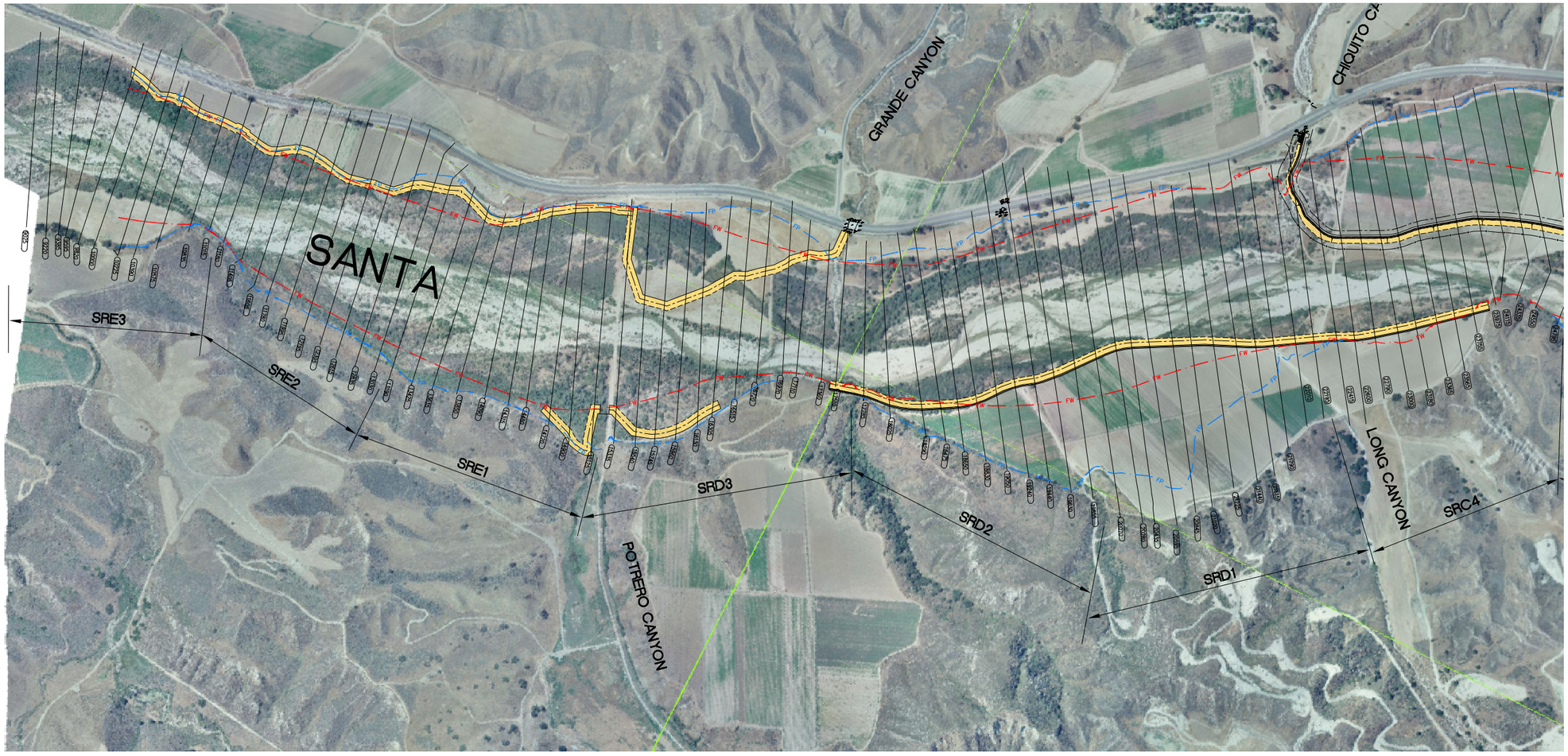
4. Determine if and the extent to which changes to the tributary watersheds will alter sediment transport potential, watershed yield and delivery.

5. Predict river bed response to the extremes in changes in sediment transport, potential, and stream yield.

6. Calculate toe-down depths and freeboard height for proposed bank protection.

   A variety of engineering analysis and tasks were associated with both the different aspects of the watershed hydrology and floodplain hydraulics. A technical framework was developed to guide the analysis of the system. These major task areas of study reflected the various objectives of the study and included the following:

   a. Tributary hydrology and MORA numerical modeling.



LEGEND

LA COUNTY FLOODPLAIN BOUNDARY (SCANNED FROM LADPW ML MAPS DATED AUG 6, 1985

LA COUNTY FLOODWAY BOUNDARY (SCANNED FROM LADPW ML MAPS DATED AUG 6, 1985

SRA4 — FLUVIAL ANALYSIS SUB REACH

NEWHALL RANCH SPECIFIC PLAN BOUNDARY LINE

PROPOSED BANK PROTECTION (PER NRMP & NEWHALL RANCH SPECIFIC PLAN)

4619S — HEC-RAS MODEL CROSS SECTION

400 200 0 400 800

NEWHALL RANCH

FIGURE 1.1

PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

A full-size reproduction of this figure can be found at Impact Sciences.

b. Baseline HEC-RAS hydraulic model – Prepare tributary models in HEC-RAS based on the 1999 digital geometry and flowrates from hydrology models. Evaluation based on single storm event and steady flow conditions.

c. HEC-2 model creation – Conversion of HEC model formats for use in SAM and HEC-6 modeling.

d. Watershed sediment production estimation – Calculations of watershed sediment production based on MUSLE, ACOE(Tatum) and Los Angeles County methodologies.

e. SAM.SED numerical modeling.

f. SAM.YLD numerical modeling.

g. Estimation of all-or-none sediment delivery impacts – Compare the impacts to Santa Clara River if sediment delivery is increased to one hundred percent of sediment produced in a tributary; compare the impacts to Santa Clara River if sediment delivery is reduced to zero percent of sediment produced in a tributary.

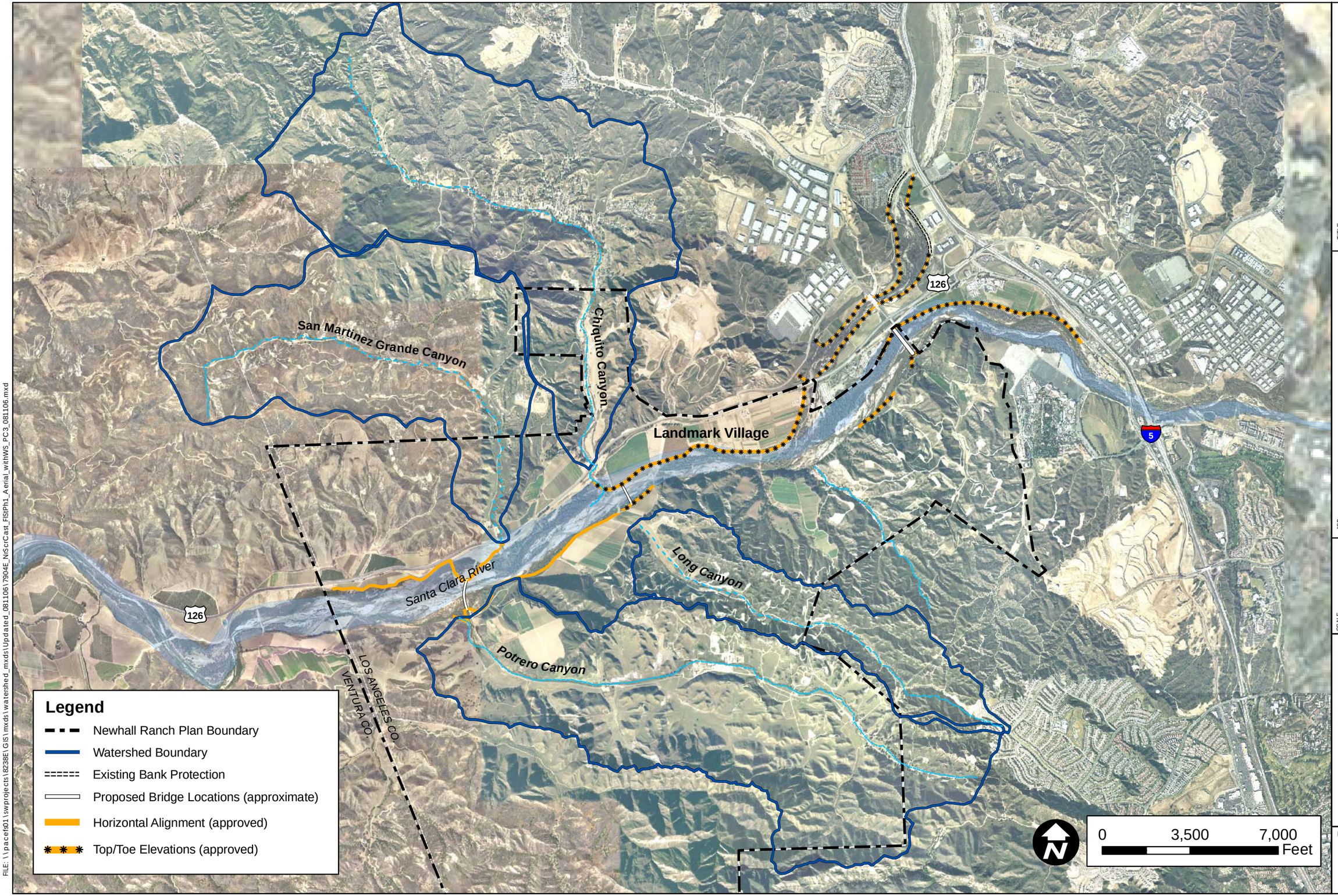
h. Comparison of results with results from previous studies.

2 River and Tributary Descriptions

2.1 Santa Clara River

The 1,634 square mile Santa Clara River watershed contains Newhall Ranch. Approximately 12,000 acres of Santa Clara River or only one percent of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The distance from the upper headwaters to the project is more than 40 miles with an average overall slope of 0.007. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.007. The majority of the Santa Clara River watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem River. A majority of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of over 5000 in the headwaters to a low elevation of approximately sea level at the ocean. Generally, the soils in the watershed in the vicinity of the Project are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Santa Clara River watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem River that are type A and group B. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the project vicinity, other than several road culvert/bridge crossings such as the Interstate 5, which would influence the watershed response to rainfall events.

The Newhall Ranch reach and vicinity along Santa Clara River extends approximately 47,000 feet downstream from Interstate 5 to the Ventura/Los Angeles County Line. The geomorphology of the active bed reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a great variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the River is more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active banks and there is little overbank flow. The changes in River geometry and form may indicate influences from the upper watershed that affect the sediment delivery. The changes in channel geometry are also reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.007. The running average slope ranges from 0.5 in the contractions to 0.0009 for the expansions. The upstream half of the study reach has a less defined active channel and a much wider canyon floor that reflects depositional area and increased floodplain vegetation within this zone. The only manmade structure that influences the hydraulic operation are the roadway bridge crossings for Interstate 5 and Old Road. A dam is located on upper Castaic Creek that limits the discharge of water and sediment from the Creek into the River. A detailed discussion of the influence of the dam can be found in “Castaic Creek Fluvial Study Phase 1 Final Draft January, 2006” (approved LACDPW April 18, 2006). Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 44% of the Project reach of the Santa Clara River floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) during a Capital flood event, while the remainder of the channel, primarily the lower portion of the study reach, was hydraulically a ”mild” channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 9 feet, ranging from approximately 4 feet to 18 feet, (2) the average velocity is approximately 12 fps, ranging from approximately 5 fps to 25 fps, and the width of the floodplain water surface averages 1070 feet, ranging from approximately 250 feet to 2300 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.



TITLE

WATERSHED BOUNDARIES

JOB

NEWHALL RANCH

LOS ANGELES COUNTY CA

SCALE	1"= 3500'
DESIGNED	T.H.
DRAWING	R.S.
CHECKED	M.K.
DATE	1/24/06
JOB NO.	7904-E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE

2.1

FILE: \\pacefs01\swprojects\8238E\GIS\mxds\watershed_mxds\Updated_081106\7904E_NScrCast_FISPh1_Aerial_withWS_PC3_081106.mxd

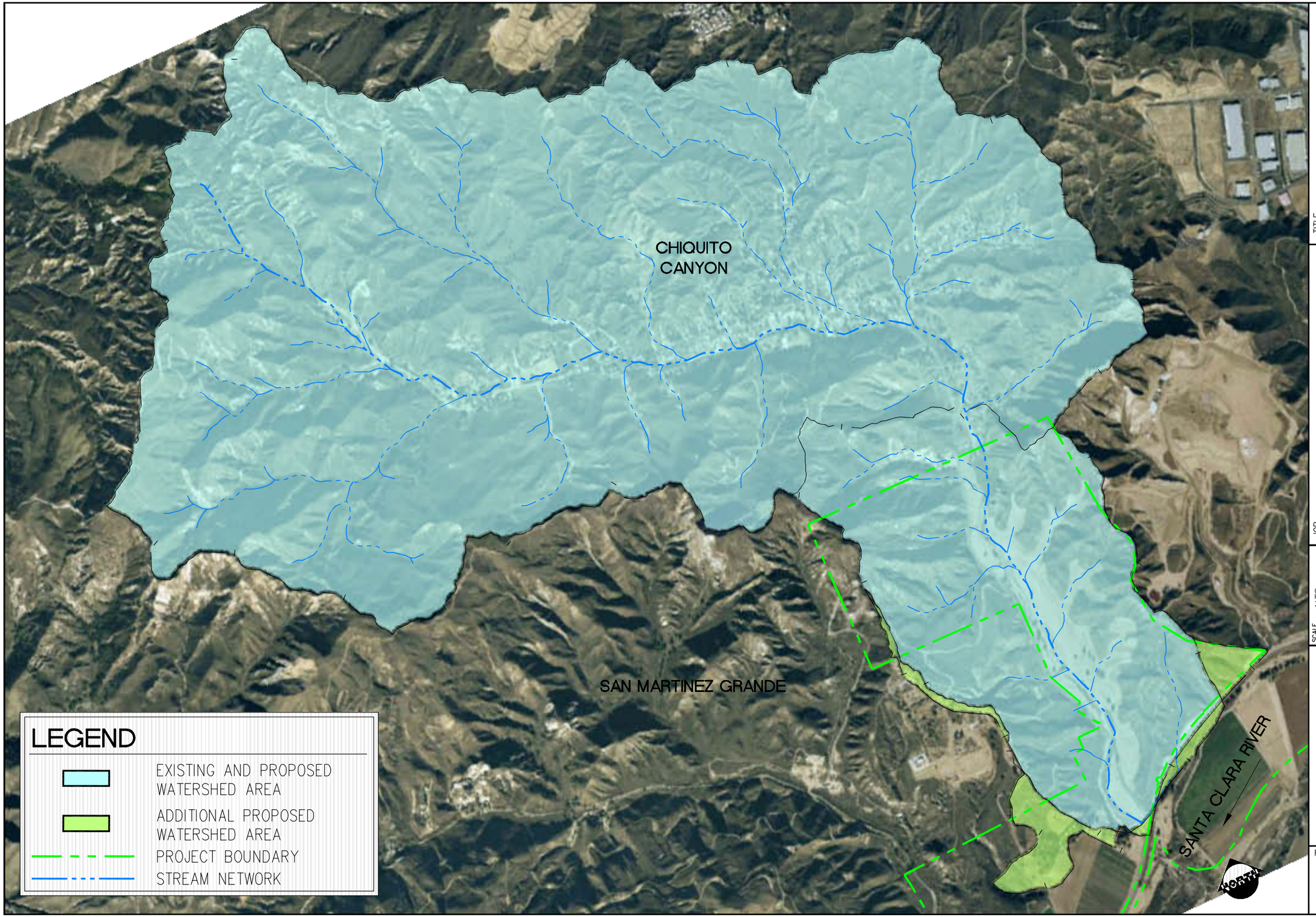
2.2 Chiquito Canyon Creek

The 4.8 square mile (3,053 acre) Chiquito Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 490 acres of Chiquito Canyon or only 16% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The Creek in the headwaters flows in a general west to east direction while the remaining lower portion of the Creek flows in a north to south direction, similar in alignment to Grande Canyon and joining the Santa Clara River floodplain valley. The overall watershed boundary develops a shape such that a larger portion of the drainage area is tributary in the upstream portion watershed, with a maximum width of 8,300 feet, and tapers down towards the mouth of the canyon, with an average width of 2,800 feet. The distance from the upper headwaters to the canyon mouth is approximately 28,318 feet with an average overall slope of 0.031. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.025. The majority of the Chiquito Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% or more of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 1800 in the headwaters to a low elevation of 925 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Chiquito Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush.

The lower Chiquito Canyon creek extends approximately 8,200 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. Detailed hydraulic modeling of the existing floodplain was performed and indicated that a major portion of the Chiquito Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 3.8 feet, ranging from 9.5 feet to 1.6 feet, (2) the average velocity is approximately 11.9 fps, ranging form 22 fps to 5 fps, and the width of the floodplain water surface averages 194 feet, ranging from 549 feet to 36 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.3 Potrero Canyon Creek

The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The Creek flows in a general west to east direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The overall watershed boundary has a fairly uniform width, with an upstream maximum width of approximately 8,600 and a minimum of 5,400 feet downstream. A significant portion of this wide region is in the south-western section near the upstream end of the creek. The shape of the watershed is important since that influences when runoff reaches the outlet. Although the watershed is relatively long, the greater width throughout the central portion of the watershed will result in a higher amount of runoff during a shorter period of time, increasing the peak discharges observed at the outlet. The distance from the upper headwaters to the canyon mouth is approximately 24,139 feet with an average overall slope of 0.033. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.024. The majority of the Potrero Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous



TITLE

CHIQUITO CANYON EXISTING & PROPOSED OVERALL WATERSHED BOUNDARIES

JOB

NEWHALL RANCH

LOS ANGELES CO., CA

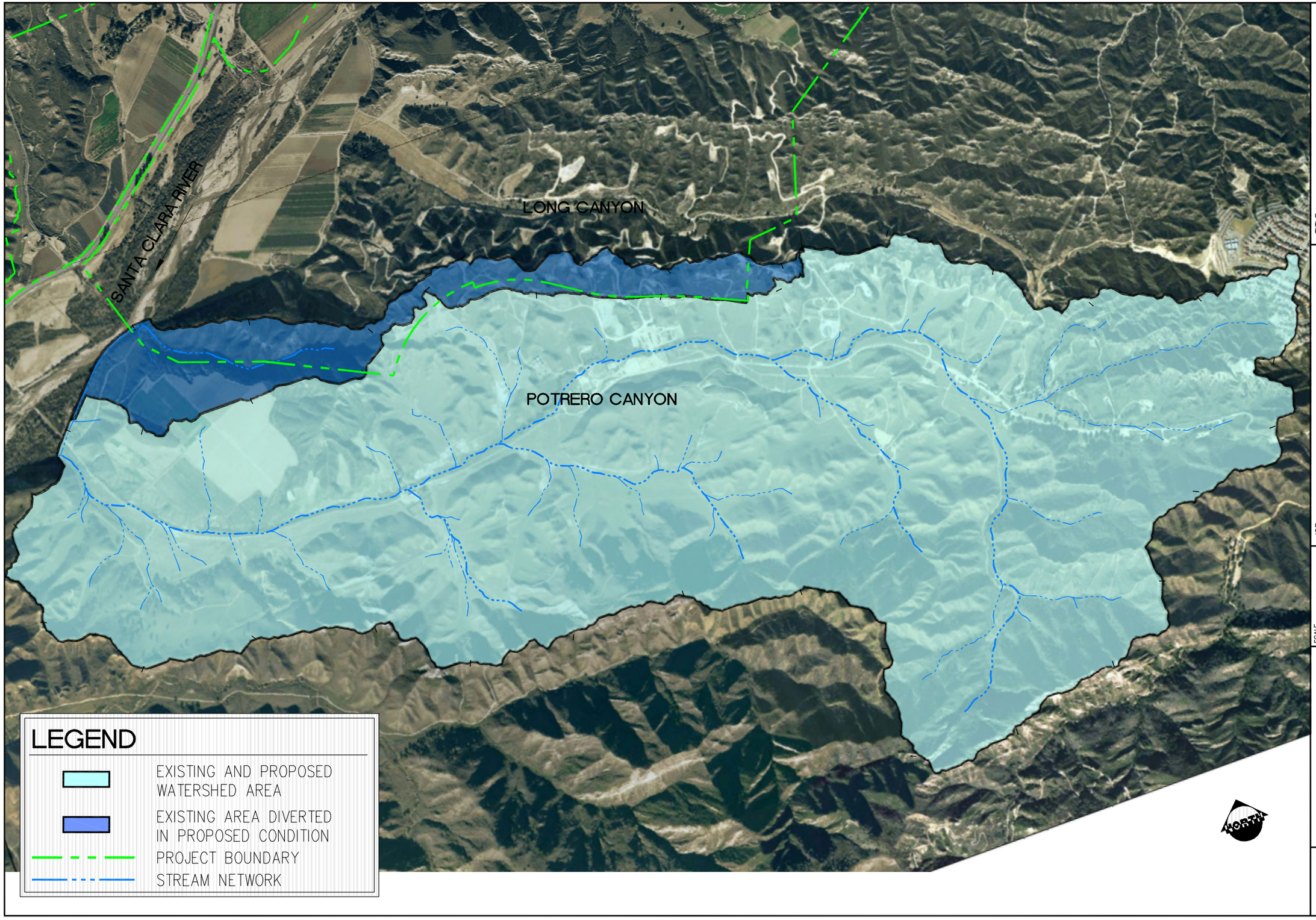
SCALE	NTS
DESIGNED	JJD
DRAWN	GA
CHECKED	JJD
DATE	JULY 2007
JOB NO.	8197-E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE

2.2

Dimscale = 40; LTscale = 1; PSltscale = 1; ACAD Ver. = 17.1s (LMS Tech) ; Visretain = 1
P:\8197E\Engineering\8197-XX (Castaic Creek Sections)\exhibits\8197-E-FIG-22B-PR-CHIQUITO.dwg – Tab: Layout1 – by enarvaez on 08/14/07 at 1:26:14 PM



TITLE

POTRERO CANYON
EXISTING & PROPOSED OVERALL WATERSHED BOUNDARIES

JOB

NEWHALL RANCH

LOS ANGELES CO.

GA

SCALE NTS
DESIGNED JJD
DRAWN GA
CHECKED JJD
DATE JULY 2007
JOB NO. 8197-E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE

2.3

Dimscale = 1; LTscale = 1; PSltscale = 1; ACAD Ver. = 17.1s (LMS Tech) ; Visretain = 1

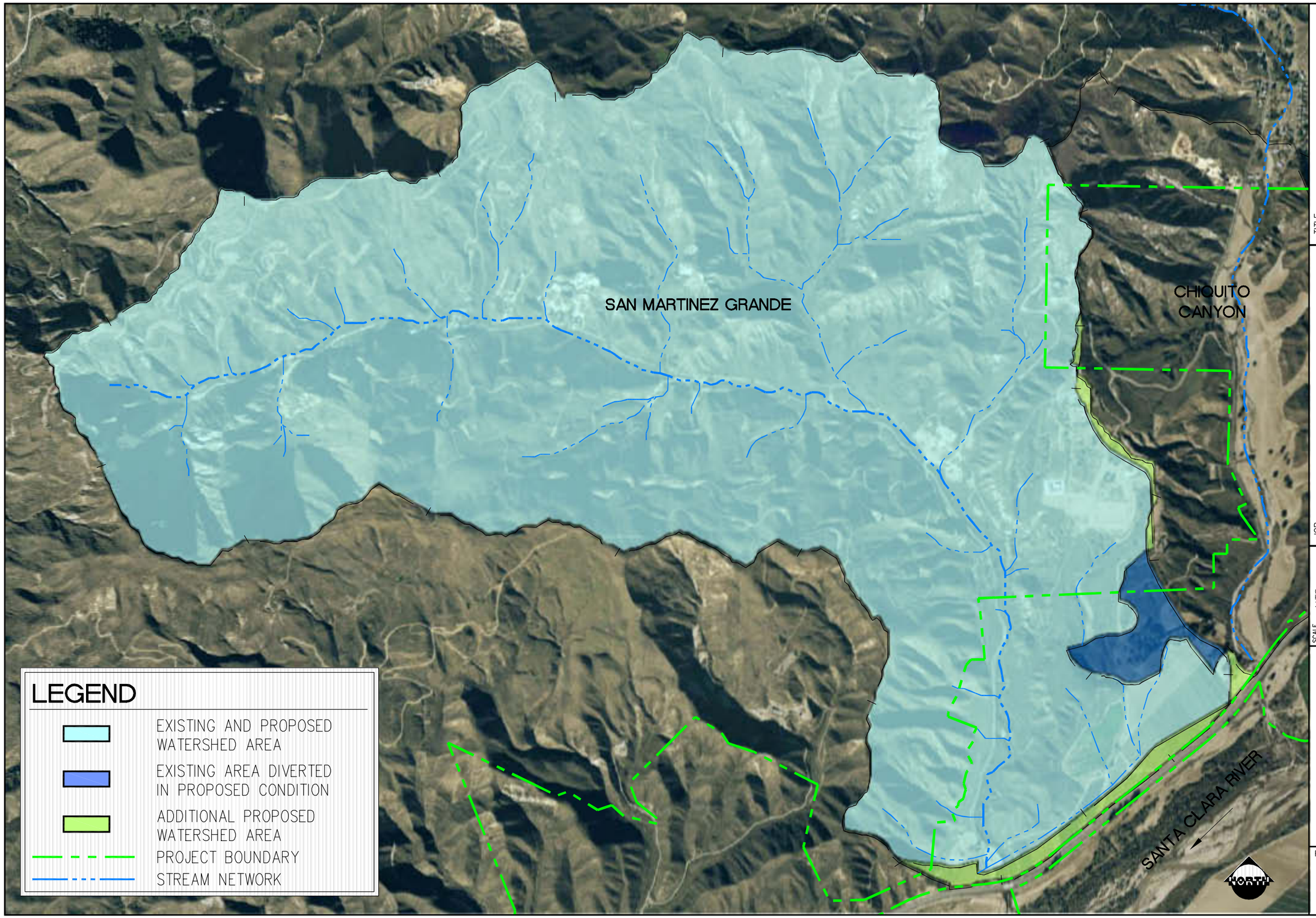
P:\8197E\Engineering\8197-XX (Castaic Creek Sections)\exhibits\8197-E-FIG-23B-PR-POTRERO CANYON.dwg – Tab: Layout1 – by enarvaez on 08/14/07 at 1:52

smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 1675 in the headwaters to a low elevation of 870 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Potrero Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the watershed, other than several road culvert/bridge crossings such as the SR 126, that would influence the watershed response to rainfall events. Detailed hydrologic modeling has been performed to evaluate the baseline existing watershed conditions and the results of the peak discharges are discussed in the Section on Hydrology.

