Workplan for Geomorphological Monitoring and Management Program

Newhall Ranch
Santa Clara River Watershed

Project No. 31090185.0100

Cardno ENTRIX
Shaping the Future

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Acronyms

cfs	cubic feet per second
DEM	digital elevation model
LAWRQCB	Los Angeles Regional Water Quality Control Board
LiDAR	Light detection and ranging
mm	millimeter
msl	mean sea level
QA	quality assurance
QC	Quality control
RMDP	Management and Development Plan
SCP	Spineflower Conservation Plan
WDR	Waste Discharge Requirement

1 Introduction

This workplan for the Geomorphological Monitoring and Management Program (Workplan) has been prepared on behalf of Newhall Land to comply with Condition 27 of the Waste Discharge Requirement (WDR) issued by the Los Angeles Regional Water Quality Control Board (LARWQCB) on September 14, 2012.

Condition 27 of the WDR was developed to address this concern and specifically requires the following:

> *"Newhall Land shall prepare a Geomorphological Monitoring and Management Program (Downstream Effects Monitoring Program) to specifically analyze downstream effects within the Santa Clara River (downstream of project tributaries and in reaches between project tributaries). Newhall Land shall utilize the services of an experienced geomorphologist with expertise in flashy and sandy rivers like the Santa Clara River to prepare the Geomorphological Monitoring and Management Program plan within six (6) months of the effective date of this Order for Executive Officer approval. The monitoring program shall at a minimum, perform annual monitoring to analyze river contours, elevations, aggradation and erosion, and any downstream impairments or changes to the Santa Clara River flow regimes as a result of the RDMP. The plan shall also identify triggers or geomorphological change action levels and identify the additional actions and schedule which Newhall Land will take if action levels are exceeded."*

In accordance with Condition 27, the Geomorphological Monitoring and Management Program (Monitoring and Management Program) was prepared under the guidance of Dr. Daniel Tormey, an experienced geomorphologist with expertise in flashy and sandy rivers, including extensive study of the Santa Clara River. Dr. Tormey's qualifications are provided in Appendix A.

The RMDP/SCP Project Area (Project Area) includes the Santa Clara River, which flows westward from northern Los Angeles County through Ventura County to the Pacific Ocean near Oxnard, California, as shown on Figure 1. This Monitoring and Management Program consists of areas upstream, within, and downstream of the Project Area (Study Area) as shown on Figure 2 and includes the following three elements:

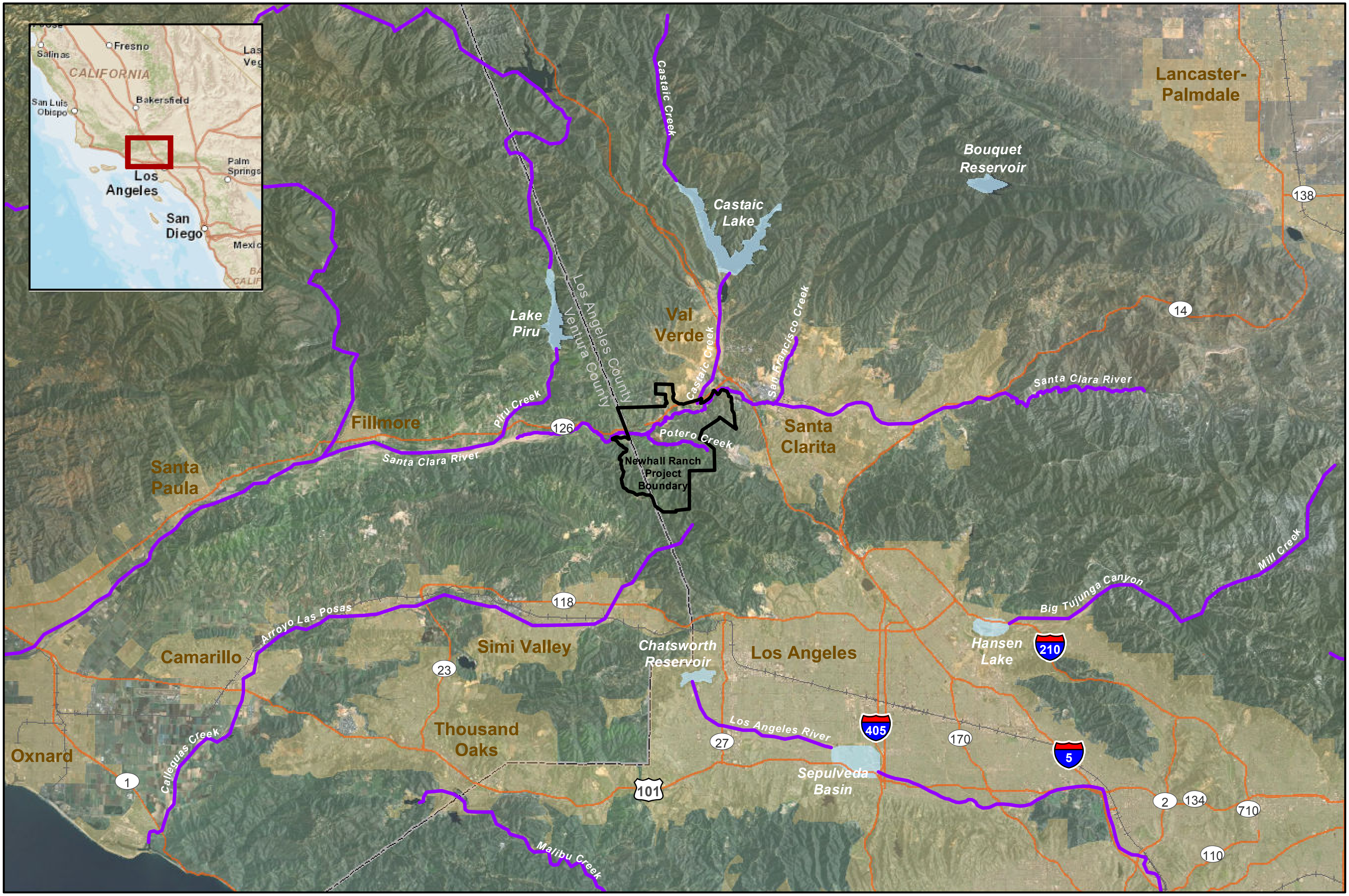
> **Establishment of Baseline Conditions.** Baseline conditions will be established that reflect the historic range in natural variation of the Santa Clara River within the Study Area including changes to topography, aggradation and erosion, and any downstream impairments and flow conditions. Baseline Conditions will be compared to the results of annual geomorphic monitoring and analyzed to determine if triggers or geomorphological changes actions levels are exceeded.

> **Annual Geomorphic Monitoring.** This element consists of performing annual monitoring of specified geomorphic indices, including topography, aggradation and erosion within the Study Area.

> **Additional Action (if warranted).** This element consists of identifying triggers or geomorphological change action levels based on observed changes to Baseline Conditions caused by the development of the Newhall Ranch Resource Management and Development Plan (RMDP) and identifying the additional actions and schedule for the additional actions which Newhall Land will take if triggers of action levels are exceeded.

The remainder of the Workplan is organized as follows:

- **Chapter 2** provides a description of the Project Area and an overview of the geology, hydrology, and geomorphology of the Santa Clara River Watershed;
- **Chapter 3** discusses the Study Area, scope of work and methods for the Monitoring and Management Program;
- **Chapter 4** outlines the Quality Assurance and Quality Control Plan; and
- **Chapter 5** provides a list of references.



Legend

- Stream/River
- Highways
- Urban Areas
- Project Boundary
- County Boundary

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NEWHALL RANCH
GEOMORPHOLOGICAL MONITORING AND MANAGEMENT

Figure 1 | Regional Location Map

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