The lower Potrero Canyon creek extends approximately 18,270 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a steady variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel, with the active portion of the creek being more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active Creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.024. The average slopes ranges from 0.055 in the contraction to 0.011. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 40% of the lower reach of the Potrero Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a ”mild” channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The characteristics of the 100-year floodplain generated by the hydraulic modeling indicate that, (1) the average depth is approximately 3.1 feet, ranging from 6.6 feet to 0.7 feet, (2) the average velocity is approximately 5.9 fps, ranging form 11.2 fps to 2.2 fps, and the width of the floodplain water surface averages 330 feet, ranging from 950 feet to 50 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.4 San Martinez Grande Canyon Creek

The 3.3 square mile (2,111 acre) San Martinez Grande Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 200 acres of San Martinez Grande Canyon, or only 10% of the watershed area, is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The Creek in the headwaters flows in a general west to east direction while the remaining lower portion of the Creek flows in a north to south direction, similar in alignment to Chiquito Canyon and joining the Santa Clara River floodplain valley. The shape of develops creates a dog-leg type appearance. The overall watershed boundary develops a shape such that a larger portion of the drainage area is tributary in the mid portion watershed since the width of the watershed narrows in either the upstream and downstream tails of the watershed while the central portion of the watershed widens to approximately 6,800 feet in width. The shape of the watershed is important since that influences when runoff reaches the outlet. The distance from the upper headwaters to the canyon mouth is approximately 20,000 feet with an average overall slope of 0.059. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.022. The majority of the San Martinez



TITLE
SAN MARTINEZ GRANDE
EXISTING & PROPOSED
OVERALL WATERSHED
BOUNDARIES

JOB
NEWHALL RANCH
LOS ANGELES CO., CA

SCALE NTS
DESIGNED JJD
DRAWN GA
CHECKED JJD
DATE JULY 2007
JOB NO. 8197-E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

FIGURE
2.4

P:\8197E\Engineering\8197-XX (Castaic Creek Sections)\exhibits\8197-E-FIG-24B-PR-HOMESTEAD CENTRAL.dwg – Tab: Layout1 – by enarvaez on 08/14/07 at

Dimscale = 40; LTscale = 1; PSltscale = 1; ACAD Ver. = 17.1s (LMS Tech) ; Visretain = 1

Grande Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% or more of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 2062 in the headwaters to a low elevation of 890 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the San Martinez Grande Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sagebrush. There are no major flood control improvements or dams within the watershed, other than several road culvert/bridge crossings such as the SR 126 that would influence the watershed response to rainfall events.

The lower San Martinez Grande Canyon creek extends approximately 4,800 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active Creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a much greater variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the Creek is more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.022. The average slopes ranges from 0.08 in the contraction to 0.005. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. The only manmade structure that influences the hydraulic operation is the roadway culvert crossing for SR 126, but this appears to have sufficient hydraulic capacity with minimal effects to the floodplain. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 50% of the lower reach of the San Martinez Grande Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a ”mild” channel. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 6.4 feet, ranging from 15 feet to 2.9 feet, (2) the average velocity is approximately 8.9 fps, ranging form 19 fps to 2.2 fps, and the width of the floodplain water surface averages 110 feet, ranging from 220 feet to 42 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.5 Long Canyon Creek

The 1.5 square mile (982 acre) Long Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 450 acres of Long Canyon or 50% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The creek in the headwaters flows in a general west to east. The watershed boundary has a shape that is rather uniform in width throughout the mid-section at approximately 2,500 ft. The boundary then gradually widens at both the upstream and downstream ends to approximately 3,750 ft. The shape of the watershed is important since that influences when runoff reaches the outlet. The distance from the upper headwaters to the canyon mouth is approximately 18,350 feet with an average overall slope of 0.052. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.11. The majority of the Long Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 85% or more of the watershed consists of the

rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 2600 ft in the headwaters to a low elevation of 930 ft near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Long Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the watershed.

The lower Long Canyon Creek extends approximately 8,350 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a much greater variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the Creek is more deeply incised below the canyon valley floor then flattens and widens near the Creek outlet. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in Creek geometry and form may indicate influences from the upper watershed that affect the sediment delivery. The changes in channel geometry are also reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.052. The average slopes ranges from 0.1 in the contraction to 0.05. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 80% of the lower reach of the Long Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a ”mild” channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 2.4 feet, ranging from 6.5 feet to 0.7 feet, (2) the average velocity is approximately 7.8 fps, ranging form 17 fps to 3.5 fps, and the width of the floodplain water surface averages 140 feet, ranging from 420 feet to 30 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

3 River and Tributary Hydrology

3.1 Methodology

The LA County approved WMS/MODRAT hydrology model was utilized as the modeling program to perform all rainfall-runoff analysis and transformation of rainfall excess into surface runoff for the project area. The hydrology models are included in Appendix Chapter 3.

3.1.1 Link Node Hydrology Models

The WMS/MODRAT hydrology model calculates the 50-year frequency design storm, which is based on rainfall with a 2% probability of being equaled or exceeded in any given year. The 50-year frequency design storm occurs over a period of four days, with the maximum rainfall falling on the fourth day. This hydrology model was adopted for this study to provide the precipitation-runoff modeling since this is the accepted method and approved for use by Los Angeles County. The program's hydrologic procedures transform the physical characteristics of the watershed into a "link-node" model in which the hydrologic process occurs at a calculation node and these processes within the watershed are linked together by hydraulic connections.

The parameters of this model are developed from physical characteristics of the watersheds, and equations of motion are used to simulate the movement of water through the system. Parameters such as catchment length and area, roughness, slope and channel geometry are used to define the flow of water conceptually over watershed surfaces, into stream channels, and through the channel network of the watershed. This method is particularly useful to study the effects of urbanization since these can be directly measured or accounted for by changing the measurable physical parameters of slope, catchment length, surface roughness, and others. The surface features of the basin are represented with two basic types of elements: (1) overland flow, and (2) channel flow. One or two overland-flow elements are combined with one or two channel-flow elements to represent the processes occurring within a sub-watershed. Three additional elements specific to each subarea within the watershed are required for modeling and include precipitation, land use, and soil type. All of these parameters are used to determine time of concentration of each subarea. Lastly, routing type is specified in the model to route runoff through a natural channel, street flow, or pipe flow. These parameters are the basic building block for determining the 50-year frequency design storm for each watershed. The entire watershed is modeled by linking the various sub-basins together in a network.

3.2 Watershed Parameters

3.2.1 Watershed and Subarea Delineation

The main framework watershed delineation is the first step to modeling the hydrology for a given area of interest. The physical topographic features and ridgelines were used to establish the major regional watershed boundaries for each of the four watersheds. The regional watershed boundaries were then subdivided into sub-basins to facilitate the modeling process and establish appropriate delineation of the interior watershed area. Located at specific collection points in the watershed, the sub-basins generally corresponded to smaller individual drainage systems based on the drainage patterns. The sub-basins were located based on the smaller tributary stream systems, confluences or streams, drainage area size, and anticipated development or ownerships. The sub-basin delineation also allows studying the local land-use changes within the regional watershed but analyzed on a local sub-basin level. The sub-basin areas are typically 40 acres each in size with a maximum of an additional 20%, for a total maximum of 48 acres or less as a modeling requirement.

The sub-watersheds and junctions were numbered sequentially from upstream to downstream in the WMS/MODRAT hydrology model. The WMS/MODRAT program using a digital elevation model (DEM) first determined all major watershed and sub-basin delineations. This DEM is an elevated topographic model that the WMS/MODRAT program uses to delineate sub-basins and calculate area, length, and

slope of sub-basins. The delineated sub-basins are then manually adjusted and fine-tuned where necessary.

3.2.2 Hydrometeorlogic Characteristics

The GIS based rainfall isohyetal shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/). The GIS 50-year, 24-hour rainfall layer was incorporated in the WMS/MODRAT program where the rainfall for each sub-basin was electronically calculated. The GIS rainfall layer contains isohyetal lines and values from Los Angeles County that correspond with the Newhall Ranch project area. Sub-basin rainfall depths for the 50-year storm event vary from 5.6 inches to 7.1 inches throughout the project area.

3.2.3 Geology

The GIS based soil type shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/). The GIS soil type layer was incorporated in the WMS/MODRAT program where a predominant hydrologic soil group is determined for each sub-basin within the 4 watersheds. Each sub-basin is given individual soil types with values ranging from 1-180. An area-weighting technique was applied to the sub-basins that had multiple soil types crossing through it. There are three main soil types in the Newhall Ranch project site: 20, 91, and 97.

3.2.4 Landuse/Vegetation

Hydrologic classification of soils have been developed by the US Soil Conservation Service (formerly the SCS and now the NRCS) and mapping of soils types is available indicating the relative amount of infiltration potential from the soils. The general defined classification of soils includes four types, ranging from type “A”, which is very permeable, representing more of a sandy soil, to a type “D” which is more impermeable representing clayey type systems. Generally, the soils in the Newhall Ranch watershed are characterized as silty clay loams from both the Castaic and Saugus formations. The soil mapping overlay of the watershed boundary indicates that the soils within the all six of the watersheds can be predominately classified as being in hydrologic soil group C (higher runoff potential) with exception of areas adjacent to the main stem creek of Chiquito Canyon and parts of Grapevine Mesa that are Type B.

The existing GIS landuse shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/) and incorporated into the WMS/MODRAT program. For the existing (regional) condition models, the WMS/MODRAT grogram determines an impervious percentage for each sub-basin from the landuse shapefile. For the proposed condition models, the proposed GIS landuse shapefile for the proposed project, obtained from the project planner, Hunsaker & Associates, was merged with the existing landuse shapefile to make a composite proposed land use layer. Each land use polygon was given a distinct proportion impervious value. However, the land use boundaries rarely corresponded with the sub-watershed boundaries. For each sub-watershed, an area-weighted proportion impervious value was calculated electronically in the WMS/MODRAT model. Percent impervious values for a given land use are taken from Los Angeles County Department of Public Works Water Resources Division, June 2002 (LACDPW, 2002) Appendix E. Results are listed in the individual WMS/MODRAT output files.

3.2.5 MORA Routing

The MORA/LAR04 model is a lumped parameter model that takes raw data from each subarea, computes the runoff, and then routes the runoff from one subarea to the next. All of the previously described parameters affect the amount of cumulative runoff routed through each subarea. The model has the ability to route hydrographs downstream through the drainage network while taking into account timing issues associated with land use and soil type.

3.2.6 MORA Burning and Bulking

The LACDPW Addendum to the Hydrology Manual requires that a certain portion of the watershed be considered burned for hydrologic calculations. Burning a watershed increases the peak discharge values and storage volumes. Each major watershed in LA County has been designated a "fire factor," or the percentage of the watershed that should be considered burned for hydrologic calculations. A fire factor of 1 was used for all existing and proposed condition simulations for each of the five watersheds. A fire factor of 1 indicates that the entire watershed is burned.

In the MORA\LAR04 model, values for the burned sub-watersheds are given a value 200 more than non-burned watersheds. For example, if a sub-watershed has a primary soil number of 20, a value of 220 is inserted into MORA\LAR04 to signify that it will be burned.

LACDPW requirements for bulking watersheds are specified in Section 3C-1 of the LACDPW Sedimentation Manual. In the case of the four tributary watersheds, equation 3.12 is used to bulk a partially developed watershed in multiple Debris Production Area (DPA) zones. There is no function in the MORA\LAR04 program that allows the user to bulk a given watershed or sub-watershed. The model allows the user to calculate burned watershed values, and then equation 3.12 in LACDPWHSM is applied to calculate burned and bulked flow rates.

The methodology used to calculate the existing conditions burned and bulked flow rates is as follows:

1. The 50-year clear water flow event was simulated in WMS. See Appendix Chapter 3 for 50- year MORA\LAR04 output.
2. The 50-year burned flow event was calculated by adding 200 to the soil values for all sub-basins. Because the existing condition assumes a pre-developed condition, the entire watershed was burned for each of the four tributary watersheds.
3. Equation 3.12 for bulking was then used to calculate burned and bulked flows. Discharge values calculated in step 2 were used in equation 3.12. The four tributary watersheds contain large channels so the burned and bulked flow rates were calculated at the main nodes in the creek channels.

3.2.7 Time of Concentration Calculator

The time of concentration, Tc, is electronically calculated in the WMS/MODRAT modeling program. The modeler draws in longest path lengths for each sub-basin. The model then calculates the length of longest path and corresponding slope. In conjunction with these parameters, the model considers imperviousness, soil type and rainfall depth, and then calculates a time of concentration. Time of concentration values varies with the above-mentioned parameters therefore; Tc is calculated separately for clear water and burned conditions simulations.

3.2.8 Debris Volume Calculations

The WMS/MODRAT program also calculates debris production volumes using the burned flow rates and the DPA Zone factors. Debris volume is an electronic calculation that the model performs using this data.

3.3 General Discussion of Results

The hydrologic modeling reflects conservative estimates of the watershed response associated with a single hypothetical rainfall event and it is not intended to reproduce historical storm events or historical time series. The watershed models illustrate that the influence of development to changes of the peak discharge is more dramatic on the smaller storm events while it has less of an influence on the larger storm events because of the larger contribution of the upstream watershed.

The watershed models do not take into account the effect from hydrologic mitigation measures that may be installed within the proposed development areas which may include flood control detention basins or storm water quality detention basins. The hydrologic modeling is intended to estimate the maximum potential change in flowrate and runoff response from the watershed affecting the floodplain areas. Modeling results are summarized in Table 3.1. For detailed model output tables for the six watersheds, see Appendix Chapter 3.

Table 3.1: Newhall Ranch Phase 2 Tributary MODRAT Results Summary

Tributary/Parameter	Chiquito		Grande		Long		Potrero	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
Outlet Node	173 A	252 A	130 A	185 AO	53 A	166 AD	173 A	173 A
Area (ac)	3048	3135	2134	2274	989	1149	2857	2857
Q_{burned} (cfs)	3181	3217	2964	3022	1125	1119	3255	3293
Burn Runoff Vol. (ac-ft)	397	467	367	400	142	212	583	685
Q_{cap} (cfs)	4195	4145	3921	3908	1450	1305	4445	4166
Debris Vol (cu yd)	126,753	117,709	93,940	90,392	35,653	28,330	162,043	126,702
DPA Zones	5, 9	5, 9	5, 9	5, 9	5, 8, 9	5, 8, 9	3, 5, 8, 9	3, 5, 8, 9

4 Watershed Sediment Production

4.1 Methods

Three different methods were use to calculate watershed sediment production. It is important to examine the results of different methodologies because each methodology incorporates distinct assumptions about the relative importance of different watershed parameters. The result of these assumptions is varying quantities of sediment production depending on the extent to which the assumptions in the calculation methodologies match the behavior of the sediment generating mechanisms naturally occurring within the watershed. The different methods were chosen for their use of data inside, near or within an environment similar to that found within the present Santa Clara River study reach.

4.2 MUSLE

The MUSLE method is a modification of the Universal Loss Equation developed to predict sediment watershed yields for single storm events in a given watershed. The modification entails a runoff factor instead of a rainfall energy factor. The MUSLE equation is applicable to ephemeral stream of the desert southwest since the equation uses runoff from individual storms, which is the primary mode of sediment delivery in the region.

The MUSLE equation is given by:

$$YIELD = \alpha (Vq)^{\beta} KLCP$$

where K is the soil erodibility factor from UDSA soil texture, L is a topographic factor, C is a cover factor taken from the SCS Agriculture Handbook 537, P=1 is an erosion control factor, V is the runoff volume for a given storm, q is the is the storm peak discharge rate, and α=95 and β=0.56 are calibration coefficients. The cropping factor, C, is not adjusted between the existing and proposed conditions because there is not a comparable procedure in land development. The erosion control factor is used in the proposed condition to reduce the area of land contributing runoff as a decimal percent of the impervious area greater than 15% impervious. The topographic factor is calculated as:

$$L = \left(\frac{\lambda}{72.6} \right)^{n} (0.065 + 0.0454S + 0.0065S^{2})$$

where λ is the slope length, S is the percent slope and n is the slope exponent given as:

$$S \leq 0.03 \rightarrow n = 0.3$$
$$S = 0.04 \rightarrow n = 0.4$$
$$S \geq 0.05 \rightarrow n = 0.5$$

The MUSLE method was originally developed to calculate soil loss for Albuquerque, New Mexico, however, because the area and climate in and around Albuquerque and Los Angeles County, California are similar the values predicted using the MUSLE method are expected to be comparable predictors of sediment production in this study.

4.3 ACOE (TATUM)

The Los Angeles District of the Army Corps of Engineers developed the ACOE (Tatum) method to estimate the quantity of debris caught by some structure at some location within a watershed during a single discrete event. The method is intended to be used in coastal-draining, mountainous watersheds in Southern California between 0.1 and 200 square miles in area and for storms with return periods greater than 5-year return periods. The data for the ACOE method was originally collected in Southern California

from both ACOE and other sources. Multiple linear regression analysis and logarithmic transformation was used to develop the coefficients in the debris yield equation.

The primary variables of analysis for the ACOE(Tatum) method are precipitation, runoff (as volume per area), drainage area, stream length, relief ratio (as watershed slope), recent burning of the watershed and channel slope. The debris yield equation has the general form:

$$LOG(YIELD) = AT(C_1 LOG(RATE) + C_2 LOG(RR) + C_3 LOG(A) + C_4 FF)$$

where YIELD is the unit debris watershed yield, RATE is either the precipitation or the discharge depending on watershed size, RR is the relief ratio, A is the watershed area and FF is the fire factor. The coefficients C_1 through C_4 are coefficients which vary with the size of the watershed and AT is an adjustment factor designed to address debris yield relative to the ACOE original study area. ACOE(Tatum) calculations for this study can be found in Appendix Chapter 4.

4.4 Los Angeles County

The Los Angeles County Department of Public Works Sedimentation Manual estimates sediment production based on debris production areas. A debris production area (DPA) is defined as a zone that yields similar volumes of sediment under similar conditions. By way of comparison, DPA Zone 1, San Gabriel Mountains (the same debris production area for which the ACOE(Tatum) method uses an AT factor of 1) the Los Angeles County method produces 120,000 cubic yards per square mile of sediment. This value of production would correspond in the ACOE(Tatum) method approximately to a watershed of 10 acres, a relief ratio of 20, a fire factor of 3.65, and a discharge of 992.

In general, debris production is the product of the DPR and the area being studied. By extension, the debris production multiple watersheds with a common confluence is the sum of the products of DPR and area. For multiple watersheds with multiple DPR zones and development debris production takes the general form (Debris Manual equation 3.5g):

$$YIELD = \sum \left[DPR_{i(A)} (A_i - A_{d_i}) \left(\frac{A_i - A_{d_i}}{A} \right) + DPR_{i(A_i - A_{d_i})} (A_i - A_{d_i}) \left(\frac{(A - A_i) + A_{d_i}}{A} \right) \right]$$

where $DPR_{i(Ai)}$ is the debris production rate for drainage area A_i in DPA zone i, A_i is the drainage area including development, and A_{di} is the developed area drainage area. This equation is applied to each tributary watershed in this study for the proposed condition to determine debris production and is part of the MODRAT model described above.

4.5 Results

Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. The proposed conditions utilize the most recent plans at the time of writing, and any revisions to the proposed condition are not expected to alter debris production. Hydrology for the calculations is discussed in Chapter 3, above. The results of the calculations based on the Capital rainfall for each tributary by each method for both the existing and proposed condition are presented in Table 4.1. The raw data for the calculations is presented in Appendix Chapter 4. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. Table 4.1 shows that on the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. The primary limiting factor to the change in debris production is the relatively small size of the proposed development on each of the northern watersheds. For the tributaries on the River's south bank (e.g. Long and Potrero), the larger change in debris production is a function of the extent of development of the south bank watersheds. Table 4.1 shows that for tributaries on the south bank of the River the average change

in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum (MUSLE method) is 67.0% and 63.6% decrease, respectively.

Table 4.1: Existing and Proposed Conditions Debris Production Yield by Watershed for the Capital Event [1]

MUSLE				
Tributary	Debris Yield (tons/event)		Δ (tons/event)	Δ (%)
	Existing	Proposed		
Chiquito	6,047	5,801	-246	-4.1
Long	17,704	5,836	-11,868	-67.0
Grande	32,191	28,791	-3,400	-10.6
Potrero	15,725	5,720	-10,005	-63.6
ACOE(Tatum)				
Tributary	Debris Yield (tons/event)		Δ (tons/event)	Δ (%)
	Existing	Proposed		
Chiquito	84,128	82,494	-1,634	-1.9
Long	35,136	31,850	-3,286	-9.4
Grande	104,408	103,131	-1,277	-1.2
Potrero	91,204	81,116	-10,088	-11.1
LA County				
Tributary	Debris Yield (tons/event)		Δ (tons/event)	Δ (%)
	Existing	Proposed		
Chiquito	282,342	262,197	-20,145	-7.1
Long	79,417	63,105	-16,312	-20.5
Grande	209,251	201,348	-7,903	-3.8
Potrero	360,951	282,229	-78,722	-21.8
Average				
Tributary	Debris Yield (tons/event)		Δ (tons/event)	Δ (%) [2]
	Existing	Proposed		
Chiquito	124,172	116,831	-7,342	-4.4
Long	44,086	33,597	-10,489	-32.3
Grande	115,283	111,090	-4,193	-5.2
Potrero	155,960	123,022	-32,938	-32.2

1: All calculations have been converted to tons/event.

2: Average of percentage change from all three methods

5 Comparison with Previous Work

5.1 SLA's Fluvial Study of the Santa Clara River and Its Tributaries Interim Report

In May of 1998, Simons, Li & Associates (SLA) submitted to Los Angeles County Department of Public Works (LACDPW) the Quantitative Analysis and Mathematical modeling of *The Existing Condition of the Santa Clara River Basin, Third Interim Report.* The report covered several areas including hydrologic analysis, hydraulic analysis, sediment yield analysis, and bed sediment analysis. The most relevant to this study is the watershed sediment yield analysis which included the LA County method, the MUSLE method and the ACOE(Tatum) method. Of the three methods discussed in the report, the authors found that the most representative equation for determining the production of sediment was the LA County equation.

To conduct the study, the Santa Clara River watershed upstream of Los Angeles County line was divided into 28 sub-areas with hydrology for each sub-area provided by the County. Because the areas of study were so large, a modified version of the County method was used. The SLA report recommends modifying the debris potential areas 3, 5, 8 and 9 to reflect certain physical characteristics of the sub-watersheds. The SLA study has two sub-watersheds that overlap with the watersheds in the present study: the Hasley Canyon group covering the north bank watersheds of Chiquito and Grande watersheds, plus additional area; and the Potrero Canyon group cover the south bank watersheds of Long and Potrero, plus additional area. The SLA sub-watersheds cover an area of 19.9 and 19.0 acres, respectively for the Hasley and Potrero groups.

Four methods were used to determine sediment debris production including the Los Angeles County method, a modified LAC method, the ACOE(Tatum) method, and MUSLE method. The LAC method predicted a debris production of 23,000 and 24,000 yd^3/mi^2 for the Hasley and Potrero groups, respectively, the MUSLE method predicted debris production of approximately 11,500 and 52,000 yd^3/mi^2, respectively, and the Tatum method predicted a debris production of 36,705 and 32,250 yd^3/mi^2, respectively. The watershed sediment yield from the SLA study is given as approximately 15,200 and 14,000 yd^3/mi^2, respectively.

5.2 PACE's Newhall Ranch River Fluvial Study Phase 1 Final Draft

PACE prepared the approved *Newhall Ranch River Fluvial Study Phase 1 Final Draft* (March 2006). The technical study provides an evaluation of the existing and proposed fluvial characteristics and long-term stability of Santa Clara River between Interstate 5 and an area generally west of the Los Angeles/Ventura County line near the Newhall Ranch Specific Plan. The study was conducted because proposed development along the River within the study area has the potential to modify the fluvial mechanics of the River. The proposed buried soil cement bank protection on both the north and south banks of the River is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. The analysis of the Phase 1 study evaluates impacts from build-out of Newhall Ranch from (1) fluvial modifications of the river bed from single hypothetical storm events, and (2) changes in the floodplain fluvial operation over the long-term.

In the Phase 1 study general adjustment, long-term adjustment, and other scour were summed to determine total potential bed adjustment following LACH&SM methodology (2006 draft and formatting). For cross-sections where SAM modeling predicts aggradation, the general adjustment contribution to total bed adjustment is not included for degradation calculations. The existing condition is predicted to have a combined bed adjustment of approximately -6.9 to -19.7 feet for the outside of curved reaches and -6.2 to -15.4 feet for the inside of curved and straight reaches. Calculations in the proposed condition predict that the combined bed adjustment ranges from approximately -6.7 to -26.2 feet for both the outside of curved reaches and for the inside of curved and straight reaches. Freeboard elevation in the Phase 1 study was calculated based on LACH&SM Chapter 5A-3, and includes LACFCDDM calculations. The freeboard for the River ranges from approximately 2.5 to 5.2 feet for both outside of curved and straight or inside of curved reaches in the proposed condition. Maximum total toe-down, total freeboard, toe-down elevation and freeboard elevation are presented in the report. The report was approved by LACDPW

horizontal and vertical position of the bank protection upstream of the Chiquito and Long confluences to the River and for horizontal position of the bank protection downstream.

5.3 Results

5.3.1 Differences in ACOE(Tatum) method results

Several differences exist between the present and SLA values used to calculate watershed sediment yield using the ACOE(Tatum) method. First, the SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. In the SLA study, slopes are generally higher than in the present study: 264 to 349 ft/mi and 163 to 312 ft/mi, respectively. This difference is due primarily to the difference in area whereby the larger slopes occur in the larger watershed groups. The SLA study notes that a fire factor of 2.5 was used, although a factor of 3.13 is used in the present study. This difference will increase the watershed sediment yield in the present study relative to the SLA study where all other factors are equal. The present study utilizes an adjustment-transposition factor following the guidelines outlined in the ACOE manual; this factor does not appear to be utilized in the SLA study. Finally, based on SLA Table 4.7 it appears that the study based runoff on rainfall while the present study utilizes peak runoff. Peak runoff was chosen in the present because the ACOE manual indicates that runoff should be used for watersheds greater than 1920 Ac. The watershed sediment yield based on the ACOE (Tatum) method for each of the watersheds considered in the present study is summarized in Table 5.1.

5.3.2 Differences in MUSLE method results

Like the ACOE(Tatum) calculation methodology, several differences exist between the PACE and SLA values used to calculate watershed sediment yield. As noted above, the SLA and present studies use different study areas. The studies also use differing soil erodibility factor, and K values. The SLA study uses a K value of K=0.43 while the present study uses a value of 0.10. The SLA value was based on estimation of the soils present in the watershed using soil survey data, and the present study based the K value on soil samples presented in Phase 1. The K=0.43 value is more indicative of silty loam soil types. In contrast, the K=0.10 represents a coarse sand or a loamy sand with gravel. The reason for the difference between the two values likely arises from the extent of data considered. The SLA study considers more upland area possessing a higher percentage of fine particles with the present study focused on single watersheds adjacent to a river valley with more coarse particles. In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values.

Different methods were used in the respective studies to calculate the slope length factor, LS: The SLA study used Williams and Berndt without comment, while the present study used Wischmeier and Smith, as directed in the AMAFCA manual. The results of this difference do not appear to be large for the north bank watersheds (6.0 vs. 1.6 to 9.3 for the SLA and the present study, respectively), however, for south bank watersheds a large disparity exists (22.1 vs. 1.6 to 7.6 for the SLA and the present study, respectively). The length-slope factor is a function of slope length and bed slope. The SLA study uses super-watersheds that are comprised of several of the watersheds considered in the present report. For example, in the present study Grande (~3.4 mi^2) and Chiquito (~4.8 mi^2) watersheds are studied separately, where as in the SLA study the individual watersheds are parts of a larger watershed (~19.0 mi^2) and studied as a whole. Because of the dissimilarity in watersheds studied, differences in the slopes and slope length are observed, changing the LS values.

The SLA study reports the product of the cropping (C) and erosion control (P) factors as CP=0.1. The present study uses cropping value of C=0.13 (40% cover with tall weeds) and an erosion control value of P=1.0 (no control). The product of these two values is CP=0.13, similar to the value reported by SLA.

SLA used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4, above.

Values reported in the SLA study for the north and south watershed groups for runoff volume are approximately 1840 and 2890 ac-ft, respectively. The values of runoff volume presented in the present study, taken from the hydrologic analysis, described above, are 641 and 464 ac-ft for the north-bank watersheds and 214 and 393 ac-ft for the south bank watersheds. Values in the SLA study for the 50-year peak discharge are approximately 18,625 and 15,825 cfs for the north and south watershed groups, respectively, while values in the present study are approximately 4065 and 2845 cfs and 1630 and 3310 cfs for the north- and south-bank watersheds. The difference in the two studies can be attributed to the differences in watershed size.

The watershed sediment yield based on the MUSLE method for each of the watersheds considered in the present study is summarized in Table 5.1.

5.3.3 Differences in Los Angeles County method results

The primary difference in debris production using the LAC method between the SLA and present studies is a function of the areas used in the calculations. In the SLA study, the debris production rate (DPR) is calculated, while in the present study the DPR is read from tables in the LAC Sedimentation Manual (reformatted 2006). This difference leads to very small differences in DPR between the two studies. There is also some difference in debris production area (DPA) acreages. In the SLA study, one hundred percent of both the north- and south-bank watershed groups are DPA 5. In the present study, all of the north-bank watersheds are DPA 5, but the south-bank watersheds are a combination of DPA 3, 5, 8 and 9. The resultant debris production in cubic yards is 457,700 (23,000 yd^3/mi^2) and 456,000 (24,000 yd^3/mi^2) for SLA north- and south-bank watershed groups, respectively, and approximately 126,754 and 93,941 (or 27,246 yd^3/mi^2), and approximately 35,654 and 162,045 cubic yards (or 32,949 yd^3/mi^2) for the present study north- and south-bank watersheds, respectively. The watershed sediment yield based on the Los Angeles County method for each of the watersheds considered in the present study is summarized in Table 5.1.

Table 5.1: Comparison of SLA and Present Study Debris Production (existing condition)

Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE	ACOE(Tatum)	LAC
Hasley	19.9	**11,469**	**36,750**	**23,000**
Potrero	19.0	**51,919**	**32,250**	**24,000**
Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE*	ACOE(Tatum)	LAC
Chiquito	4.8	566	7,868	26,407
Grande	3.3	4,379	14,204	28,467
Combined	8.1	**2,119**	**10,449**	**27,246**
Long	1.5	5,299	10,516	23,769
Potrero	4.5	1,569	9,099	36,010
Combined	6.0	**2,501**	**9,453**	**32,949**

*Assumes soil densiity of 165 lb/ft^3

6 Sediment Transport and Delivery

6.1 Methods

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River. The SAM Sediment Hydraulic Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity and stream yield in a given channel or floodplain hydraulic cross-section for a given discharge at a single point in time. A number of sediment transport functions are available for this analysis and SAM has the ability to assist in selecting the most appropriate sediment transport equation.

The three primary fluvial components of SAM are SAM.HYD, SAM.SED and SAM.AID. SAM.HYD provides a steady state, normal-depth, one-dimensional representation of channel hydraulics. The SAM.SED module combines the hydraulic parameters with the bed material gradation curve to compute bed material discharge rating curves by size classification. The SAM.AID module provides the user with recommended sediment transport equations based on the best matches between hydraulic parameters and grain size distribution of the study reach with parameters from widely accepted and published research.

The SAM numerical model is built upon hydraulic and fluvial components. The hydraulic components include representations of river bed characteristics that are input into an analytical procedure. The fluvial component includes representation of bed gradation as percent finer statistics and a selection of up to twenty sediment transport equations. SAM's hydraulic component will accept either average reach parameters or cross-section data imported from HEC-2/HEC-6 models. Hydraulic modeling is based on a uniform flow equation where discharge is the dependent variable such that,

$$Q = f(D, n, W, z, S)$$

where Q is discharge in cfs, D is flow depth in feet, n is the Manning's number, W is bottom width in feet, z is the channel side slope, and S is the energy slope. The bottom width is representative of the total moveable bed width of the channel and Manning's number is a composite value. Normal depth is calculated using Manning's equation, and effective values of width and depth are calculated following normal depth calculations. In cases where HEC-2 cross-sections are used for modeling, as in this study, the effective depth and width are calculated from the cross-section data based on the channel hydraulics.

The fluvial component is based on sediment transport functions to calculate the bed portion of the sediment discharge-rating curve.

The sediment transport equations are of the form,

$$GS_i = f(V, D, S_e, B_e, d_e, \rho_s, G_{sf}, d_s, i_b, \rho_f, T)$$

where GS_i is the transport rate for sediment size class i; the hydraulic terms V, D, S_e, and B_e, are the average velocity, effective flow depth, energy slope, and effective flow width, respectively; the sediment particle parameters d_e, ρ_s, and G_{sf} are the effective particle size, particle density, and grain size shape factor, respectively; the sediment mixture properties, d_s and i_b are the geometric mean particle size of sediment class i and fraction of class i in the bed, respectively; and the fluid properties ρ_f, and T, the water density and temperature, respectively. Twenty well known, published, peer-reviewed transport equations are available including Ackers-White, Colby, Laursen-Copeland, Laursen–Madden, MPM, Toffaleti, Yang, Van Rijn and others. Once the data assembly is complete, the SAM.SED module can be

used to create a sediment discharge-rating curve based on grain size distribution. The reader is referred to the SAM user's documentation for further reference.

It is important to note that the SAM model is a zero-dimensional computational package that is only based on a single cross-section at a particular point in time. As such, SAM simulations can only represent a reach average during a steady state discharge. Because SAM applies sediment transport to a point, no variability in size distribution in either space or time is calculated. With these limitations in mind, in this study SAM is intended to provide a first approximation to sediment transport to which other more sensitive calculations can be compared.

6.1.1 SAM Transport Potential

Representation of sediment grain size distribution in SAM takes the form of percent finer data obtained from sieve analysis of channel sediment grab samples. At each sampling location, multiple samples are collected and analyzed, and the average data is input into the model. Sediment transport equations used in all SAM modeling were chosen with the assistance of the Army Corps' SAM.AID subroutine. The SAM.AID subroutine determines the most representative transport function based on the hydraulic parameters and percent finer data for each subreach by comparing model data with the results of 20 peer-reviewed and widely acknowledged sediment transport studies. This case-by-case transport equation selection is more likely to provide a robust representation of channel sediment transport than choosing an individual transport equation for all reaches.

Application of different transport functions to an individual channel reach may provide significantly differing model output. This is because the parameters of a given study from which the function is derived, vary greatly. To accomplish the task of guiding the user in selecting an appropriate transport function, SAM.AID assumes that the function that best represents sediment transport in a gauged stream would also best represent transport in an ungauged stream with similar sediment and hydraulic characteristics. SAM.AID begins by comparing study parameters (V, D, S_e, B_e, D_{50}) with parameters in the transport function database. Comparison begins by determining if D_{50} falls within one of the ranges identified in the database. Once the initial matches have been made in the database, the three best-matched sediment transport functions for the study reach are listed along with the parameters that matched the data set.

Once the best transport equation matches have been determined by SAM.AID, the most representative equations are run in SAM.SED for each subreach. Yang (Yang, 1984) and MPM (Meyer-Peter and Muller, 1948) equations are added to all simulations where they are not explicitly matched by SAM.AID so that there is a continuity of comparison between subreaches. Following SAM.SED computations, sediment transport potential for each subreach can be estimated by reviewing the calculations from each equation and analyzing the results. The raw data is presented in Appendix Chapter 3.

The MPM equation was found to be the representative transport equation for tributary and river confluence subreaches for the existing and proposed conditions.

6.1.2 SAM Yield

The SAM.YLD module calculates the stream yield passing a section during a specific period as defined by a hydrograph or duration curve. The hydrograph can range in duration from a specific event to a year or more. Calculations are based on the flow-duration sediment-discharge rating curve method. Hydrographs are taken from MODRAT model output in the case of the tributaries and as an SCS type hydrograph for the River.

6.1.3 SAM Model Assembly

Hydraulic representation of a channel bed is accomplished in several distinct steps. First, the HEC-RAS numerical model is thinned to no more than 100 stations per cross-section using HEC-RAS's cross-section points filter. HEC-RAS is a rigid boundary hydraulic model, which assumes the channel bed does not fluctuate. HEC-RAS executes a one-dimensional solution of the energy equation, where energy

losses are evaluated by friction through Manning's equation and contraction/expansion based on the coefficient and change in velocity head. The channel cross-section data is first obtained from existing topography for the project site. A Manning's coefficient is then applied to the study reach and a discharge selected for analysis. In this study a Manning's value of n=0.035 us used based on site visits and aerial photography. Boundary conditions for the design Capitol discharge are entered to initiate hydraulic calculations based on "mixed" flow. Second, the HEC-RAS geometry is converted to HEC-2 format using the Army Corps RAS2UNET software. Like HEC-RAS, HEC-2 is a one-dimensional rigid boundary hydraulic model. Next, the HEC-2 model deck is arranged to run in subcritical mode and all features, such as ineffective flow areas and levees, are added. Once the HEC-2 model is complete, it is re-imported into HEC-RAS and compared to the original model. Any cross-sectional differences between the RAS and 2 models are resolved. Once the original and re-imported models match, the HEC-2 model is run to produce the Army Corps' T95 binary hydraulic simulation output file. Next, the T95 file is then read directly into SAM using the SAM model's M95 subroutine using the reach length option.

6.2 Results

For each tributary, sediment potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. Table 6.1 shows the downstream subreach extents. Seward Engineering Geology (as presented in Phase 1) provided sediment data for SAM modeling. Hydraulic data was taken from HEC-RAS models of the tributaries (as presented in Phase 1), and the hydrographs used were taken from the hydrologic modeling presented in Chapter 2.

Table 6.1: River* and Tributary SAM Modeling Subreach Section Boundaries

Channel	Bounding Sections		River Subreach
	Existing	Proposed	
Chiquito	1560-1000	1708-1007	-
Chiquito Confluence*	22195-20070		D1
Long	1100-1000	1900-1200	-
Long Confluence*	22195-20070		D1
Grande	1050-1000	900	-
Grande Confluence*	17510-15335		D3
Potrero	1000		-
Potrero Confluence*	15125-13190		E1

Table 6.2 compares the existing and proposed conditions stream sediment yields for the various tributaries as well as the tributary confluences with the River. The table shows that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases stream sediment yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

Table 6.2: Existing and Proposed Conditions Sediment Yield (SAM.yld) by Channel for The Q_{burn} Discharge (Ton)				
Tributary Sediment Transport Yield				
Tributary	Sediment Yield (tons/event) Existing	Sediment Yield (tons/event) Proposed	Δ (tons)	Δ (%)[1]
Chiquito	1,980	2,182	202	**10.20**
Long	1,235	1,517	282	**22.83**
Grande	1,087	1,623	536	**49.31**
Portrero	1,994	2,364	370	**18.56**
River Sediment Transport Yield				
Tributary	Sediment Yield (tons/event) Existing	Sediment Yield (tons/event) Proposed	Δ (tons)	Δ (%)
Chiquito Confluence	172,027	174,434	2,407	**1.40**
Long Confluence	172,027	174,434	2,407	**1.40**
Grande Confluence	179,143	183,265	4,122	**2.30**
Potrero Confluence	228,107	207,302	-20,805	**-9.12**

1. Positive means there is an increase from existing to proposed

To determine the fluvial impacts to the River resulting from development of the tributary watersheds a comparison between the proposed River stream sediment yield and the change in tributary stream sediment yield is examined at the River confluence locations. Table 6.3 compares the stream sediment yield in the River with the change in stream sediment yield from the tributaries for the tributary Capitol event and either the Capitol or Peak Observed event on the River (31,800 cfs, winter 1968-1969). The Peak Observed event was chosen as a basis for comparison since there is a lower probability of the Capitol event on both the tributaries and River simultaneously than a Capitol event on the tributaries coincident with a sub-Capitol extreme event on the River. The table shows that for coincident Capitol events that the tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the transport of one River subreach, depending on tributary. The table also shows that during the Peak Observed event on the River that the tributary stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary.

Table 6.3: Comparison of River Stream Yield with Change in Tributary Stream Yield Resulting from Watershed Development During a Tributary Capitol Event (Tons/Event)			
Capital Event			
Subreach	Q_s - River	ΔQ_s - Creek	Δ%
Chiquito Confluence	174,434	202	**0.12**
Long Confluence	174,434	282	**0.16**
Grande Confluence	183,265	536	**0.29**
Potrero Confluence	207,302	370	**0.18**
Peak Observed Event (31,800 cfs)			
Subreach	Q_s - River	ΔQ_s - Creek	Δ%
Chiquito Confluence	36,804	202	**0.55**
Long Confluence	36,804	282	**0.77**
Grande Confluence	49,933	536	**1.07**
Potrero Confluence	51,371	370	**0.72**

1. Positive means there is an increase from existing to proposed

To examine the relative contribution of each tributary's stream yield to the River stream yield, the Capitol tributary stream sediment yield is compared to the River stream sediment yield during the Capitol and Peak Observed events for the proposed condition. Table 6.4 shows that the total stream sediment yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River stream sediment yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of the River. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the river represents between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the stream sediment yielded by the tributary delivered to the River. The results are shown graphically in Appendix Chapter 6.

Table 6.4: Comparisonof River Yield with No Tributary Yield Resulting from Watershed Development (Tons/Event)			
Tributary with No Delivery - Capitol in River			
Subreach	Q_s - River	Q_s - Creek	Δ%
Chiquito Confluence	174,434	2,182	**1.25**
Long Confluence	174,434	1,517	**0.87**
Grande Confluence	183,265	1,623	**0.89**
Potrero Confluence	207,302	2,364	**1.14**
Tributary w/ No Delivery - Peak Observed in River (31,800 cfs)			
Subreach	Q_s - River	Q_s - Creek	Δ%
Chiquito Confluence	36,804	2,182	**5.93**
Long Confluence	36,804	1,517	**4.12**
Grande Confluence	49,933	1,623	**3.25**
Potrero Confluence	51,371	2,364	**4.60**

1. Positive means there is an increase from existing to proposed

7 Summary and Recommendations

7.1 Summary

The MODRAT numerical model was used to determine the hydrology of the tributary watersheds within the study area. The model was run for both the existing and proposed conditions. The model is based on the LACFCD hydrology manual.

Three different methods were use to calculate watershed sediment production: MUSLE, ACOE(Tatum), and Los Angeles County. Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. On the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. The primary limiting factor to the change in debris production on north-bank watersheds is the relatively small size of the proposed development, while for the tributaries on the River's south bank the larger change is debris production is a function of the extent of development of the watersheds. For tributaries on the south bank of the River, Long and Potrero, the average change in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum is 67.0% and 63.6% decrease (MUSLE method), respectively.

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River.

For each tributary sediment transport potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. Modeling predicts that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases sediment stream yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

To determine the fluvial impacts to the River resulting from development of the tributary watersheds, a comparison between the proposed River stream sediment yield and the change in tributary stream sediment yield is examined at the River confluence locations. For coincident Capitol events, tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the stream sediment yield of one River subreach, depending on tributary. During the Peak Observed event on the River, the stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary.

To examine the relative contribution of each tributary's stream yield to the River stream yield, the Capitol tributary stream sediment yield is compared to the River stream sediment yield during the Capitol and Peak Observed events for the proposed condition. Modeling shows that the total stream sediment yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River stream sediment yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of one River subreach. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the River represents between approximately 3.2 and 5.9 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the sediment yielded by the tributary delivered to the River.

Several differences exist between the present study's parameter values and the previous SLA study parameter values used to calculate watershed sediment yield. The SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. This difference in area impacts study slopes, land use ratios, soil parameter ratios, and other parameter ratios in the calculation methods. Additionally, since the SLA study was completed, Los Angeles County has modified the manner in which the Capital discharge is computed. Some of difference in discharge and subsequently watershed sediment yield between the two studies can be attributed to these ratios.

7.2 Recommendations

In Phase 1 of this study, SAM numerical modeling was used to estimate the change in bed elevation. Bed change was determined by calculating the difference between subreach upstream and downstream sediment potential transport for the Q_{CAP} discharge. The difference in transport potential, ΔTP, between subreach inflow and outflow was converted to general adjustment, GA, as:

$$GA = \frac{\Delta TP}{\rho bRL} day$$

where ρ is the sediment density taken as 165.36 lb/ft^3, *b* is channel width in feet, *day* denotes one day's time (for the 24 hour hydrograph), and *RL* is reach length in feet. To estimate how the proposed changes in sediment delivery from the tributaries impact the fluvial mechanics of the River the general adjustment equation was modified to take the form:

$$GA = \frac{TP_{IN} - \Delta TP_{TRIBUTARY} - TP_{OUT}}{\rho bRL} day$$

where TP_{IN} is the transport potential flowing into a subreach, TP_{OUT} is the transport potential flowing out of a subreach, and $\Delta TP_{TRIBUTARY}$ is the change in tributary sediment delivery given that none of the sediment produced on the watershed reaches the River confluence.

The results for the proposed condition where both the tributaries and the River are flowing at the Q_{CAP} discharge are shown in Table 7.1. The table shows that the transport potential grade change ranges from -1.5 to 2.1 feet where the highest degradation occurs in Subreach SRE3 and the greatest aggradation occurs in Subreach SRE2. Table 7.2 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed potential grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no potential grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

Table 7.1: Phase 2 Santa Clara River Proposed Conditions General Adjustment Potential Bed Stability - Q_{CAP} River Transport Potential VS. Tributary Yield										
Subreach	US Sta	DS Sta	Trans Eq	Potential** Transport (ton)	Trib Inflow Yld. (ton)	Potential - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	603,656	0	603,656	860.1	0.2	**AGGRADE**	**0.2**
SRD1*	22195	20070	MPM	661,922	3,699	658,223	1,511.4	0.2	**DEGRADE**	**-0.2**
SRD2	19855	17785	MPM	319,200	0	319,200	1,431.8	1.4	**AGGRADE**	**1.4**
SRD3	17510	15335	MPM	620,768	1,623	619,145	1,274.3	1.3	**DEGRADE**	**-1.3**
SRE1	15125	13190	MPM	731,941	2,364	729,577	1,588.9	0.4	**DEGRADE**	**-0.4**
SRE2	13030	11180	MPM	291,031	0	291,031	1,375.5	2.1	**AGGRADE**	**2.1**
SRE3	11015	9025	MPM	636,713	0	636,713	1,399.3	1.5	**DEGRADE**	**-1.5**

* Chiquito and Long Canyon Creeks confluence into the same subreach

** Q Cap

*** Q Burn

Table 7.2: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{CAP}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.2	0.2	**0.0**	**NO CHANGE**
SRD1	22195	-0.2	-0.2	**0.0**	**NO CHANGE**
SRD2	19855	1.4	1.4	**0.0**	**NO CHANGE**
SRD3	17510	-1.3	-1.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.4	-0.4	**0.0**	**NO CHANGE**
SRE2	13030	2.1	2.1	**0.0**	**NO CHANGE**
SRE3	11015	-1.5	-1.5	**0.0**	**NO CHANGE**

The results for the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) are shown in Table 7.3. The table shows that the potential grade change ranges from -0.3 to 0.4 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. It is important to note that the potential general adjustment in this scenario is very small relative to the potential general adjustment that occurs during the Q_{CAP} scenario. Table 7.4 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability for the Q_{CAP}-Q_{31800} scenario. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

Table 7.3: Phase 2 Santa Clara River Proposed Conditions General Adjustment Potential Bed Stability - Q_{31800} River Transport Potential VS Tributary Creek Yield										
Subreach	US Sta	DS Sta	Trans Eq	Potential** Transport (ton)	Trib Inflow (ton)**	Potential - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	161,304	0	161,304	705.5	0.0	**AGGRADE**	**0.0**
SRD1*	22195	20070	MPM	139,888	3,699	136,189	832.4	0.1	**AGGRADE**	**0.1**
SRD2	19855	17785	MPM	119,715	0	119,715	1,023.9	0.1	**AGGRADE**	**0.1**
SRD3	17510	15335	MPM	169,432	1,623	167,809	1,076.4	0.3	**DEGRADE**	**-0.3**
SRE1	15125	13190	MPM	181,691	2,364	179,327	1,484.5	0.1	**DEGRADE**	**-0.1**
SRE2	13030	11180	MPM	121,496	0	121,496	1,071.8	0.4	**AGGRADE**	**0.4**
SRE3	11015	9025	MPM	148,010	0	148,010	1,060.7	0.2	**DEGRADE**	**-0.2**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

** Q Peak

*** Q Burn

Table 7.4: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.0	**0.0**	**NO CHANGE**
SRD1	22195	0.1	0.1	**0.0**	**NO CHANGE**
SRD2	19855	0.1	0.1	**0.0**	**NO CHANGE**
SRD3	17510	-0.3	-0.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.4	0.4	**0.0**	**NO CHANGE**
SRE3	11015	-0.2	-0.2	**0.0**	**NO CHANGE**

The same comparison was made with tributary stream yield replacing potential transport in the calculations. The results for the proposed condition where both the tributaries and the River are flowing at the Q_{CAP} discharge are shown in Table 7.5. The table shows that the stream yield grade change ranges from -0.3 to 0.5 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. Table 7.6 compares the yield grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) yield bed stability. The table shows that influence of the tributary's stream sediment yield considered is minimal relative to local river bed stream yield grade change.

Table 7.5: Phase 2 Santa Clara River Proposed Conditions Yield Bed Stability - Qburn River VS Creek Yield										
Subreach	US Sta	DS Sta	Trans Eq	Yield (ton)	Trib Inflow (ton)	Yield - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	176,022	0	176,022	860.1	0.1	**AGGRADE**	**0.1**
SRD1*	22195	20070	MPM	174,434	3,699	170,735	1,511.4	0.0	**AGGRADE**	**0.0**
SRD2	19855	17785	MPM	112,540	0	112,540	1,431.8	0.3	**AGGRADE**	**0.3**
SRD3	17510	15335	MPM	183,265	1,623	181,642	1,274.3	0.3	**DEGRADE**	**-0.3**
SRE1	15125	13190	MPM	207,302	2,364	204,938	1,588.9	0.1	**DEGRADE**	**-0.1**
SRE2	13030	11180	MPM	110,603	0	110,603	1,375.5	0.5	**AGGRADE**	**0.5**
SRE3	11015	9025	MPM	175,157	0	175,157	1,399.4	0.3	**DEGRADE**	**-0.3**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

Table 7.6: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{Burn}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.1	**0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	0.1	0.3	**0.2**	**CHANGE**
SRD3	17510	-0.2	-0.3	**-0.1**	**CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.3	0.5	**0.2**	**CHANGE**
SRE3	11015	-0.1	-0.3	**-0.2**	**CHANGE**

The results for the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) are shown in Table 7.7. The table shows that there is no change in stream yield grade. It is important to note that the stream yield general adjustment in this scenario is very small relative to the stream yield general adjustment that occurs during the Q_{CAP} scenario. Table 7.8 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) yield bed stability for the Q_{CAP}-Q_{31800} scenario. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. The results of the stream yield-based analysis are similar to those for the potential-based analysis: that influence of the tributary's sediment delivery considered is minimal relative to local river bed stream yield grade change.

Table 7.7: Phase 2 Santa Clara River Proposed Conditions Yield Bed Stability - Q_{31800} River yield VS Creek Yield										
	US Sta	DS Sta	Trans Eq	Yield (ton)	Trib Inflow (ton)	Yield - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	43,989	0	43,989	860.1	0.0	**AGGRADE**	**0.0**
SRD1*	22195	20070	MPM	36,804	3,699	33,105	1,511.4	0.0	**AGGRADE**	**0.0**
SRD2	19855	17785	MPM	42,154	0	42,154	1,431.8	0.0	**DEGRADE**	**0.0**
SRD3	17510	15335	MPM	49,933	1,623	48,310	1,274.3	0.0	**DEGRADE**	**0.0**
SRE1	15125	13190	MPM	51,371	2,364	49,007	1,588.9	0.0	**DEGRADE**	**0.0**
SRE2	13030	11180	MPM	46,105	0	46,105	1,375.5	0.0	**AGGRADE**	**0.0**
SRE3	11015	9025	MPM	40,660	0	40,660	1,399.4	0.0	**AGGRADE**	**0.0**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

Table 7.8: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.1	0.0	**-0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	-0.1	0.0	**0.1**	**CHANGE**
SRD3	17510	0.1	0.0	**-0.1**	**CHANGE**
SRE1	15125	-0.1	0.0	**0.1**	**CHANGE**
SRE2	13030	0.0	0.0	**0.0**	**NO CHANGE**
SRE3	11015	0.1	0.0	**-0.1**	**CHANGE**

Because the findings of the present study suggest that the impacts of development on the four watersheds considered within will be small but measurable with respect to the fluvial mechanics of Santa Clara River, PACE recommends that the top and toe elevations calculated in Phase 1 of this study be approved for final design. The values for top and toe are presented here in Table 7.9.

Table 7.9: Phase 1 & Phase 2 Toe Down and Freeboard Adjustment (Feet)					
Subreach	US Sta	Toe[1]		Freeboard[2]	
		Δ Curved / Outside	Δ Straight/ Inside	Δ Curved / Outside	Δ Curved / Outside
SRC4	24795	-0.1	-0.1	0.1	0.1
SRD1*	22195	-	-	-	-
SRD2	19855	-	-	0.1	0.1
SRD3	17510	-	-	-	-
SRE1	15125	-0.1	-0.1	-	-
SRE2	13030	-	-	0.2	0.2
SRE3	11015	-	-	-	-

1 Only Station 22790, and 15125

2 All Station in Subreach

7.3 A Note Concerning Differences between Calculated Tributary and Stream Yields

Several possible reasons exist to explain the discrepancy between the SAM stream yield and MORA watershed yield calculations. It could be expected that aggradation would occur when watershed yield exceeded stream yield, or conversely, that degradation would occur when stream yield exceeded watershed yield. In the case of Newhall Ranch Canyons fans or delta-type features are present at the confluence with Santa Clara River. To some extent, as yet uncharacterized, the shape and extent of the fan is mediated by large discharges within the River. The Creek as a whole, however, is not aggrading as suggested by the difference in watershed and stream yields presented above. Two of the explanations are the lack of fines in the SAM model and location of debris basin data within the watershed.

The study used to develop the LAC method for watershed yield relied on measurements based on debris basins. These debris basins have the potential to catch all particle sizes ranging from silts and clays to large cobbles and even larger particles. Some portion of the sediment trapped in the basins will be fine material, which is generally transported as wash load. The SAM numerical model excludes the fine materials smaller than 0.075 mm (sieve #200) from calculation. Heretofore, the focus of fluvial analysis on Santa Clara River and its tributaries has dealt with particles greater than 0.075 mm. The fine sediments (ϕ < 0.075 mm) not considered by SAM, but measured in the sediment basins used to calibrate the LAC method, may account for the difference between stream and watershed yield calculations.

The location of sediment basins within a watershed may be significant for determining the rate of sediment delivery into a sediment basin. Not all sediment basins within the same watershed will have the same sediment yield. The sediment yield is strongly a function of local bed slope, sub-watershed ground cover, sub-watershed soil type, local valley width, and other locally varying watershed factors. The tributary watersheds located within Newhall Ranch have steep sub-watersheds upstream, and flatter sub-watersheds at the River confluence, for example. In the present study SAM numerical modeling is focused on the downstream, transport-limiting stream subreaches located near the River confluence, while watershed modeling occurs over the entire tributary watershed area. This difference may account for some of the watershed and stream yield discrepancy.

Additional discussion of the nature of the study watershed's stream and watershed yield is included in a memorandum by Phillip Williams & Associates, included in Appendix Chapter 7.

8 References

Kennedy, J.F. (1963). The Mechanics of Dunes and Antidunes in Erodible Bed Channels: Journal of Fluid Mechanics, 16, 521-544.

Los Angeles County Department of Public Works Hydrology and Sedimentation Manual (LACH&SM) (December 2006 Draft and formatting, respectively)

Los Angeles County Flood Control District Design Manual (LACFCDDM) (October 1979)

Sikand Engineering in the *Newhall Ranch Santa Clara River HEC-RAS Study* (June 2000)

Simons, Li & Associates (November 1990) Fluvial Study of Santa Clara River and the Tributaries.

US Army Corps of Engineers (ACOE) (September 2002) SAM Hydraulic Design Package For Channels.

US Geological Survey (USGS) (August 1979) Sediment Discharge in the Santa Clara River Basin, Ventura and Los Angeles Counties, California. Water Resource Investigations 79-78.

Table 7.1: Santa Clara River Summary of Maximum Proposed Toe-down & Freeboard (ft)

Subreach	HEC-RAS Section	Z_{99} [2]	Outside Curved Reach		Straight-Inside Curved Reach		WSE	Outside Curved Reach		Straight-Inside Curved Reach	
			Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]		Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRA1	46195	1035.0	14.0	1021.0	14.0	1021.0	1063.1	3.1	1066.3	3.1	1066.3
	46020	1032.0	14.0	1018.0	14.0	1018.0	1062.0	3.0	1065.0	3.0	1065.0
	45545	1030.0	14.0	1016.0	14.0	1016.0	1057.9	3.4	1061.3	3.4	1061.3
	45030	1025.0	14.0	1011.0	14.0	1011.0	1054.2	3.0	1057.3	3.0	1057.3
	44585	1022.0	14.0	1008.0	14.0	1008.0	1050.6	3.2	1053.8	3.2	1053.8
	44210	1020.0	14.0	1006.0	14.0	1006.0	1047.8	2.9	1050.8	2.9	1050.8
SRA2	43820	1018.0	15.4	1002.6	15.4	1002.6	1042.1	3.9	1046.0	3.9	1046.0
	43610	1017.0	17.0	1000.0	17.0	1000.0	1038.3	4.0	1042.2	4.0	1042.2
	43410	1016.0	15.8	1000.2	15.8	1000.2	1035.8	3.6	1039.4	3.6	1039.4
	43200	1014.0	16.3	997.7	16.3	997.7	1033.2	3.5	1036.7	3.5	1036.7
	42975	1012.0	15.5	996.5	15.5	996.5	1031.0	2.9	1033.8	2.7	1033.7
	42815	1011.0	15.5	995.5	15.5	995.5	1029.7	2.5	1032.2	2.5	1032.2
	42590	1010.0	21.0	989.0	14.7	995.3	1028.4	2.5	1030.9	2.5	1030.9
	42430	1008.0	21.0	987.0	15.3	992.7	1027.5	2.5	1030.0	2.5	1030.0
	42215	1006.0	21.0	985.0	14.7	991.3	1026.7	2.5	1029.2	2.5	1029.2
	41940	1005.0	15.0	990.0	11.9	993.1	1025.6	2.5	1028.1	2.5	1028.1
	41730	1004.0	15.0	989.0	12.0	992.0	1024.6	2.5	1027.1	2.5	1027.1
	41460	1002.0	15.0	987.0	11.9	990.1	1023.2	2.5	1025.7	2.5	1025.7
SRA3	41280	1001.0	12.5	988.5	12.5	988.5	1021.8	2.5	1024.3	2.5	1024.3
	41080	1000.0	14.0	986.0	14.0	986.0	1020.5	2.5	1023.0	2.5	1023.0
	40825	999.5	21.0	978.5	14.0	985.5	1019.3	2.5	1021.8	2.5	1021.8
	40585	998.0	18.0	980.0	12.5	985.5	1018.3	2.5	1020.8	2.5	1020.8
	40335	996.0	15.0	981.0	10.0	986.0	1017.4	2.5	1019.9	2.5	1019.9
	40130	995.0	15.0	980.0	10.0	985.0	1016.6	2.5	1019.1	2.5	1019.1
	39945	994.0	15.0	979.0	10.0	984.0	1015.9	2.5	1018.4	2.5	1018.4
	39755	994.0	12.5	981.5	12.5	981.5	1014.6	2.5	1017.1	2.5	1017.1
	39605	993.0	14.0	979.0	14.0	979.0	1013.7	2.5	1016.2	2.5	1016.2
	39310	992.0	18.0	974.0	12.5	979.5	1012.2	2.5	1014.7	2.5	1014.7
	39100	990.0	14.0	976.0	14.0	976.0	1011.1	2.5	1013.6	2.5	1013.6
	38925	989.5	10.0	979.5	10.0	979.5	1010.3	2.5	1012.8	2.5	1012.8
SRA4	38710	988.0	10.0	978.0	10.0	978.0	1009.2	2.5	1011.7	2.5	1011.7
	38475	986.0	12.5	973.5	12.5	973.5	1007.0	2.6	1009.5	2.6	1009.5
	38300	985.5	14.0	971.5	14.0	971.5	1005.8	2.5	1008.3	2.5	1008.3
	38065	984.0	10.0	974.0	10.0	974.0	1004.1	2.5	1006.6	2.5	1006.6
	37810	983.0	14.0	969.0	14.0	969.0	1001.4	2.8	1004.2	2.8	1004.2
	37655	982.0	14.0	968.0	14.0	968.0	999.9	2.6	1002.5	2.6	1002.5
	37390	981.0	14.0	967.0	14.0	967.0	998.5	2.5	1001.0	2.5	1001.0
	37135	980.0	12.5	967.5	12.5	967.5	996.8	2.5	999.3	2.5	999.3
	36930	978.0	14.0	964.0	14.0	964.0	995.7	2.5	998.2	2.5	998.2
	36735	977.0	12.5	964.5	12.5	964.5	994.6	2.5	997.1	2.5	997.1
	36515	975.0	15.0	960.0	10.0	965.0	993.6	2.5	996.1	2.5	996.1
	36265	974.0	15.0	959.0	10.0	964.0	992.3	2.5	994.8	2.5	994.8
SRB1	36080	973.0	22.9	950.1	22.0	951.0	990.6	2.5	993.1	2.5	993.1
	35845	971.0	15.0	956.0	10.0	961.0	989.1	2.5	991.6	2.5	991.6
	35725	970.0	15.0	955.0	10.0	960.0	988.3	2.5	990.8	2.5	990.8
	35515	969.0	18.0	951.0	12.5	956.5	986.9	2.5	989.4	2.5	989.4
	35245	968.0	18.0	950.0	12.5	955.5	985.0	2.5	987.5	2.5	987.5
	35040	967.0	21.0	946.0	14.0	953.0	983.6	2.5	986.1	2.5	986.1
	34860	966.0	21.0	945.0	14.0	952.0	982.3	2.5	984.8	2.5	984.8
	34720	965.5	21.0	944.5	14.0	951.5	981.3	2.5	983.8	2.5	983.8
	34495	964.0	18.0	946.0	12.5	951.5	979.7	2.5	982.2	2.5	982.2
	34310	963.0	18.0	945.0	12.5	950.5	978.4	2.5	980.9	2.5	980.9
	34090	962.0	18.0	944.0	12.5	949.5	977.0	2.5	979.5	2.5	979.5
SRB2	33880	960.0	18.0	942.0	12.5	947.5	975.7	2.5	978.2	2.5	978.2
	33710	959.0	18.0	941.0	12.5	946.5	974.6	2.5	977.1	2.5	977.1
	33500	958.0	18.0	940.0	12.5	945.5	973.3	2.5	975.8	2.5	975.8
	33310	957.0	18.0	939.0	12.5	944.5	972.3	2.5	974.8	2.5	974.8
	33115	956.0	15.0	941.0	10.0	946.0	971.4	2.5	973.9	2.5	973.9
	32795	954.0	15.0	939.0	10.0	944.0	969.7	2.5	972.2	2.5	972.2
	32605	952.0	15.0	937.0	10.0	942.0	968.7	2.5	971.2	2.5	971.2
SRC1	32265	950.0	18.0	932.0	12.5	937.5	967.2	2.5	969.7	2.5	969.7
	31875	949.0	15.0	934.0	10.0	939.0	965.6	2.5	968.1	2.5	968.1
	31585	946.0	15.0	931.0	10.0	936.0	964.7	2.5	967.2	2.5	967.2
	31360	944.0	15.0	929.0	10.0	934.0	963.9	2.5	966.4	2.5	966.4
	31060	942.0	12.0	930.0	8.0	934.0	963.2	2.5	965.7	2.5	965.7
	30720	940.0	12.0	928.0	8.0	932.0	962.5	2.5	965.0	2.5	965.0
	30445	938.0	12.0	926.0	8.0	930.0	962.1	2.5	964.6	2.5	964.6
	30095	936.0	12.0	924.0	8.0	928.0	961.5	2.5	964.0	2.5	964.0
	29815	935.0	12.0	923.0	8.0	927.0	960.8	2.5	963.3	2.5	963.3
	29565	934.0	12.0	922.0	8.0	926.0	960.3	2.5	962.8	2.5	962.8
	29385	933.0	12.0	921.0	8.0	925.0	959.6	2.5	962.1	2.5	962.1
SRC2	29140	932.0	12.0	920.0	9.1	922.9	958.4	2.5	960.9	2.5	960.9
	28895	930.0	21.0	909.0	14.0	916.0	953.8	4.8	958.6	4.7	958.5
	28695	928.0	15.0	913.0	15.0	913.0	952.9	2.5	955.4	2.5	955.4
	28500	927.5	14.7	912.8	14.7	912.8	950.5	3.1	953.5	2.9	953.4
	28280	926.0	21.0	905.0	14.0	912.0	949.8	2.5	952.3	2.5	952.3
	28080	925.0	15.0	910.0	10.0	915.0	949.1	2.5	951.6	2.5	951.6
	27925	924.0	10.3	913.7	10.3	913.7	948.1	2.5	950.6	2.5	950.6
	27725	923.0	14.0	909.0	14.0	909.0	946.1	2.9	949.0	2.9	949.0
	27545	922.0	15.0	907.0	15.0	907.0	944.3	3.1	947.4	3.1	947.4
	27335	921.0	14.1	906.9	14.1	906.9	943.0	2.7	945.7	2.6	945.6
	27155	920.5	14.0	906.5	14.0	906.5	941.5	2.9	944.4	2.8	944.2
SRC3	26990	920.0	21.0	899.0	14.0	906.0	940.4	2.5	942.9	2.5	942.9
	26780	918.0	21.0	897.0	14.0	904.0	939.3	2.5	941.8	2.5	941.8
	26575	917.0	21.0	896.0	14.0	903.0	938.5	2.5	941.0	2.5	941.0
	26355	916.0	18.0	898.0	12.5	903.5	937.6	2.5	940.1	2.5	940.1
	26170	915.0	18.0	897.0	12.5	902.5	936.9	2.5	939.4	2.5	939.4
	25965	914.0	21.0	893.0	14.0	900.0	936.2	2.5	938.7	2.5	938.7
	25785	913.5	21.0	892.5	14.0	899.5	935.5	2.5	938.0	2.5	938.0
	25600	912.5	21.0	891.5	14.0	898.5	934.8	2.5	937.3	2.5	937.3
	25425	911.0	21.0	890.0	14.0	897.0	934.1	2.5	936.6	2.5	936.6
	25215	910.0	15.0	895.0	10.0	900.0	933.3	2.5	935.8	2.5	935.8
	25000	909.0	15.0	894.0	10.0	899.0	932.5	2.5	935.0	2.5	935.0
SRC4	24795	908.0	15.0	893.0	10.0	898.0	931.5	3.7	935.2	3.4	934.9
	24550	906.0	18.0	888.0	12.5	893.5	930.1	3.4	933.4	3.2	933.2
	24335	905.0	21.0	884.0	14.0	891.0	928.5	3.7	932.2	3.4	931.9
	24115	904.0	21.0	883.0	14.0	890.0	927.0	3.8	930.8	3.5	930.5
	23975	903.5	21.0	882.5	14.0	889.5	926.1	3.6	929.7	3.4	929.5
	23755	902.0	21.0	881.0	14.0	888.0	924.7	3.6	928.4	3.4	928.1
	23565	900.0	21.0	879.0	14.0	886.0	923.6	3.5	927.1	3.3	926.9
	23365	900.0	21.0	879.0	14.0	886.0	922.4	3.5	925.9	3.3	925.7
	23180	899.0	21.0	878.0	14.0	885.0	921.5	3.6	925.0	3.3	924.8
	23000	898.0	21.0	877.0	14.0	884.0	920.0	3.6	923.6	3.3	923.4
	22790	897.5	26.8	870.7	23.0	874.5	917.5	3.9	921.4	3.6	921.1
	22600	896.0	21.0	875.0	14.0	882.0	915.8	3.8	919.6	3.5	919.3
	22415	895.5	21.0	874.5	14.0	881.5	914.4	3.5	918.0	3.3	917.7

1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

Table 7.1: Santa Clara River Summary of Proposed Toe-down & Freeboard (ft) continued

Subreach	HEC-RAS Section	Z_{99} [2]	Outside Curved Reach		Straight-Inside Curved Reach		WSE	Outside Curved Reach		Straight-Inside Curved Reach	
			Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]		Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRD1	22195	894.0	15.0	879.0	10.0	884.0	913.1	2.5	915.6	2.5	915.6
	22010	892.0	18.0	874.0	12.5	879.5	911.4	3.0	914.3	2.7	914.0
	21790	891.5	21.0	870.5	14.0	877.5	909.9	2.8	912.7	2.5	912.4
	21615	892.0	21.0	871.0	14.0	878.0	908.9	2.5	911.4	2.5	911.4
	21440	890.0	18.0	872.0	12.5	877.5	907.8	2.6	910.4	2.5	910.3
	21225	888.0	21.0	867.0	14.0	874.0	906.7	2.5	909.2	2.5	909.2
	21020	887.0	21.0	866.0	14.0	873.0	905.6	2.5	908.1	2.5	908.1
	20845	886.0	18.0	868.0	12.5	873.5	904.7	2.5	907.2	2.5	907.2
	20595	885.0	15.0	870.0	10.0	875.0	903.6	2.5	906.1	2.5	906.1
	20435	884.0	15.0	869.0	10.0	874.0	902.8	2.5	905.4	2.5	905.3
	20280	883.7	18.0	865.7	12.5	871.2	901.8	2.6	904.4	2.5	904.3
	20070	882.0	21.0	861.0	14.0	868.0	900.6	2.6	903.2	2.5	903.1
SRD2	19855	880.5	21.0	859.5	14.0	866.5	899.6	3.4	903.0	3.2	902.8
	19630	880.0	21.0	859.0	14.0	866.0	898.6	3.4	902.0	3.1	901.8
	19440	878.0	15.0	863.0	10.0	868.0	897.9	3.3	901.1	3.1	901.0
	19240	877.5	18.0	859.5	12.5	865.0	896.9	3.3	900.2	3.2	900.0
	19050	876.0	21.0	855.0	14.0	862.0	896.2	3.1	899.3	3.0	899.2
	18830	874.0	15.0	859.0	10.0	864.0	895.4	3.1	898.5	3.0	898.4
	18650	873.5	15.0	858.5	10.0	863.5	894.7	3.1	897.8	3.0	897.7
	18475	872.0	13.6	858.4	8.0	864.0	894.3	2.9	897.2	2.9	897.1
	18290	871.5	14.1	857.4	8.0	863.5	893.6	3.0	896.6	2.9	896.5
	18025	870.0	8.0	862.0	8.0	862.0	892.9	2.9	895.7	2.9	895.7
	17785	868.0	8.0	860.0	8.0	860.0	892.0	3.0	895.0	3.0	895.0
SRD3	17510	868.0	10.0	858.0	10.0	858.0	890.4	2.5	892.9	2.5	892.9
	17360	868.0	12.5	855.5	12.5	855.5	888.3	2.7	890.9	2.7	890.9
	17110	864.0	14.0	850.0	14.0	850.0	885.5	2.6	888.1	2.6	888.1
	16970	863.7	14.0	849.7	14.0	849.7	884.0	2.6	886.5	2.6	886.5
	16720	863.5	14.0	849.5	14.0	849.5	882.3	2.5	884.8	2.5	884.8
	16515	862.0	14.0	848.0	14.0	848.0	881.2	2.5	883.7	2.5	883.7
	16305	860.0	10.0	850.0	10.0	850.0	880.4	2.5	882.9	2.5	882.9
	16130	860.0	12.5	847.5	12.5	847.5	879.4	2.5	881.9	2.5	881.9
	15960	859.0	12.5	846.5	12.5	846.5	878.6	2.5	881.1	2.5	881.1
	15745	858.0	10.0	848.0	10.0	848.0	877.6	2.5	880.1	2.5	880.1
	15540	857.5	10.0	847.5	10.0	847.5	876.7	2.5	879.2	2.5	879.2
	15335	856.0	12.5	843.5	12.5	843.5	874.8	2.5	877.3	2.5	877.3
SRE1	15125	854.0	26.1	827.9	26.1	827.9	872.0	2.5	874.5	2.5	874.5
	14900	853.0	14.0	839.0	14.0	839.0	869.7	2.5	872.2	2.5	872.2
	14720	852.0	21.0	831.0	14.0	838.0	868.4	2.5	870.9	2.5	870.9
	14480	850.5	21.0	829.5	14.0	836.5	866.9	2.5	869.4	2.5	869.4
	14315	850.0	15.0	835.0	10.0	840.0	866.0	2.5	868.5	2.5	868.5
	14090	850.0	15.0	835.0	10.0	840.0	864.8	2.5	867.3	2.5	867.3
	13850	848.0	15.0	833.0	10.0	838.0	863.6	2.5	866.1	2.5	866.1
	13635	846.0	18.0	828.0	12.5	833.5	862.5	2.5	865.0	2.5	865.0
	13425	845.0	21.0	824.0	14.0	831.0	861.8	2.5	864.3	2.5	864.3
	13190	844.0	15.0	829.0	10.0	834.0	861.1	2.5	863.6	2.5	863.6
SRE2	13030	843.0	15.0	828.0	10.0	833.0	860.6	3.6	864.3	3.6	864.2
	12835	842.0	10.0	832.0	10.0	832.0	860.0	3.6	863.7	3.6	863.6
	12615	841.0	10.0	831.0	10.0	831.0	859.3	3.7	863.0	3.7	863.0
	12395	840.0	10.0	830.0	10.0	830.0	858.7	3.7	862.4	3.7	862.4
	12195	839.0	10.0	829.0	10.0	829.0	858.1	3.7	861.7	3.7	861.7
	11995	837.0	10.0	827.0	10.0	827.0	857.3	3.8	861.1	3.8	861.1
	11780	836.0	10.0	826.0	10.0	826.0	856.6	3.8	860.4	3.8	860.4
	11605	835.5	10.0	825.5	10.0	825.5	855.8	3.9	859.7	3.9	859.7
	11405	834.0	10.0	824.0	10.0	824.0	854.6	4.1	858.7	4.1	858.7
	11180	833.0	12.5	820.5	12.5	820.5	852.7	4.6	857.3	4.6	857.3
SRE3	11015	831.5	14.0	817.5	14.0	817.5	850.2	5.2	855.5	5.2	855.5
	10835	831.0	14.0	817.0	14.0	817.0	848.1	5.1	853.2	5.1	853.2
	10575	830.0	14.0	816.0	14.0	816.0	846.1	4.2	850.3	4.2	850.3
	10390	828.0	14.0	814.0	14.0	814.0	845.1	4.1	849.2	4.1	849.2
	10225	827.5	12.5	815.0	12.5	815.0	844.1	4.0	848.1	4.0	848.1
	10000	826.0	10.0	816.0	10.0	816.0	842.6	4.0	846.5	4.0	846.5
	9820	824.0	14.0	810.0	14.0	810.0	841.4	3.9	845.3	3.9	845.3
	9595	823.8	10.0	813.8	10.0	813.8	839.9	4.0	843.8	3.9	843.8
	9385	823.0	18.0	805.0	12.5	810.5	838.6	3.8	842.4	3.8	842.4
	9220	822.0	18.0	804.0	12.5	809.5	837.6	3.8	841.4	3.7	841.3
	9025	821.0	18.0	803.0	12.5	808.5	836.6	3.8	840.4	3.8	840.4

1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

ACOE (TATUM) DEBRIS YIELD: CHIQUITO CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	163.68	CRR=	0.53
A (AC)=	3048.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	880.84		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	12,329		
DY (AC FT)=	36		
DY (TON/MI^2)=	17,665		
DY (TON)=	84,128		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

4061.64	3068.3	847.1954
1626.47	989.1	1052.412
2842.13	2139	850.3802
3309	2938	720.8169
4070.88	2866.6	908.8688
784	4737	105.9236
2937.53	1968.8	954.9061
1363	850	1026.259

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: CHIQUITO CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	163.68	CRR=	0.53
A (AC)=	2900.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	914.80		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	12,707		
DY (AC FT)=	36		
DY (TON/MI^2)=	18,205		
DY (TON)=	82,494		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: GRANDE CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	311.54	CRR=	0.53
A (AC)=	2134.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1175.93		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	21,855		
DY (AC FT)=	45		
DY (TON/MI^2)=	31,312		
DY (TON)=	104,408		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: GRANDE CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	311.54	CRR=	0.53
A (AC)=	2030.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1232.10		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	22,694		
DY (AC FT)=	45		
DY (TON/MI^2)=	32,514		
DY (TON)=	103,131		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: LONG CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	274.56	CRR=	0.53
A (AC)=	989.00	CA/Q=	0.04
FF=	3.07	CFF=	0.22
Q (FT^3/S/MI^2)=	938.30		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	15,870		
DY (AC FT)=	15		
DY (TON/MI^2)=	22,737		
DY (TON)=	35,136		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: LONG CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	274.56	CRR=	0.53
A (AC)=	945.00	CA/Q=	0.04
FF=	3.07	CFF=	0.22
Q (FT^3/S/MI^2)=	883.80		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	15,056		
DY (AC FT)=	14		
DY (TON/MI^2)=	21,570		
DY (TON)=	31,850		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

ACOE (TATUM) DEBRIS YIELD: POTRERO CANYON CREEK EXISTING Q_{CAP}

P (IN)x100=	0.00	CP/CQ=	0.85
RR (FT/MI)=	174.24	CRR=	0.53
A (AC)=	2857.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	995.70		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	14,260		
DY (AC FT)=	39		
DY (TON/MI^2)=	20,431		
DY (TON)=	91,204		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP x100
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
MARCH, 2006

ACOE (TATUM) DEBRIS YIELD: POTRERO CANYON CREEK PROPOSED Q_{CAP}

P (IN)x100=	0.00	CP/CQ=	0.85
RR (FT/MI)=	174.24	CRR=	0.53
A (AC)=	2060.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1294.30		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	17,590		
DY (AC FT)=	35		
DY (TON/MI^2)=	25,201		
DY (TON)=	81,116		

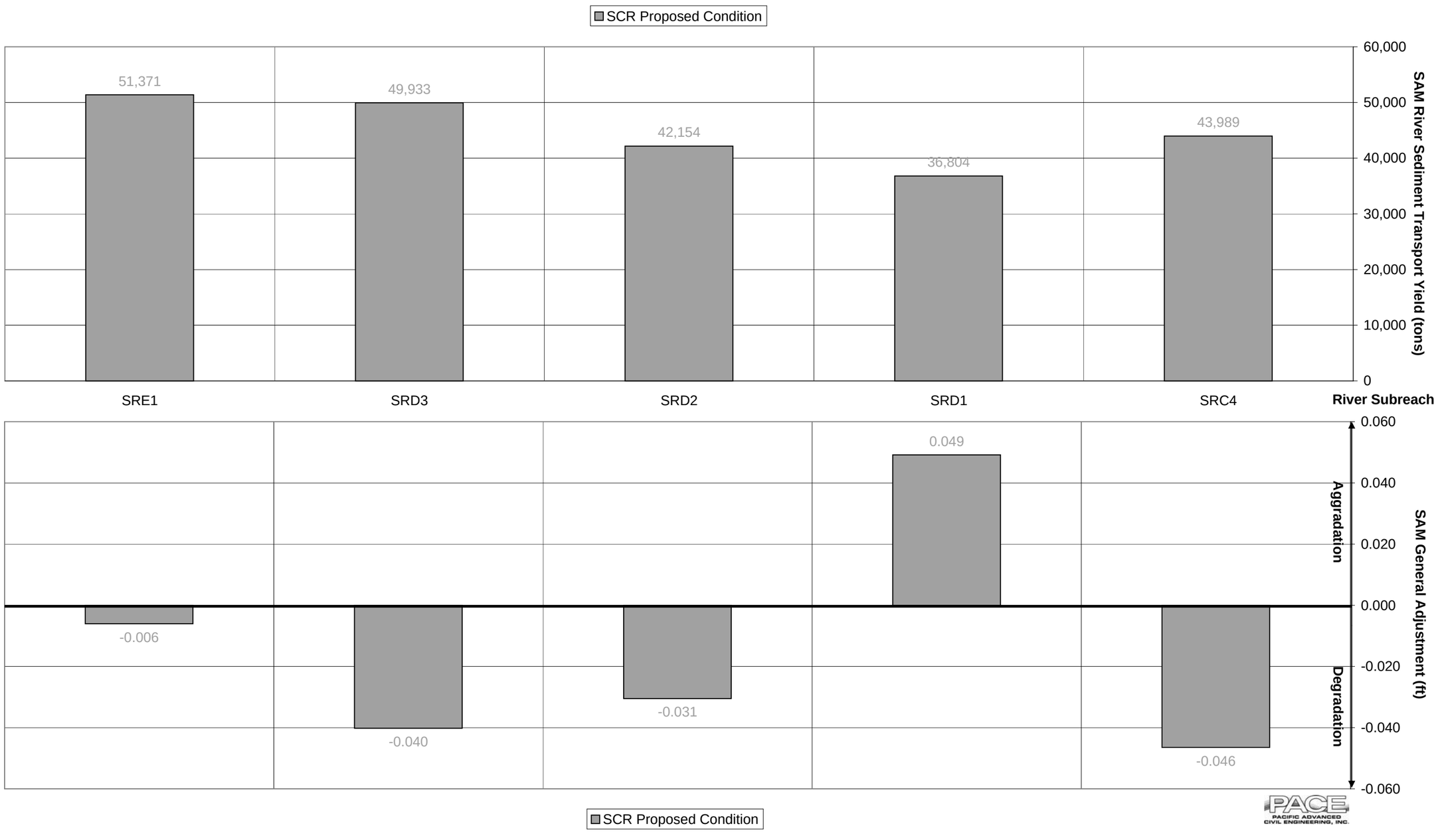
VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

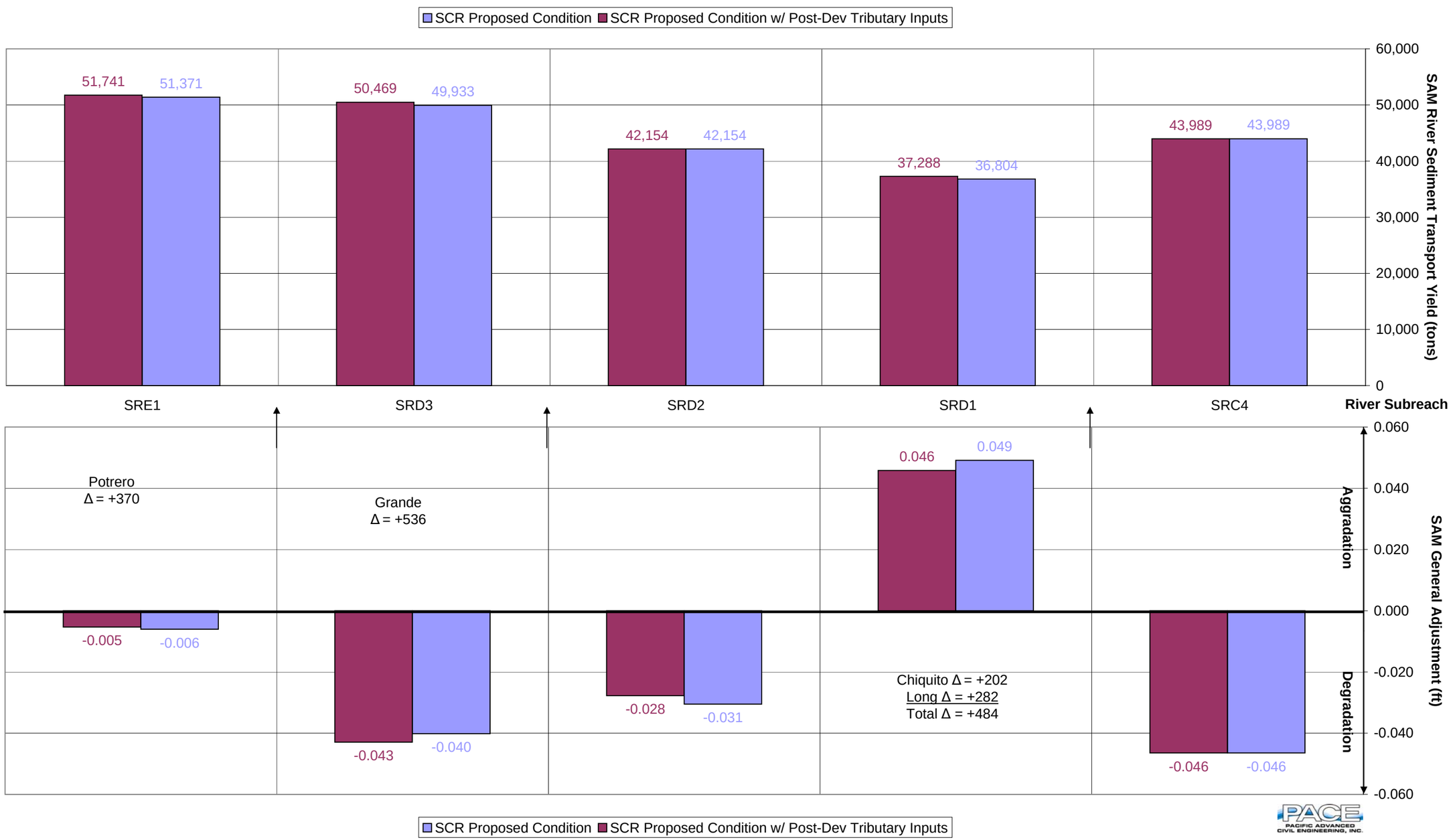
CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

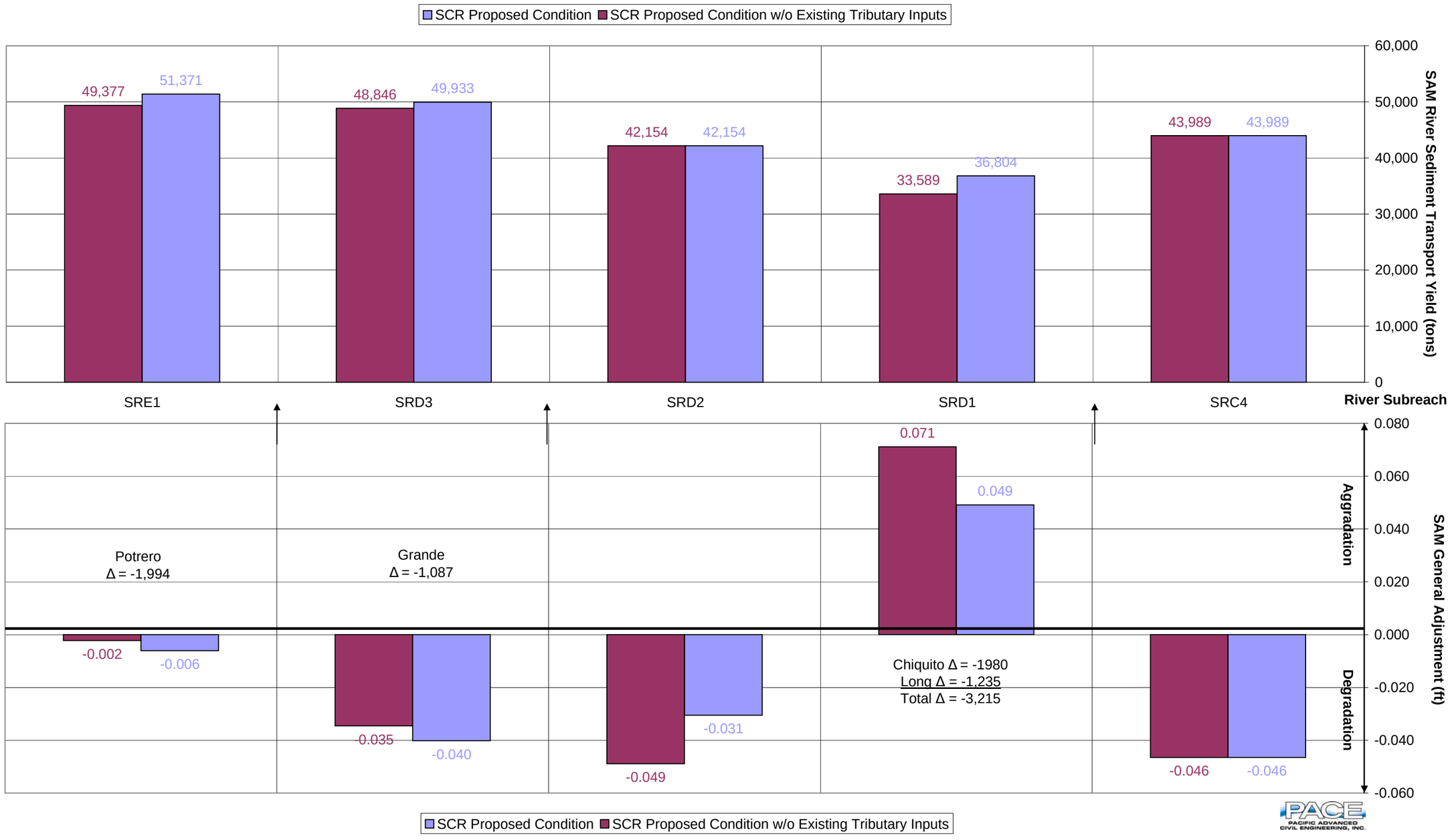
DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP x100
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

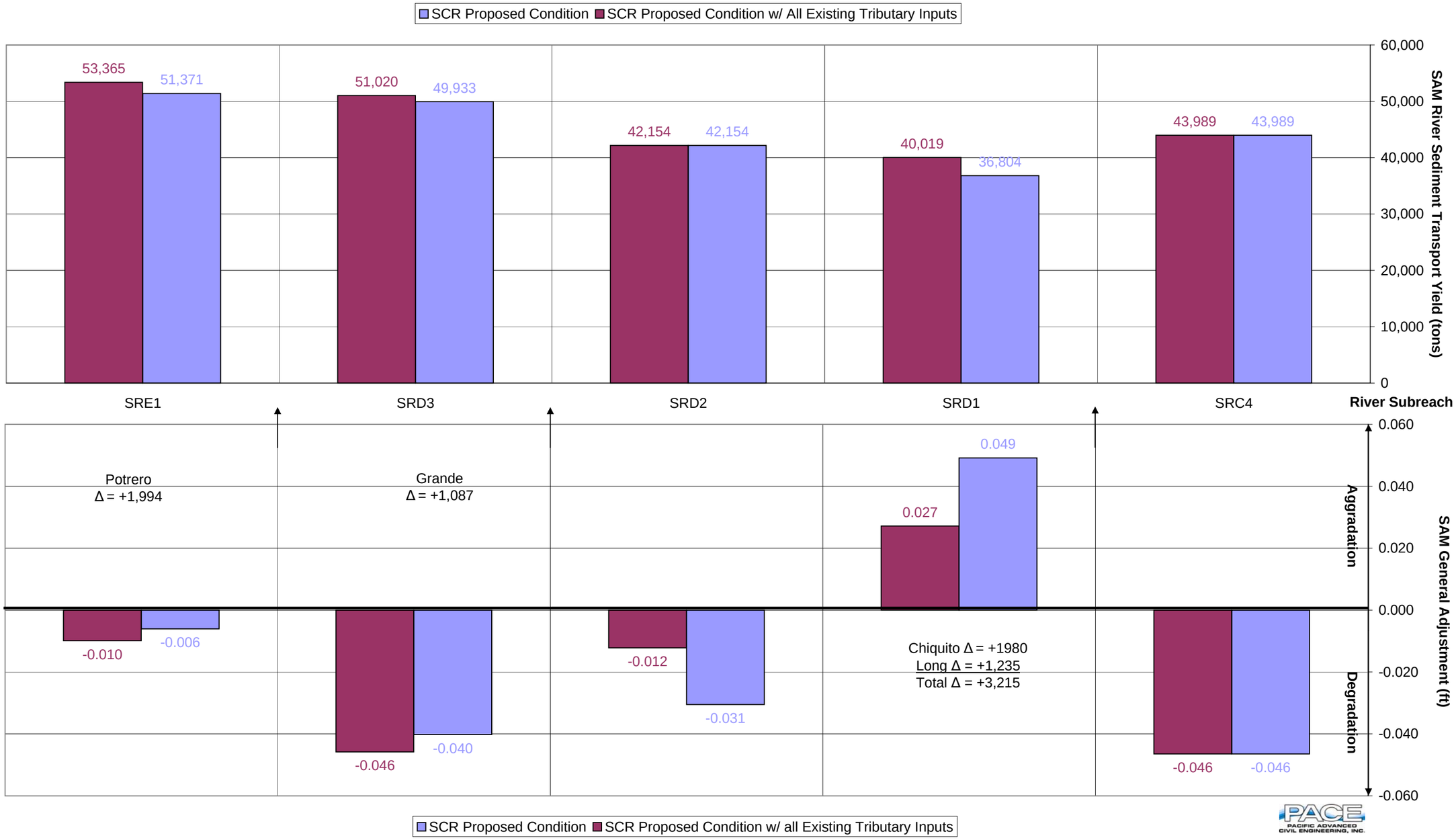
CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

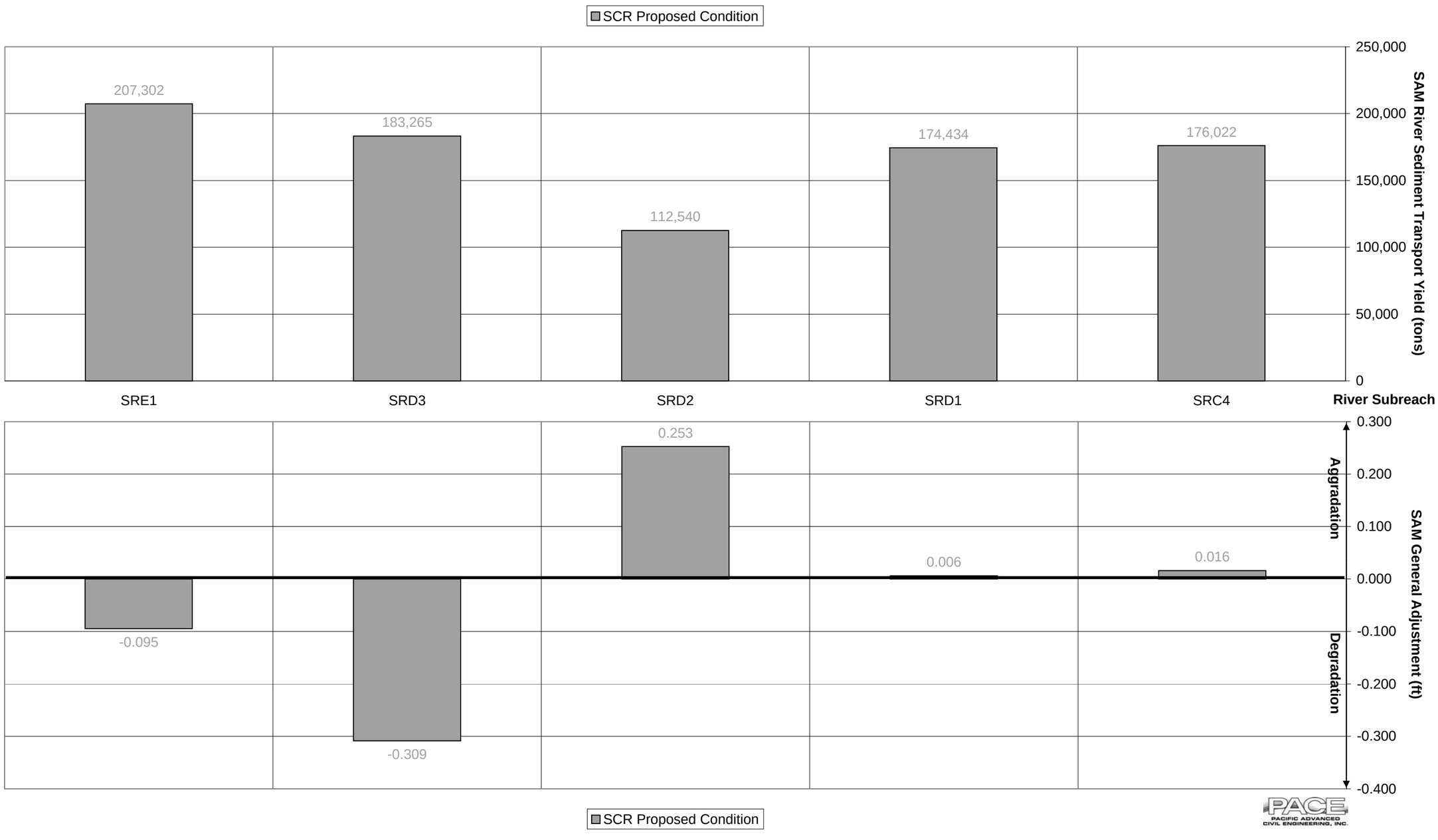
BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

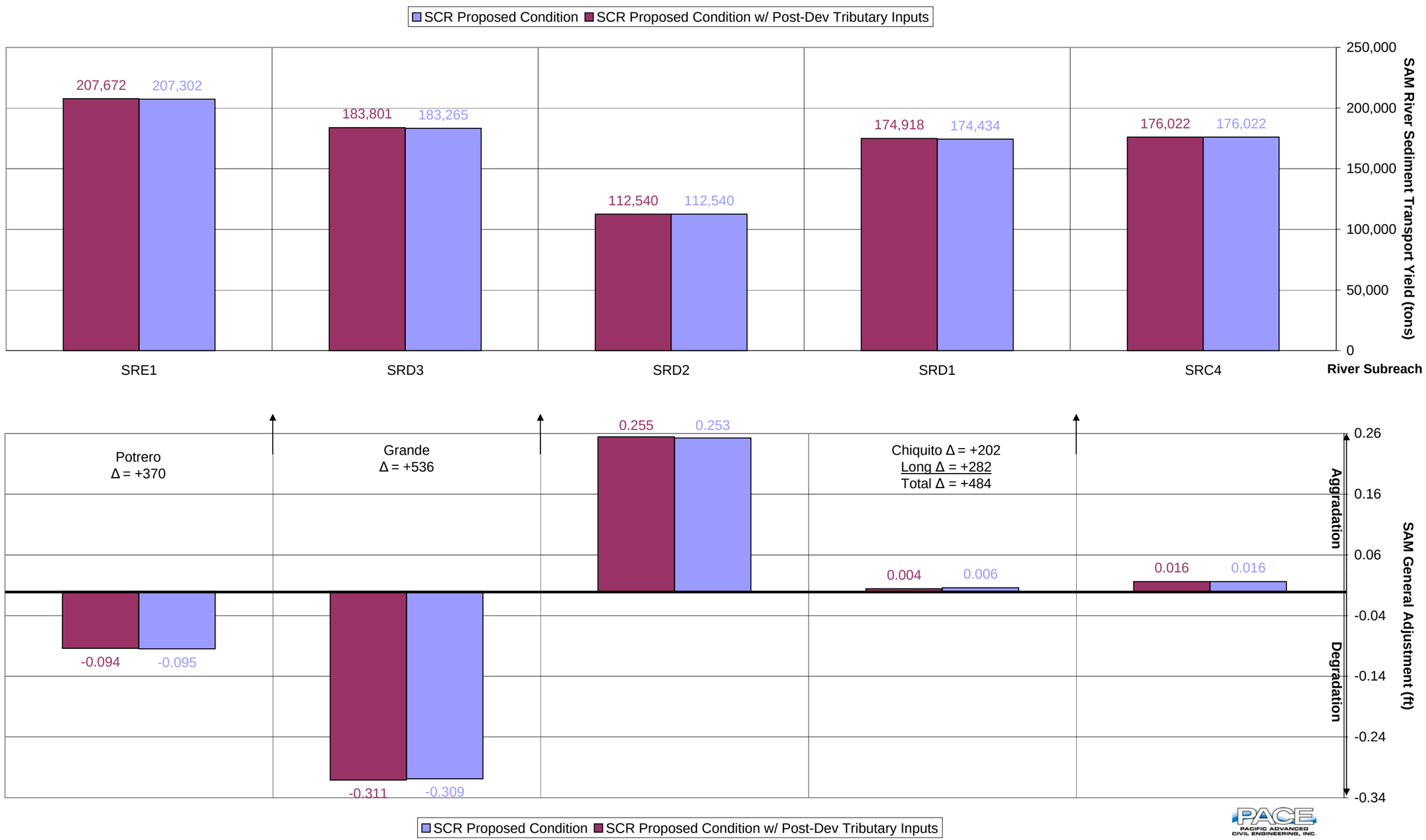

SCR Proposed Condition
51,371
49,933
42,154
36,804
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.049
-0.006
-0.040
-0.031
-0.046
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition

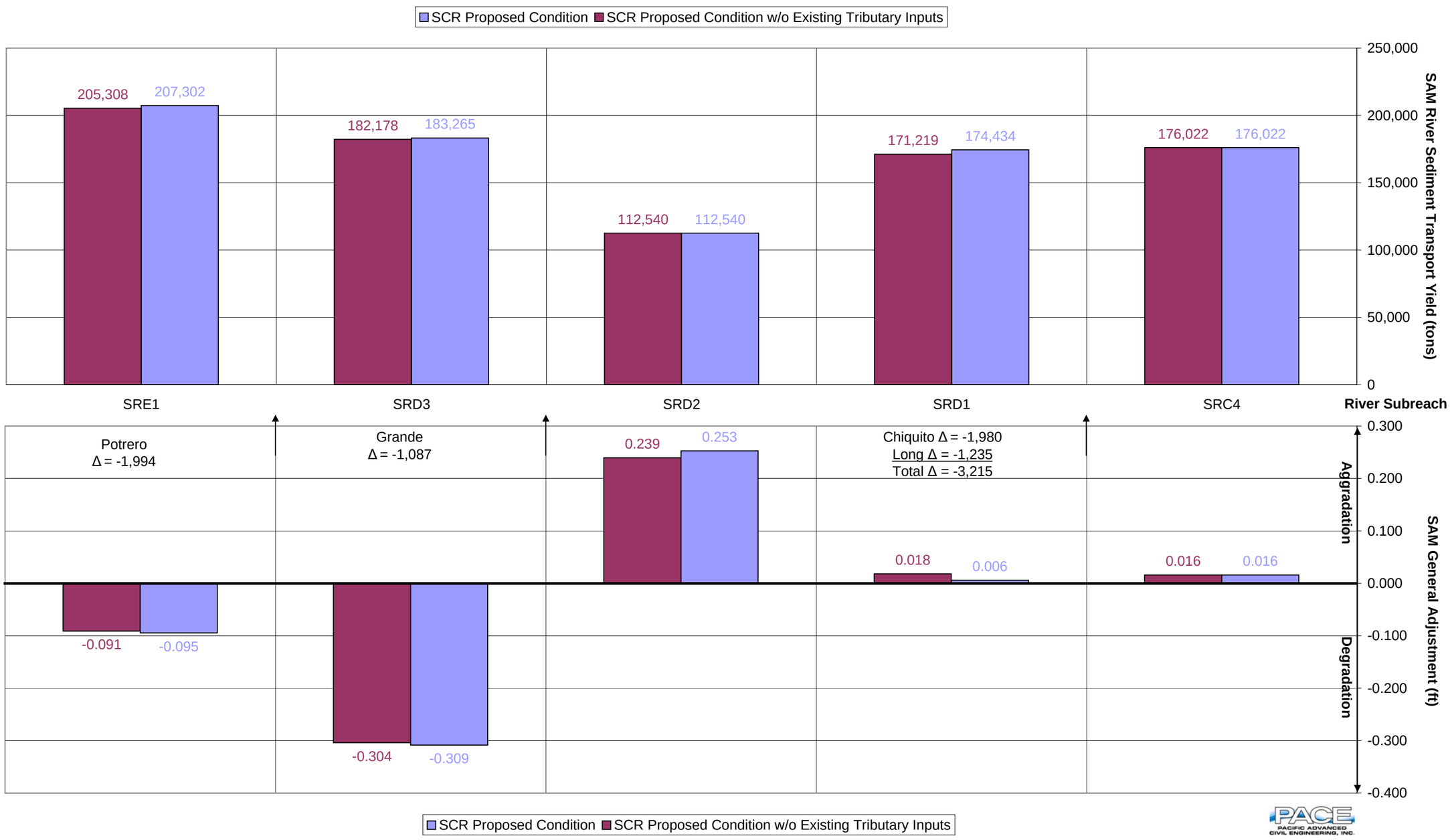

SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs
51,741
51,371
50,469
49,933
42,154
42,154
37,288
36,804
43,989
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +370
Grande
Δ = +536
0.046
0.049
-0.005
-0.006
-0.043
-0.040
-0.028
-0.031
Chiquito Δ = +202
Long Δ = +282
Total Δ = +484
-0.046
-0.046
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs


SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
49,377
51,371
48,846
49,933
42,154
42,154
33,589
36,804
43,989
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.080
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
SAM General Adjustment (ft)
Aggradation
Degradation
Potrero
Δ = -1,994
Grande
Δ = -1,087
0.071
0.049
-0.002
-0.006
-0.035
-0.040
-0.049
-0.031
Chiquito Δ = -1980
Long Δ = -1,235
Total Δ = -3,215
-0.046
-0.046
SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs


SCR Proposed Condition
SCR Proposed Condition w/ All Existing Tributary Inputs
53,365
51,371
51,020
49,933
42,154
42,154
40,019
36,804
43,989
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +1,994
Grande
Δ = +1,087
0.049
0.027
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
-0.010
-0.006
-0.046
-0.040
-0.012
-0.031
Chiquito Δ = +1980
Long Δ = +1,235
Total Δ = +3,215
-0.046
-0.046
SCR Proposed Condition
SCR Proposed Condition w/ all Existing Tributary Inputs


SCR Proposed Condition
207,302
183,265
112,540
174,434
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.253
0.006
0.016
-0.095
-0.309
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition


SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs
207,672
207,302
183,801
183,265
112,540
112,540
174,918
174,434
176,022
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +370
Grande
Δ = +536
Chiquito Δ = +202
Long Δ = +282
Total Δ = +484
0.255
0.253
0.004
0.006
0.016
0.016
-0.094
-0.095
-0.311
-0.309
0.26
0.16
0.06
-0.04
-0.14
-0.24
-0.34
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs


SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
205,308
207,302
182,178
183,265
112,540
112,540
171,219
174,434
176,022
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = -1,994
Grande
Δ = -1,087
0.239
0.253
Chiquito Δ = -1,980
Long Δ = -1,235
Total Δ = -3,215
0.018
0.006
0.016
0.016
-0.091
-0.095
-0.304
-0.309
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs

SCR Proposed Condition
SCR Proposed Condition w/ All Existing Tributary Inputs
209,296
207,302
184,352
183,265
112,540
112,540
177,649
174,434
176,022
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +1,994
Grande
Δ = +1,087
Chiquito Δ = +1,980
Long Δ = +1,235
Total Δ = +3,215
0.266
0.253
-0.098
-0.095
-0.313
-0.309
-0.006
0.006
0.016
0.016
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ all Existing Tributary Inputs

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
TEL 415.262.2300 FAX 415.262.2303
www.pwa-ltd.com

MEMORANDUM

Date:	January 14, 2008
To:	Corey Harpole[1], Matt Carpenter[1], Mark Krebbs[2] and David Jaffey[2]
Organization:	[1]Newhall Land, [2]PACE
From:	Setenay Bozkurt and Andrew Collison
PWA Project #:	1820
PWA Project Name:	Newhall Ranch
Subject:	A review of sediment yield and sediment transport estimates in the Newhall Ranch tributary watersheds
Copy(ies) To:	File

Analytical studies performed by PACE have highlighted the discrepancy between estimated watershed sediment yield and estimated channel sediment transport capacity in the Newhall Ranch tributaries, with a surplus of sediment yield over transport capacity. This raises the potential need for sediment management to prevent channel aggradation and loss of flood capacity. To develop a better understanding of the tributaries PWA reviewed PACE's analysis as reported in the River Fluvial Study Phase 2 (August 2007) and the revised summary table provided via e-mail by David Jaffe (December 2007). We compared their modeled estimates for existing conditions with other estimates based on field measurement of sediment in similar environments. We supplemented PACE's data with other studies and estimates that were carried out either in Los Angeles County or in watersheds with similar physical characteristics.

PACE used three different methods to calculate hillslope sediment yields: MUSLE, ACoE (Tatum), and the LA County Method. The hillslope sediment yield estimates were performed for the Capital Event (Q_{cap}) and are summarized in Table 1 below (originally reported in PACE [2007], pages 14 and 17, revised in December 2007).

Table 1 – Existing Conditions Hillslope Sediment Yield for the Q_{cap}

Location	Area	MUSLE		Tatum Method		LA County Method	
	(mi^2)	(yd^3/mi^2) 1	($tons/mi^2$) 2	(yd^3/mi^2) 1	($tons/mi^2$) 2	(yd^3/mi^2) 1	($tons/mi^2$) 2
Chiquito	4.8	880	1,279	12,248	17,802	41,105	59,746
Long	1.5	8,248	11,988	16,369	23,792	36,998	53,777
Grande	3.3	6,817	9,909	22,110	32,137	44,311	64,406
Potrero	4.5	2,442	3,549	14,163	20,586	56,053	81,473

PACE (2007) report also included the results of a study prepared by Simons, Li and Associates (SLA) (1998) for the LACDPW titled the Quantitative Analysis and Mathematical Modeling of the Existing Condition of the Santa Clara River Basin, Third Interim Report. This study was carried out for adjacent watersheds and for a similar discharge. Table 2 presents the unit sediment yield estimates by the PACE and SLA studies.

Table 2 - Comparison of SLA and PACE Studies for Existing Conditions

SLA (1998)				
Location	**Area (mi^2)**	**Debris Production (yd^3/mi^2)**		
		MUSLE	**Tatum**	**LA County**
Hasley	19.9	11,469	36,750	23,000
Potrero	19.0	51,919	32,250	24,000
PACE (2007)				
Location	**Area (mi^2)**	**Debris Production (yd^3/mi^2)**		
		MUSLE	**Tatum**	**LA County**
Chiquito	4.8	880	12,248	41,105
Grande	3.3	6,817	22,110	44,311
Combined	*8.1*	*3,299*	*16,266*	*42,411*
Long	1.5	8,248	16,369	36,998
Potrero	4.5	2,442	14,163	56,053
Combined	*6.0*	*3,893*	*14,715*	*51,289*

The unit sediment yield estimates are dissimilar between the two studies because of differences in watershed area and some parameter values selected (e.g. the SLA study aggregated the PACE watersheds within a much larger watershed area, and so reflects different locations).

The unit sediment yield estimates using the LA County method as reported in the Phase 2 Study were revised by PACE in December 2007. The revised estimates by PACE are approximately 42,000 and 51,000 for the north and south bank watersheds, respectively. These estimates are approximately 2 times larger than the SLA estimates, and therefore, the differences between the two studies are not considered to be significant given the spatial area differences, changes in soil types and uncertainties involved in estimating sediment yield using empirical methods.

In summary, we conclude the following for sediment yield estimates:

- LA County method is the most representative equation for determining sediment production in the Newhall Ranch watersheds (based on comparison to other studies);
- Debris production rates for the Newhall Ranch watersheds would range from 30,000 to 50,000 tons/mi^2 (or 20,000 to 35,000 yd^3/mi^2) under the Q_{cap} or events of comparable magnitude such as the 50-year event; and

- Based on debris basin monitoring data in the Santa Clara Basin and the Los Angeles County, as well as data from San Gabriel Mountains, average annual sediment yield in the region is approximately 10,000 tons/mi^2.

PACE (2007) study also estimated tributary channel sediment transport capacity using the ACoE SAM steady-state model. The results are presented in Table 3 below.

Table 3 –Channel Sediment Yield Estimates for the Q_{burn}

	Hillslope Sediment Yield Estimates (tons/event)	**SAM Sediment Transport (tons/event)**
Chiquito	6,000 – 285,000	1,980
Long	18,000 – 83,000	1,235
Grande	33,000 – 215,400	1,087
Potrero	16,000 – 374,000	1,994

As Table 3 indicates, hillslope sediment yield estimates are significantly higher than channel transport capacities and yields (ranging from three times as much to three orders of magnitude as much). This discrepancy can partly be explained by four factors:

1. Hillslope sediment models estimate the total amount of sediment produced in the watershed and includes both the coarse and fine materials. However, channel transport capacity estimates only take into account the coarse load. In Newhall Ranch watersheds, soils are silty clay loams where the fine materials constitute a large percentage of the soils (approximately 90% given that all watersheds are primarily underlain by Castaic soils). Therefore, in order to compare hillslope sediment yield estimates to channel sediment transport estimates, approximately 10% (depending on the watershed) of the hillslope yields should be considered.
2. Sediment yield calculations are biased towards the steep headwater areas of watersheds (where most sediment is produced, and where sediment trapping basins are generally located). The sediment transport capacity calculations are performed in the flatter downstream portions of the tributaries. In the south side tributaries these headwaters are included within the project area and sediment generate here may have an impact downstream. However, in the north side tributaries much of the sediment generated in the headwaters is likely to deposit in the flatter channel and floodplain reaches upstream of the Newhall Ranch project area.
3. Watershed storage and channel storage partially accounts for the discrepancy between hillslope sediment yield versus channel sediment transport estimates. Typically, there is a lag time between when a sediment particle is mobilized from a hillslope and when it reaches the channel. Not all sediment that is eroded from the hillslopes reaches the channel during the same event. Sediment can be stored in fans, landslides, terraces, or behind or beneath vegetation. In addition, some of the sediment that reaches the channel during a large event can be stored within the channel to be transported downstream during a subsequent flood. Sediment is stored on the bed, bars, or behind coarse material or vegetation in the channels. It is possible that sediment generated during larger floods is stored temporarily in the channel and eroded during smaller events.

4. Natural processes are inherently very complex and difficult to model. Any attempt to mimic nature to estimate rates of processes is bound to have significant errors without actual measurements. All the models used to estimate sediment yield and transport incorporate many assumptions, ignore many details that may be important, and have considerable uncertainties and error margins. Therefore, all the above estimates should be viewed as rough estimates to obtain a representative rate that is at best within an order of magnitude of actual rates.

Summary

PACE's estimated values for sediment production are within the range of observed sediment accumulation rates for similar settings. The apparent discrepancy between sediment production and sediment transport capacity in the Newhall Ranch watersheds is potentially up to an order of magnitude smaller than initially appears based on sediment size fraction, and in the case of the north side tributaries the true sediment yield entering the project area may undergo a further significant reduction due to upstream storage. Notwithstanding these observations, field evidence from the Newhall ranch tributaries supports the case that some sediment is accumulating in the floodplain and channel (i.e. sediment yield has exceeded transport capacity for some time prior to our fieldwork). For example, sediment is accumulating under the Highway 126 Bridge, representing long term sediment accumulation. In the case of the south side tributaries the developed condition will greatly reduce sediment delivery and a sediment surplus is highly unlikely to occur (indeed, we anticipate sediment-limited conditions in these watersheds). In the north side tributaries the proposed development is much smaller as a percentage of the watershed, and the potential for continued sediment accumulation can not be excluded.

PACE
Advanced Water Engineering
17520 Newhope Street, Suite 200
Fountain Valley, CA 92708
714.481.7300

Philip Williams and Associates, Ltd., "Newhall Ranch Tributary Channel Design Guidelines" (November 20, 2008)

NEWHALL RANCH
TRIBUTARY CHANNEL DESIGN GUIDELINES

Prepared for

Newhall Land

Prepared by

Philip Williams & Associates, Ltd.

November 20, 2008

PWA Reference # 1820

Services provided pursuant to this Agreement are intended solely for the use and benefit of the Newhall Land.

No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of Philip Williams & Associates, Ltd., 550 Kearny Street, Suite 900, San Francisco, CA 94108.

TABLE OF CONTENTS

	Page No.
1. DESIGN METHODOLOGY	**1**
2. DESIGN DISCHARGES	**3**
3. CHANNEL SLOPE	**4**
3.1 METHOD 1. LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS METHODS	4
3.1.1 Method 1a: LACDPW Empirical Method	4
3.1.2 Method 1b: LACDPW Analytical Method	5
3.2 VERIFICATION USING EROSION POTENTIAL METHOD	6
3.3 VERIFICATION USING FIELD DATA AND SAM SIMULATIONS	7
3.3.1 Field Data	7
3.3.2 Sam Simulations	8
3.4 SELECTION OF DESIGN CHANNEL SLOPE	9
3.5 DESIGN SLOPE IMPLEMENTATION	9
4. CHANNEL WIDTH AND DEPTH	**12**
4.1 SOUTHERN CALIFORNIA FIELD REGRESSIONS	12
4.2 SELECTION OF A DESIGN CHANNEL WIDTH AND DEPTH	13
5. STEP-POOL DESIGN	**14**
5.1 SELECTION OF MULTIPLE SMALL STEPS OR FEWER LARGE STEPS	14
5.2 DESIGN PROCEDURE	14
5.3 GRADE CONTROL CONCEPTS	14
5.3.1 Grouted Sloping Boulder (GSB) Drop	14
5.3.2 Soil Cement Grade Control Structure	15
5.3.3 Sculpted Concrete Drop Structure	15
5.3.4 Non-Grouted Boulder Step-Pool	15
5.3.5 Grade Control Scour Apron	16
6. CHANNEL MIGRATION	**17**
6.1 PREDICTING CHANNEL MIGRATION	17
6.1.1 Maximum Safe Spacing Allowed Between Fixed Points to Avoid Migration into the Floodplain Edge	17
6.2 PROJECT APPLICATION	18
7. BANK PROTECTION	**20**

7.1 TOE PROTECTION ALTERNATIVES 20
7.2 BANK PROTECTION SELECTION PROCEDURE 21

8. HYDRAULIC CRITERIA 23
8.1 HYDRAULIC ANALYSIS 23

9. MONITORING AND MAINTENANCE OF THE CHANNEL 25

10. ACCESS REQUIREMENTS 26

11. REFERENCES 27

LIST OF TABLES

Table 1. Summary of LA County Methodologies 4
Table 2. Description of Ep Verification Method 7
Table 3. Summary of Southern California Field Regressions 12
Table 4. Bank Protection Alternatives and Application Criteria 21
Table 5. Model Simulation Scenarios 24

LIST OF FIGURES

Figure 1. Nomograph for Estimating Equilibrium Slope 5
Figure 2. Equilibrium Slope for Rural Reference Reaches 8
Figure 3. Sensitivity of Channel Slope to Reductions in Sediment Supply 9
Figure 4. Southern California Stream Morphology Relationships 13
Figure 5. Conceptual Sketch of Step-pool Structures Showing Relationship Between Design Gradient and Lowest Predicted Gradient 16
Figure 6. Reference Reach in Salt Canyon Showing Typical Sinuosity and Corridor Width (sinuosity of 1.3) 18
Figure 7. Example Model Output 18
Figure 8. Typical Detail for Channel Training Structure 19
Figure 9. Typical Cross-Section Detail for Planted Soil-Rock Toe Protection 20

ATTACHMENTS

Attachment A – Step Pool Information
Attachment B – Appendix G of the NRSP SRSMP

1. DESIGN METHODOLOGY

This guideline presents the design methodology that will be used for the hydromodification control and enhancement program for the tributary channels within the Newhall Ranch Specific Plan (NRSP) projects. This guideline focuses on the physical parameters of the channels, providing design guidelines to create stable stream channels that conform to Los Angeles County Department (LADPW) policies while supporting the desired ecosystems (in-channel habitat, riparian, wetland etc) following project implementation. These physical parameters include channel width, depth, slope, and planform. The approach focuses on developing these parameters based on the future flow and sediment regime, using an integrated geomorphic and engineering approach that predicts stable characteristics, and uses structures only in locations where erosional forces will exceed the natural stability of the channel. All structures (bank and channel bed protection) are designed to mimic natural features and use either biological, biotechnical (combination of structural and vegetative methods) or structural methods to provide stream channels that are stable, attractive and support the desired habitat elements.

Channel width, depth and slope are interdependent. In keeping with standard stream restoration design practices, a "slope first" design approach will be used in which channel equilibrium gradient is determined, followed by width and depth. The difference between the existing and future (stable) slope then determines the amount of the total gradient that must be stabilized using grade control structures (GCSs), which may be designed as a sequence of "step-pools." These step-pool structures are then designed to be hydraulically-stable during the LADPW design flow (capital flood or "Q_{cap}").

Three different methods of calculating channel width, depth and slope that fulfill the LACDPW and Newhall Ranch Specific Plan Sub-Regional Stormwater Mitigation Plan (NRSP Sub-Regional SWMP) requirements will be used that are based on performance of channel designs in a variety of settings. Channel width and depth will be calculated assuming a compound channel cross-section with a low-flow channel and adjacent floodplain terrace within the overall channel section.

The key objectives for channel design are:

1. Accommodate runoff flows from existing and future development.
2. Stabilize the channel bed and banks so that they do not degrade.
3. Preserve the waterway and canyon characteristics and environment, as applicable.
4. Protect existing and proposed infrastructure and homes from being endangered by erosion and excessive movement of the stream.
5. Minimize riparian and bank disturbance during construction, where applicable.

6. Implement improvements that are the most compatible with the environment and character of the region, yet sustainable on a long-term basis.
7. Allow for construction access and maintenance activities.
8. Minimize channel maintenance requirements

2. DESIGN DISCHARGES

The dominant discharge will be used as the design basis for the main low flow channel, in keeping with standard geomorphic practices. Dominant discharge is the flow that cumulatively transports the majority of sediment over a long period of time. This analysis approach assumes dominant discharge is equivalent to the 2-year flow for purposes of channel design. Using a long-term continuous rainfall-runoff hydrologic simulation for the Newhall Ranch watersheds, Geosyntec (2006) calculated the 2-year recurrence interval storms for the post-developed conditions. These 2-year storms will be used as the design event for the low flow channel, in so far as hydraulic analysis shows that these designs are also consistent with the LACDPW approaches.

3. CHANNEL SLOPE

The tributary channel slopes will be designed using LA County methods. The resulting slope will then be verified using the erosion potential (Ep) method (described in detail below) and field geomorphic data, and adjusted if necessary. The reasonableness of the design slopes will also be verified using actual channel slopes measured from undeveloped watersheds in the region (described in detail below).

3.1 METHOD 1. LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS METHODS

Both LACDPW methods of calculating equilibrium channel gradient (Table 1) will be applied. The first is an empirical method that is suitable for rapid analyses of small channels. The second is an analytical method, using sediment transport equations, that is more complex.

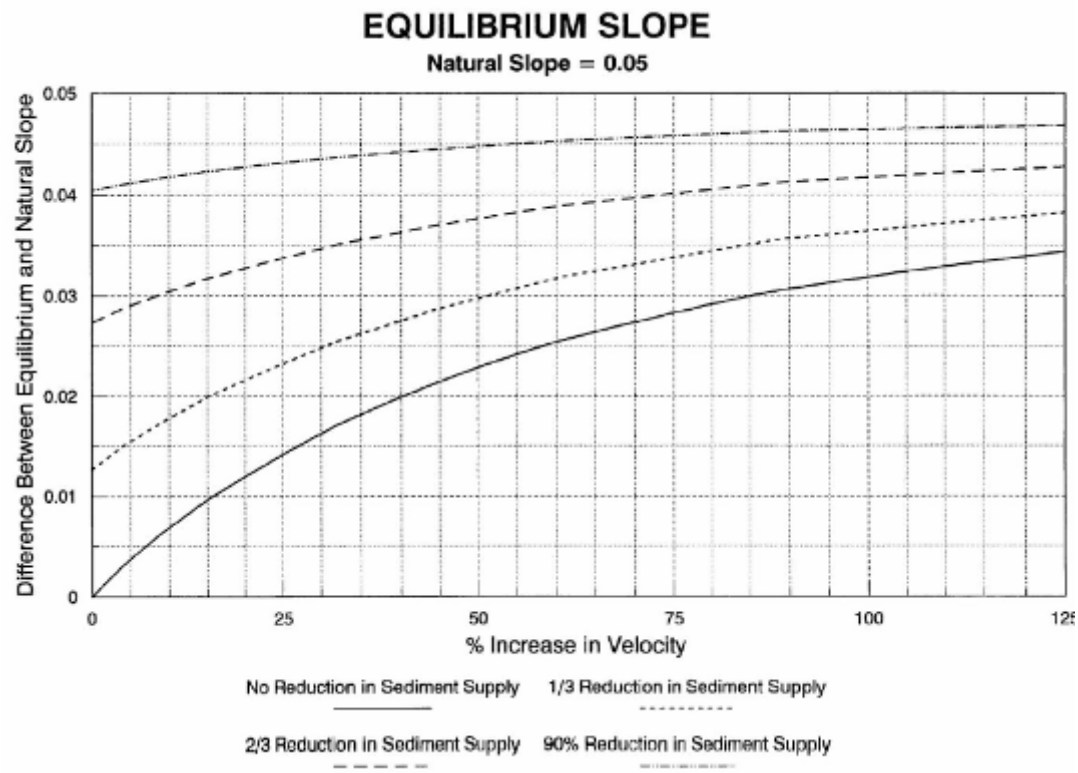
Table 1. Summary of LA County Methodologies

	Method 1a – LACDPW empirical method	**Method 1b – LACDPW analytical method**
Inputs	Existing conditions flow velocity Proposed conditions flow velocity Existing conditions channel slope Proposed conditions reduction in sediment supply	Upstream water and sediment inputs
Events Assessed	Qcap and 0.25Qcap	0.25Qcap
Approach	Nomograph based on empirical relationships for LA County. Use nomograph to identify slope reduction for both events and use the lower of the two slopes	Use sediment transport modeling to size channel to convey water and sediment at design flows without erosion and use the lower of the two slopes
Output	Reduction in existing slope required to achieve equilibrium	Equilibrium width, depth and slope of channel

3.1.1 Method 1a: LACDPW Empirical Method

The LACDPW empirical method involves comparing pre- and post-project channel velocity and sediment availability for Qcap and 0.25 Qcap. Equilibrium slope is estimated from the nomograph (Figure 1) based on changes in velocity and sediment supply. PWA developed a spreadsheet to automate interpolation from the nomograph and calculate the resulting stable channel slope.

Figure 1. Nomograph for Estimating Equilibrium Slope



Source: LA County Dept of Public Works, 2006. Appendix C.

3.1.2 Method 1b: LACDPW Analytical Method

This method is specified for soft bottomed channels with levees. The approach is based on applying a sediment transport equation for pre- and post-project conditions and iteratively adjusting channel slope until post-project sediment transport is equal to pre-project. The method requires selection of the most appropriate of the following sediment transport equations:

1. Meyer-Peter, Muller equation
2. Einstein bed load equation
3. Einstein suspended load methodology
4. Colby methodology

Reid and Dunne (1996) review a large number of sediment transport equations for suitability based on the number and accuracy of field verifications on different types of channel. They recommend the following applications (Table 11, p.100):

- Meyer-Peter/Muller model: gravel bedded and braided channels, and small sand bedded streams
- Einstein and Colby: medium and large sand bedded channels

3.2 VERIFICATION USING EROSION POTENTIAL METHOD

Erosion potential (Ep) is a measure of the change in the long-term, cumulative effective work done on the channel by hydraulic forces between a pre-project and post-project condition, which represents the change in sediment transport capacity. 'Effective work' is calculated based on the difference between the applied boundary shear stress and the critical shear stress of the boundary materials or bed sediments represented by the complete grain size distribution. The ratio between existing and proposed effective work or sediment transport capacity (Ep) is used to evaluate whether the designed channels will be stable under proposed flow conditions. The methodology uses continuous rainfall-runoff simulations in the EPA Storm Water Management Model (SWMM) for 31 years of available record. The resulting flow time series are applied to a sediment transport model to calculate Ep for a series of existing and proposed cross sections.

Proposed conditions are typically compared to the existing condition; however, for channel design where the existing condition is unstable, the baseline used for comparison is based on stable reference reach(es). When reduction in sediment supply is an important physical element in stable channel conditions, the target Ep is adjusted accordingly. When post-developed flows are increased and reductions in sediment supply are not important, the target ratio of existing and proposed Ep is set to 1.0. That is, the proposed design attempts to match the baseline conditions (i.e., the future sediment transport condition is equal to the existing sediment transport condition). When reduction in sediment supply is important, an equivalent reduction in the transport capacity is needed. For example, a project that reduces sediment supply to 30% of its baseline level requires the transport capacity to also be reduced to 30% of its baseline condition; i.e., Ep = 0.30.

A correlation between observed field conditions (channel stability) and predicted erosion potential for 49 cross-sections within four separate California watersheds showed that as the erosion potential begins to exceed the target by 20 to 30 percent, the probability of stream channel instabilities begins to increase rapidly (SCVURPPP, 2005). The Ep verification methodology therefore incorporates a risk-based approach that limits the variance in erosion potential to ±20% of the target, as the risk of hydromodification impacts is low in this range.

Table 2. Description of Ep Verification Method

	Verification Method - Geosyntec Application of the Erosion Potential Model
Inputs	Runoff from continuous rainfall-runoff model (SWMM) Reduction in sediment supply Bed particle size distribution, bank material type, vegetation density Existing and proposed channel geometry and longitudinal slope
Events Assessed	Continuous range of geomorphically significant flows
Approach	1. Compute work done and sediment load transported for existing geometry and flow conditions using range of sediment transport and work equations. Identify stable and unstable sections. 2. Scale target Ep based on reduction in sediment delivery (e.g., 40% reduction in sediment requires 40% reduction in E_p). Identify the appropriate baseline condition for comparison. 3. Calculate Ep for the proposed channel design at several cross sections. 4. Refine slope until future Ep does not deviate from the target Ep by more than ±20%.
Output	Slope of channel that is within 20% of target Ep, adjusted for sediment reduction.

3.3 VERIFICATION USING FIELD DATA AND SAM SIMULATIONS

3.3.1 Field Data

In addition to verification using the Ep method, we assess the proposed channel design using field data from the Newhall Ranch area. This check is performed to assess the geomorphic stability of the creek. Data on equilibrium slope were collected in Newhall Ranch by measuring channel gradient in stable channel reaches. These are often located immediately upstream of grade control structures. These were compared with watershed area, (used as a surrogate for channel forming discharge). Although the data have a low R^2 value reflecting scatter around a central regression line, they provide an *envelope* of actual observed field conditions from the creeks in question. While this envelope of data should not be, and is not, the sole basis for design, it is an important line of supportive evidence with which to verify the estimates provided by the sediment transport models that are also used in the analysis. When using sediment transport models it is important to back them up with as much additional field evidence as possible. The resulting plot is shown in Figure 2. A measure of stable channel gradient under post-development conditions can be determined by looking at the channel gradient of watersheds with the same runoff as the post development watershed. For example, as a first step approximation, a 1 square

mile watershed in which post-development runoff is doubled will lead channel slopes to adjust to a gradient appropriate to a 2 square mile watershed, assuming the same sediment delivery.

3.3.2 Sam Simulations

To compensate for reductions in sediment supply we performed a sensitivity analysis to determine the degree to which reductions in sediment supply affected equilibrium slope. We ran a series of simulations using the USACE Stable Channel Design Model SAM. In these simulations we simulated equilibrium slopes and then progressively cut back sediment delivery to calculate the resulting channel gradient adjustment. The resulting graphs (see Figure 3) allow us to calculate the equilibrium channel gradient for a watershed in which water flow has increased and sediment supply has decreased. We used this method as a check to ensure the channel designs were geomorphically-appropriate to the site.

Figure 2. Equilibrium Slope for Rural Reference Reaches

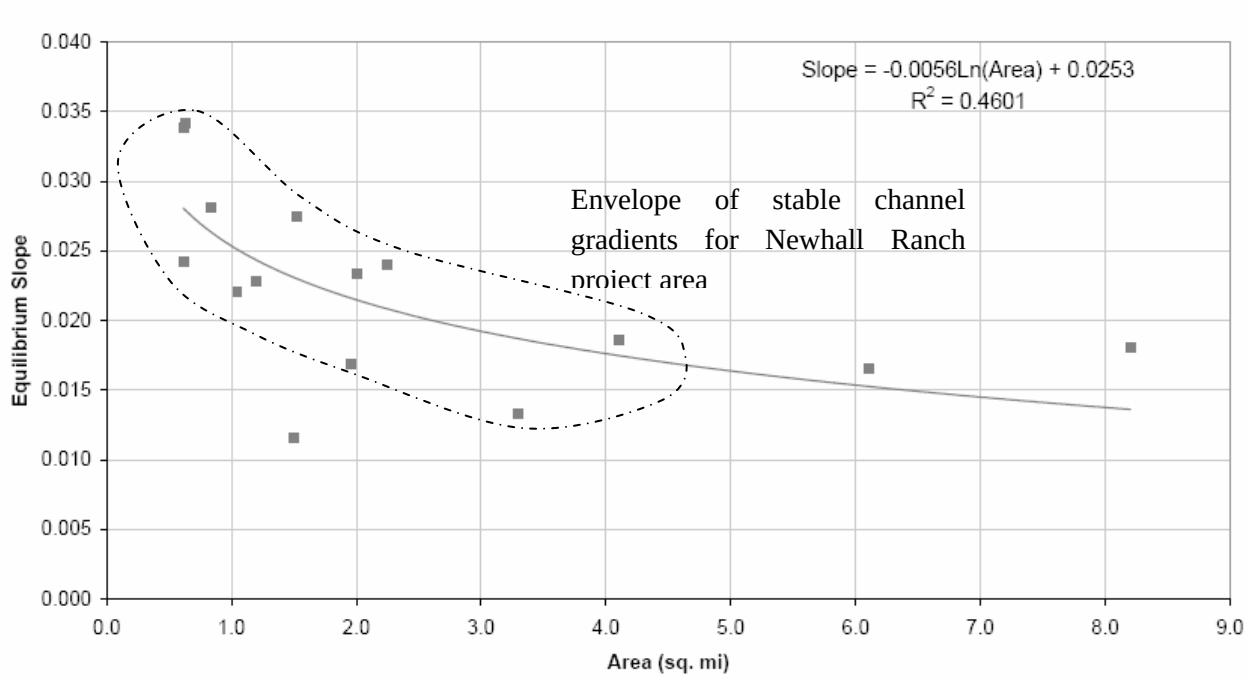
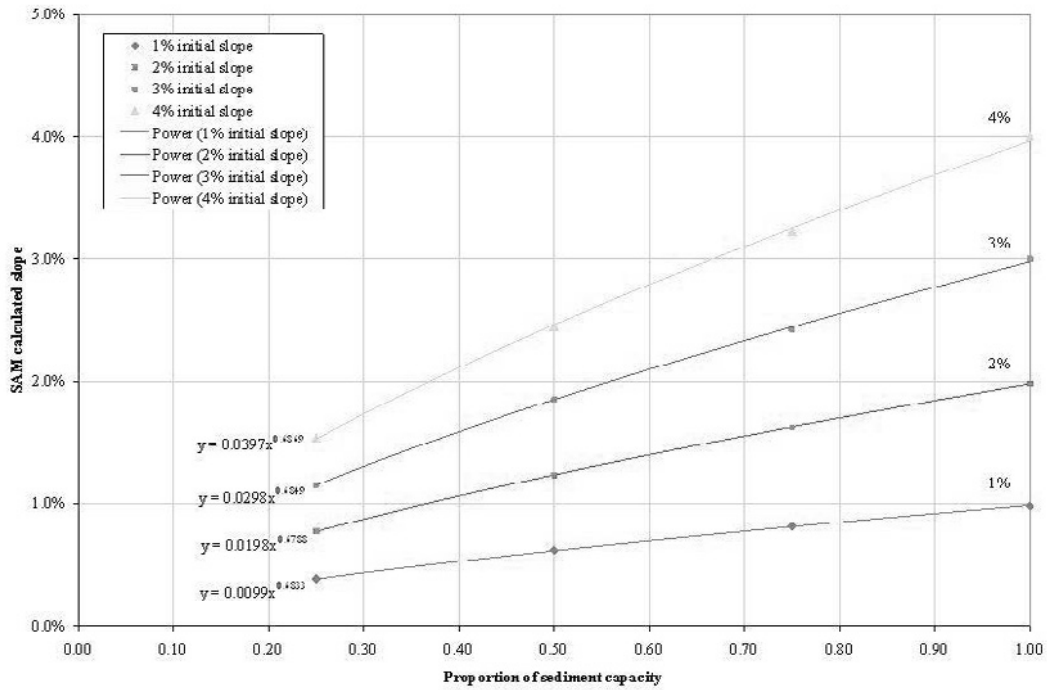


Figure 3. Sensitivity of Channel Slope to Reductions in Sediment Supply



3.4 SELECTION OF DESIGN CHANNEL SLOPE

Each of the above design approaches produces a slightly different estimate of stable slope. Based on these estimates, we will select a design slope that falls between the high and low end of the estimates. This slope will be tested using the Ep method and adjusted as necessary to meet the appropriate Ep standard. In general, this approach produces a relatively conservative estimate of the stable channel slope, to insure that stabilization structures are not undermined. In order to anticipate possible aggradation impacts on flood control performance, the highest of the previously estimated design slopes will be used to calculate potential channel sedimentation between drop structures, and hence flood capacity.

3.5 DESIGN SLOPE IMPLEMENTATION

Where extensive development will take place in the watershed and plans call for channel regrading (Long Canyon and Potrero Canyon), or where the existing channel is degraded and some development will take place in the watershed (Lion Canyon), step-pool design structures (described in Section 5) will be set at the selected channel slope.

Where channels are not degraded and less extensive development will take place in the watershed (San Martinez Grande Canyon and San Martinez Chiquito Canyon), grade control structures will be used to maintain the existing slope.

The north bank tributary channel design approach can be summarized as follows:

1) Develop existing condition floodplain and creek hydraulic characteristics. (HEC-RAS)

2) Minimize impacts to existing condition floodplain. As a result of reducing the development impacts to the floodplain, the amount of environmental and hydraulic impacts from the proposed development is minimized.

3) Creek bank flood protection (soil cement, rip rap or other suitable method) is located to provide for bank erosion protection and to provide flood protection from the LACDPW Capital design flood event. In most cases, the bank protection is buried with soil at a 3:1 slope over the hard bank protection. The soil backfill slope will vary from flatter to steeper and may be totally eliminated in some areas where necessary such as at structures, storm drain outlets or other pinch points.

4) The north bank tributary channels will not include a re-grading of the creek invert although the E_p of the proposed condition will be evaluated. For Grande and Chiquito, the invert stabilization method will be as follows:

    a. Creek bed Grade Control Structures (GCS) at 200 to 400 foot spacing along the creek corridor will be included.

    b. These GCS's will be (attempt to be) located at points along the creek where proposed project grading impacts will already be disturbing the creek bed and banks.

    c. The GCS's will be constructed with soil cement, rip rap or other grade stabilization methods acceptable to LACDPW.

    d. The GCS will be at grade or below the existing grade and invert of the creek bed.

    e. The GCS will be designed to function as a drop structure in the event the creek bed slope flattens overtime.

5) North bank tributary channel top and toe elevation will be established based upon LACDPW standards:

    a. Toe down Q_{CAP} and n=0.025, maximum velocity and Toe from design manual.

    b. Top Q_{CAP} and n=0.085, maximum water surface and freeboard from design manual.

The above two HEC-RAS models will be evaluated for the following project conditions:

- proposed creek invert profile with below-grade GCS's and,

- the theoretical E_p slope invert profile (note the GCS's will become drop structures with equilibrium slope predicted in the E_p analysis)

Based upon the results of the above HEC-RAS modeling, the most conservative values for Top and Toe of the bank protection will be determined using LACDPW design manual criteria.

The overall north bank tributary creek design approach will allow the creek to naturally fluctuate between the stabilized existing condition and estimated equilibrium slope while providing suitable erosion and flood protection for public safety. Based upon the proposed design and use of LACDPW standards for bank protection top and toe these northerly channels would meet the minimal required maintenance design objective provided by LACDPW.

4. CHANNEL WIDTH AND DEPTH

Channel width and depth are calculated using an empirical approach using local reference reaches (Coleman et. al. 2005), verified by an erosion potential assessment to ensure that the design meets the appropriate target erosion potential within the 20 percent threshold.

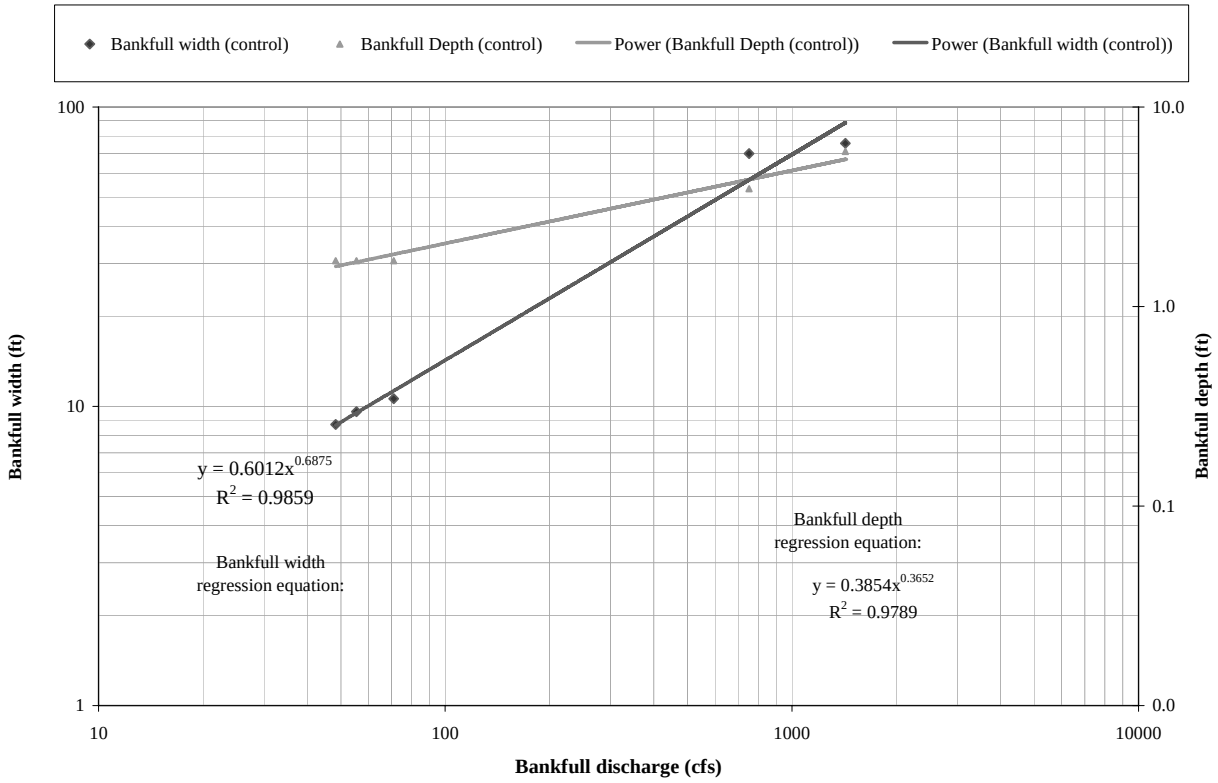
4.1 SOUTHERN CALIFORNIA FIELD REGRESSIONS

The Stormwater Monitoring Coalition (SMC) (Coleman et al., 2005) performed a geomorphic assessment of streams in disturbed and un-disturbed watersheds of Southern California. This study provides regional regressions between dominant discharge and channel geometry for Southern California stream channels, and identifies predictive relationships between changes in impervious cover and stream channel enlargement for use in stream management. Figure 4 shows predictive relationships between dominant discharge and bankfull width and depth based on the reference watersheds (undeveloped or very lightly developed) from the SMC study. We integrate the results from these channel systems with the estimates produced by other methods.

Table 3. Summary of Southern California Field Regressions

	Method 4 - SMC method
Inputs	Dominant discharge
Events Assessed	Bankfull discharge
Approach	Use regression equation from regional reference reaches to estimate channel width and depth
Output	Equilibrium width and depth of channel

Figure 4. Southern California Stream Morphology Relationships



Note: Plots derived from Coleman et al. (2005) Table 5.6. Data are only from control (undeveloped) sites

4.2 SELECTION OF A DESIGN CHANNEL WIDTH AND DEPTH

Following estimation of design parameters with the different methods, a proposed channel cross-section is selected which is likely to be most stable (falls between the high and low end of the estimates). The selected combinations of width, depth and slope are evaluated hydraulically to ensure that flow velocities are reasonable and unlikely to erode over the longer term.

5. STEP-POOL DESIGN

Where the slope estimation methods utilized predict that the proposed channel gradient will be considerably flatter than the existing gradient, drop structures and/or armored channels will be required to take up the elevation difference between the existing and proposed stable slopes. To maximize vegetation, aquatic, and wildlife habitat and maintain a natural channel appearance, a range of types of step-pool structures and armored riffles will be used to accommodate the drops in channel elevation. Construction of these structures will likely include large boulders, soil cement or concrete and will mimic natural step-pool function and morphology (as identified in reference reaches) in appearance and hydraulic function.

5.1 SELECTION OF MULTIPLE SMALL STEPS OR FEWER LARGE STEPS

Two approaches have been taken to controlling channel grade, to be used in different settings. Where the existing stream course and valley is going to be significantly altered by mass grading we consolidate drops into a smaller number of larger drops, to allow for greater lengths of non-armored channel between drops. Where the goal is preservation of existing channel habitat and little mass grading is proposed for the channel and floodplain area we use larger numbers of smaller drops (approx. height 3 feet) to control grade. Selection of these approaches is made based on the habitat value of the existing creek corridor and the infrastructure and mass grading needs of the surrounding development.

5.2 DESIGN PROCEDURE

The approximate initial step-pool dimensions are determined using the approach of Thomas et. al. (2000). Once the approximate structure dimensions are determined, this initial dimension is then tested using HEC-RAS to optimize the height of the step, gradient of the ramp, depth and width of pool and elevation of the apron/tail water. HEC-RAS flow estimates are also used to develop flow discharge per unit width for sizing rock to be used in the grade control structures or for bank protection. The detailed analysis and final design for the step-pool structures will be described in final design technical memorandums.

5.3 GRADE CONTROL CONCEPTS

The types of step-pool structures and armored riffles that would be used to accommodate drops in channel elevation are described below and illustrated in Attachment A.

5.3.1 Grouted Sloping Boulder (GSB) Drop

Boulders, typically 24-inch minimum in all directions, would be placed on the face of the grade control structure, the crest, the lower part of the side slopes, and the stilling basin. Twelve inches of grout would be placed at the bottom 30-50% depth of the boulders to lock them together. Typical vertical drop heights for this type of grade control structure may be greater than 3 feet and are proposed at up to 15 vertical

feet. The structure length and width varies depending on the design flow; typical structure dimensions may be 100 feet long by 60 feet wide. Planted riprap would be placed along the approach, in the upper voids of the boulders, along the upper banks, and downstream of the stilling basin (lay down toe). Seepage control would consist of a metal or vinyl sheet pile across the width of the structure and weep drains that daylight through the grouted boulders.

5.3.2 Soil Cement Grade Control Structure

On-site sandy soils will be combined with adequate cement to form a soil cement mixture that when placed mimics the sandstone outcrops in the area. Facings and lateral protection will be built by constructing the soil cement slope protection in successive horizontal layers (6-10 inches thick). Facing slopes can be steeper than GSB Drops with the steepest recommendation at nearly 0.5:1 (H:V); constructed by setting back subsequent lifts. Typical vertical drop heights for this type of grade control structure may be greater than 3 feet and are proposed at up to 15 vertical feet. The structures in some locations will be combined to make up vertical grades exceeding 15 feet which is acceptable given adequate geotechnical and structural design. The structure length and width varies depending on the design flow; typical structure dimensions may be 80 feet long by 80 feet wide. Planted riprap would be placed along the approach, in the approach at the crest, along the upper banks, and downstream of the stilling basin (lay down toe). Soil cement would be mixed on-site, placed, compacted, finished and cured resulting in a strong durable, erosion-resistant material with low permeability. Seepage control would consist of a metal or vinyl sheet pile across the width of the structure and weep drains that daylight through the soil-cement lifts.

5.3.3 Sculpted Concrete Drop Structure

Colored, poured and shaped concrete will be molded to form an aesthetic modification to the grouted sloping boulder style of drop. Design of for these drops will be conducted individually but similar to the GSB Drop. Construction is typically conducted with a single monolithic full-depth pour or using a two pour system over steel reinforcement then contoured and textured to finish. Planting wells may be considered to help revegetate and conceal the structure. Facing slopes are roughly similar to GSB Drops with the steepest recommendation at nearly 3:1 (H:V). Typical vertical drop heights for this type of grade control structure may be greater than 3 feet and are proposed at up to 15 vertical feet. The structures in some locations will be combined to make up vertical grades exceeding 15 feet which is acceptable given adequate geotechnical and structural design. The structure length and width varies depending on the design flow; typical structure dimensions may be 100 feet long by 80 feet wide. Planted riprap would be placed along the approach, in the approach at the crest, along the upper banks, and downstream of the stilling basin (lay down toe). Seepage control, where necessary, could consist of a metal or vinyl sheet pile across the width of the structure and weep drains that daylight through the poured grout mixture.

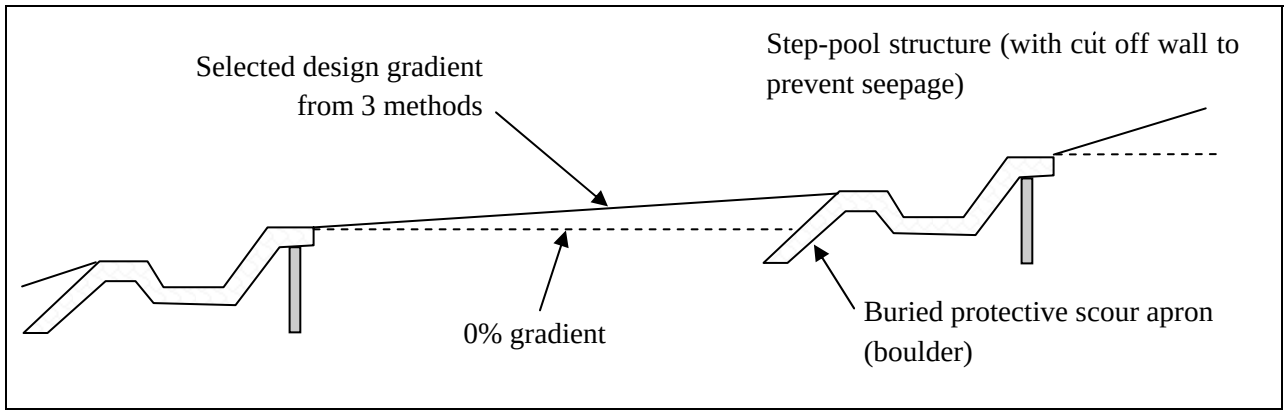
5.3.4 Non-Grouted Boulder Step-Pool

Boulders, comprised of various sizes between 24-inch and 36-inch minimum in all directions, would be placed on the face of the step-pool structure, the crest, the lower part of the side slopes, and pool. The sub-base of the structure will be adequately designed using a mixture of compacted soil and riprap. The boulders would be individually placed and chinked to lock them together. Plants will also be used to prevent boulders from dislodging. The crest boulders would be placed on top of a metal or vinyl sheet pile wall and grouted to the buried check wall to form the crest. The check wall would extend to the width of the floodplain corridor and will be notched at the step-pool structure. While the structure will be designed to be stable at Qcap, the capacity of the non-grouted boulder step-pool will be designed for less than Qcap and have typical dimensions of roughly 50 feet by 50 feet, with excess water passing onto the floodplain as dispersed flow. Planted riprap would be placed along the approach, in the upper voids of the boulders, along the upper banks, and downstream of the pool.

5.3.5 Grade Control Scour Apron

Grade control structures would include a buried toe scour apron made of appropriately sized rock on the downstream end of the step-pool structure to accommodate the most conservative slope assumptions (i.e., assume that a 0% slope develops) to insure that the structures will still have integrity and channel downcutting will be prevented (see Figure 5 below). The designs will also include intermittent buried rock sills across the floodplain to protect from erosion or outflanking of the step pools. For a typical design of 1% channel gradient and structures every 100 feet, the worst case scenario (adjustment of the channel to zero gradient) would be 12 inches of toe erosion on each structure.

Figure 5. Conceptual Sketch of Step-pool Structures Showing Relationship Between Design Gradient and Lowest Predicted Gradient



6. CHANNEL MIGRATION

Where feasible, many reaches of channel that will be either restored or designed for Newhall Ranch will have some degree of natural geomorphic dynamic function, including a limited ability to meander and laterally migrate within proscribed limits. A design standard has been developed to assess and constrain the potential for the constructed or restored channels to migrate laterally into the toe of the valley side, without putting adjacent development at risk from bank erosion. The method is based on the observation that for given geomorphic settings stream channels have a maximum sinuosity above which they avulse to a straighter course. By forcing the channel to occupy the middle of the floodplain at set spacings we can prevent the outside of a meander bend from reaching the edge of the floodplain (and eroding the corridor banks). The method uses predictions of the upper sinuosity and calculations of the location of a meander bend in response to a given sinuosity.

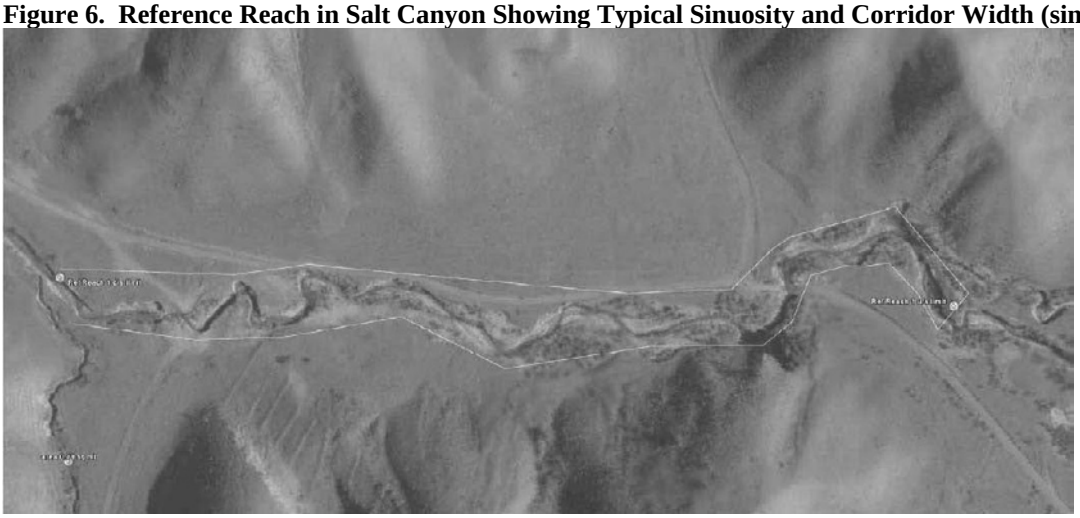
6.1 PREDICTING CHANNEL MIGRATION

We have integrated the variables which control migration into an analytic model of meandering to calculate the maximum appropriate spacing between fixed channel control points to avoid a channel migrating into the edge of a floodplain of given width.

6.1.1 Maximum Safe Spacing Allowed Between Fixed Points to Avoid Migration into the Floodplain Edge

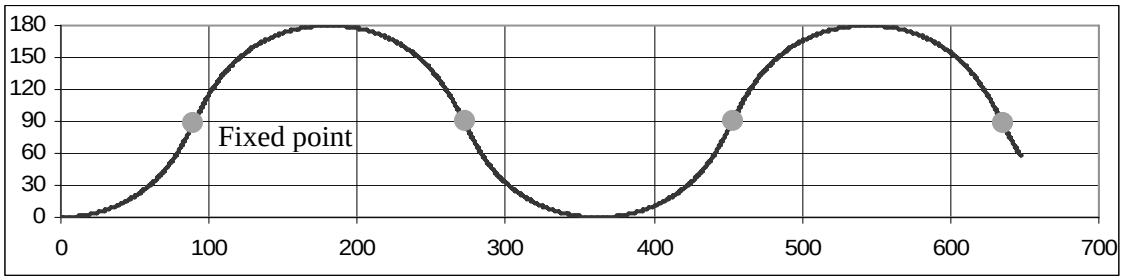
Meanders are often modeled as sine generated curves (see for example Dunne and Leopold, 1978). A series of sine generated curves were created with different amplitudes (corresponding to the range of valley floodplain widths proposed for Newhall Ranch). Sinuosity was set at 1.5, which is the highest sinuosity observed on any stream in the vicinity of Newhall Ranch (found on a reach of Salt Canyon with a valley floor of 1.3% and a watershed area of 8 square miles).

Figure 6. Reference Reach in Salt Canyon Showing Typical Sinuosity and Corridor Width (sinuosity of 1.3)



An example plot from the analytical model is shown below, for a corridor width of 180 feet: With a 180 foot wide corridor, the fixed points should be spaced within 180 feet of each other to such that if the channel migrates to the floodplain edge, it will form a cut-off and move back towards the centerline.

Figure 7. Example Model Output



This relationship was used to determine the appropriate spacing for structures for various sinuosity and corridor width combinations. For a sinuosity of 1.5 (a conservative upper value) a fixed point is required once every floodplain width.

6.2 PROJECT APPLICATION

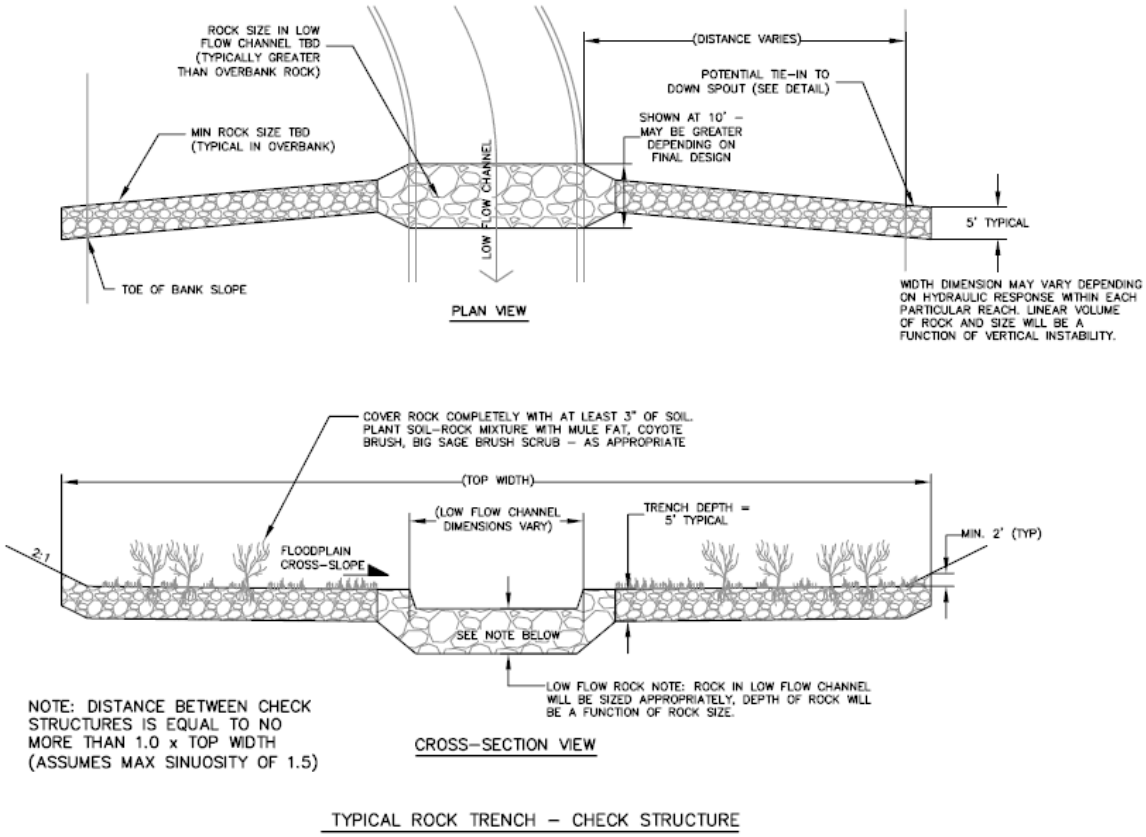
In most locations along the canyons where small drop structures are proposed, the proposed GCS spacing is less than the predicted minimum required spacing, and the risk of channel migration is low. Where the floodplain narrows (near channel culverts and location where detention basins confine the floodplain) we propose the use of floodplain toe armor (rock or comparable protection).

Several portions of the canyons have longer reaches without step-pool structures, where channel migration could reach the floodplain edge if unconstrained. We will use one of two approaches in these cases:

1. Construct channel training structures that force the channel to occupy the middle of the valley floor. Structures will be located with spacing equal to one floodplain floor width. Training structures will be buried rock-filled trenches as shown in Figure 8.

2. Construct slope toe protection along the floodplain edge (see Figure 9).

Figure 8. Typical Detail for Channel Training Structure



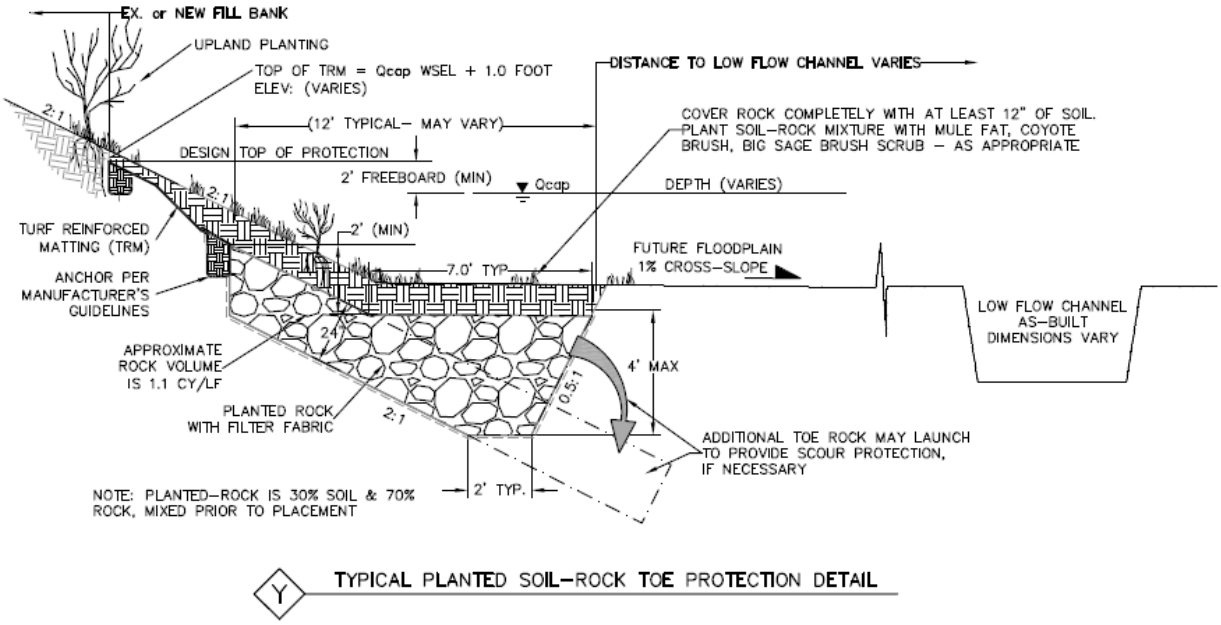
7. BANK PROTECTION

The canyon stabilization plan is based on the establishment of stable stream slopes which will reduce velocities and thus erosion potential. With the stream profile controlled, bank erosion can be mitigated and future impacts due to development minimized.

7.1 TOE PROTECTION ALTERNATIVES

The selected bank improvements are designed to minimize environmental impacts, mitigate impacts, and preserve the character of the existing canyons where possible. Since grade stabilization will minimize streambed lowering, will reduce velocities and shear stresses, and will improve hydraulic stability, the potential for bank erosion and undercutting will be reduced. It is anticipated that the improved hydraulic response of the channel will result in a reduction in the level of bank protection required and allow selection of a lower-impact toe protection method (see **Error! Reference source not found.**9 below).

Figure 9. Typical Cross-Section Detail for Planted Soil-Rock Toe Protection



Toe protection will be located at newly constructed banks, areas where infrastructure, homes, structures, are proposed, and areas where significant lateral channel movement is expected. Toe protection will be designed as a permanent, continuous treatment that will protect from cut-bank scalloping, under-cutting, or bank failure caused by the lateral migration of the low flow channel or localized scour. Rock placement

along the toe of slope will be wide enough to provide maximum protection from migration of the low flow channel and is designed to launch as needed to protect the bank from localized scour.

The following Table provides a description of the various permanent bank and toe protection alternatives and establishes the application criteria for their use.

Table 4. Bank Protection Alternatives and Application Criteria

Permanent Bank and Toe Protection (Longitudinal)	Min Side Slope (H:V)	Permissible Shear Stress (lbs/SF)	Permissible Velocity* (fps)	Hydraulic Requirement (Moisture regime)
VEGETATION				Low to Moderate
Vegetation – Short Native Grass	3:1	0.7 – 0.95	3.0	mesic/xeric
Vegetation – Long Native Grass	3:1	1.2 – 1.7	4.0	mesic/xeric
Vegetation - Shrubs	2:1	1.5 – 3.0	5.0 - 7.0	mesic/xeric
VEGETATION WITH REINFORCEMENT				
Turf Reinforced Matting	2:1	3.0 - 4.5	7.0	Low
ROCK WITH VEGETATION				
Planted-Rock 6-in D50	2:1	2.5	5.0 - 7.0	Varies - Plant Dependent
Planted-Rock 9-in D50	2:1	3.8	7.0 - 11.0	Varies - Plant Dependent
Planted-Rock 12-in D50	2:1	5.1	10.0 - 13.0	Varies - Plant Dependent
Planted-Rock 18-in D50	2:1	7.6	12.0 - 16.0	Varies - Plant Dependent
Placed Rock / Boulders 24-in +	2:1	7.6 – 10.0	15+	Varies - Plant Dependent
Stacked Planted Boulders	1.5:1	8.0 – 11.0	15+	Varies - Plant Dependent
STRUCTURAL				Plant Dependent
Soil Cement	0.5:1	11.0 +	15+	N/A
Cribwalls, Vegetated	0:1	12.0 +	15+	Varies - Plant Dependent
Stacked Grouted Boulders	0.5:1	12 +	15+	N/A

*Velocities shown are guidelines only – refer to Chart C-10 in Appendix C of the LACDPW Sedimentation Manual

7.2 BANK PROTECTION SELECTION PROCEDURE

Results from proposed conditions hydraulic analysis will be used to determine the shear stress and velocity along the subject reach. Where shear stress is determined to exceed the natural resistance of the channel banks, bank protection will be required. Bank protection will be selected by comparing the

predicted bank erosion shear with the bank protection application criteria in Table 4. We will use the following steps to determine what type of bank protection is required:

a. Toe protection shall be, at a minimum, assessed for the following channel conditions:

- At bends,
- In areas of fill,
- At contractions and expansions,
- Along maintenance roads,
- Where the low flow channel is adjacent to the corridor edge, and
- Where corridor side slopes are steeper than 2:1 (Note: At this stage all side slopes are assumed to be 2:1 or flatter).

b. Toe protection shall be required to mitigate for hydraulic conditions that do not meet the established hydraulic criteria;

1. Typical Cross-Section Detail for Planted Soil-Rock Toe Protection (Figure 9) shall be used to design toe protection based on channel geometry and hydraulic characteristics.
2. Use the application criteria to estimate rock size based on permissible shear stress (Table 4) and permissible velocity using Chart C-10 of Appendix C of the LA County sedimentation manual.

c. Toe protection shall be required downstream of storm outfalls or down drains and continue to the next downstream grade control structure;

d. Toe protection shall not be required in natural channels or modified channels that provide a succession of grade control or check structures that will prevent the lateral movement of the low flow channel into the banks – based on a geomorphic assessment of the potential sinuosity of the stable channel (see section 7);

e. Toe protection shall not be required when the Qcap floodplain does not intersect above the toe of the channel bank.

f. If hydraulic criteria for the proposed biotechnical slope protection measures are not met, revise channel characteristics, grade control selection or select a structural bank protection method using grouted stacked boulders, soil cement, riprap lined channel or other LA County bank protection method (LACFCD 1982).

8. HYDRAULIC CRITERIA

This section describes hydraulic criteria for the design of natural channels utilizing grade control alternatives described in subsequent sections to achieve stable channel slope. Once the initial channel design and step-pool design is completed, the channel configuration is evaluated for stability and hydraulic performance using HEC-RAS. HEC-RAS is used to assess the channel, floodplain and steps at a range of flow conditions to determine:

- Final design of step-pools
- Rock sizing
- Compliance with LACDPW freeboard requirements (3 feet during Qcap)
- Compliance with established hydraulic criteria
- Sufficient dissipation of energy by step structures during high flow events
- Non-erosive velocities on floodplain and along constructed slopes

Initially, individual step-pools will be modeled through a range of flows to optimize hydraulic design. Sequences of steps are then added to the model to simulate proposed conditions throughout the project reach.

8.1 HYDRAULIC ANALYSIS

The design procedure currently uses a one-dimensional hydraulic model (HEC-RAS) to evaluate hydraulic criteria. The model is used to characterize existing conditions and to examine the function and capacity for grade control to meet the defined hydraulic criteria for future channel conditions (post-project).

A model of the existing channel conditions is used to establish the baseline hydraulic performance. The Existing Conditions model must adequately represent existing (pre-project) topographic and hydrologic conditions.

Use the Existing Conditions model to:

- Determine the hydraulic response of the existing conditions capital flood (existing Q_{cap}) and 25% of the capital flood existing ($0.25Q_{cap}$).
- Determine the hydraulic response of the proposed conditions capital flood (proposed Q_{cap}) and 25% of the capital flood (proposed $0.25Q_{cap}$).
- Identify extent of the existing 100-year floodplain and elevation of the flood profile.

The Existing Conditions model is then modified to reflect and test channel design alternatives for their ability to satisfy the hydraulic design criteria. Simulation scenarios are summarized in Table 5.

- Revise the existing conditions model for at least two representative channel reaches to test the various grade control options (see Section 2).
- Estimate dimensions and spacing for grade control structures
- If applicable, estimate dimensions of low-flow channel to (1) contain proposed conditions Q_2 flows in low-flow channel, (2) allow floodplain activation during flows > Q_2 in compound channel section.
- Develop Proposed Conditions model using grade control dimensions and spacing and design channel section estimated above.
- Run Proposed Conditions model for Q_2 , $0.25Q_{cap}$, and Q_{cap}.
- Check model results against hydraulic criteria in Table 4.

Table 5. Model Simulation Scenarios

Simulation	Land Use	Comments
Existing Conditions	Current	Existing channel geometry with Existing Conditions Flow rates
Existing Conditions (Manning's "n" Sensitivity Test)	Current	Existing channel geometry with Existing Conditions Flow rates. Increased roughness to account for flow resistance due to sediment transport of the bed load and floodplain resistance
No channel Improvements	Post-Project	Existing channel geometry with Proposed Conditions Flow rates
Conceptual Channel Improvements	Post-Project	Proposed conditions channel geometry for 2 typical reaches (A and B). Grade Control Structures located within the two reaches
Preliminary Channel Improvements	Post-Project	Proposed conditions channel geometry with selected Grade Control structures.

9. MONITORING AND MAINTENANCE OF THE CHANNEL

A monitoring and maintenance plan is being prepared as part of the project EIR/EIS, and will be attached to this Basis of Design document on completion.

10. ACCESS REQUIREMENTS

The property ownership underlying the channel will be either by HOA, environmental stewardship organization such as Center for Natural Land Management or a quasi-governmental organization such as a Geologic Hazard Abatement District (GHAD). Access to the facilities that may need maintenance or observation will be provided through easements granted to Flood Control. Newhall Land has had several discussions with Flood Maintenance as to the type and need for maintenance access to this type of channel design. Details will be shown as part of the project-level analyses and plans.

11. REFERENCES

Coleman, D., MacRae, C., Stein, E.D. (2005). Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams – Southern California Coastal Water Research Project Technical Report 450.

Geosyntec (2006) Flow frequencies and work curves for Lion Canyon

LACFCD, (1982). Design Manual, Hydraulic, Los Angeles County Flood Control District, March, 1982.

Los Angeles County of Public Works. (2006). Sedimentation Manual. 2nd Edition.

LADPW, (2006). Hydrology Manual, Los Angeles County Department of Public Works, Alhambra, California, December 1971, revised 2006.

Ponce, V. M. (2001). Colby (1964) Sediment Transport Online Calculator. http://octavian.sdsu.edu /~ponce/colby/colbyform.html

Reid, L. M. and T. Dunne, (1996). Rapid Evaluation of Sediment Budgets. GeoEcology Paperback. Catena Verlag Gmbh. 164 p.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), (2005). Hydromodification Management Plan. Prepared by Geosyntec Consultants for the Santa Clara Valley Urban Runoff Pollution Prevention Program. April 21, 2005.

Thomas D. B., Abt, S. R., Mussetter, R. A, and Harvey, M. D. (2000). A Design Procedure for Sizing Step-Pool Structures. Joint Conference on Water Resource Engineering and Water Resources Planning and Management 2000

Thomas, William, and Gee, D. M. (2005). Sedimentation in Stream Networks (HEC-6T) – Supplement to the User Manual. 36 p.

US Army Corps of Engineers. (2004). HEC-RAS and SAM Software. Version 3.1.2.

ATTACHMENTS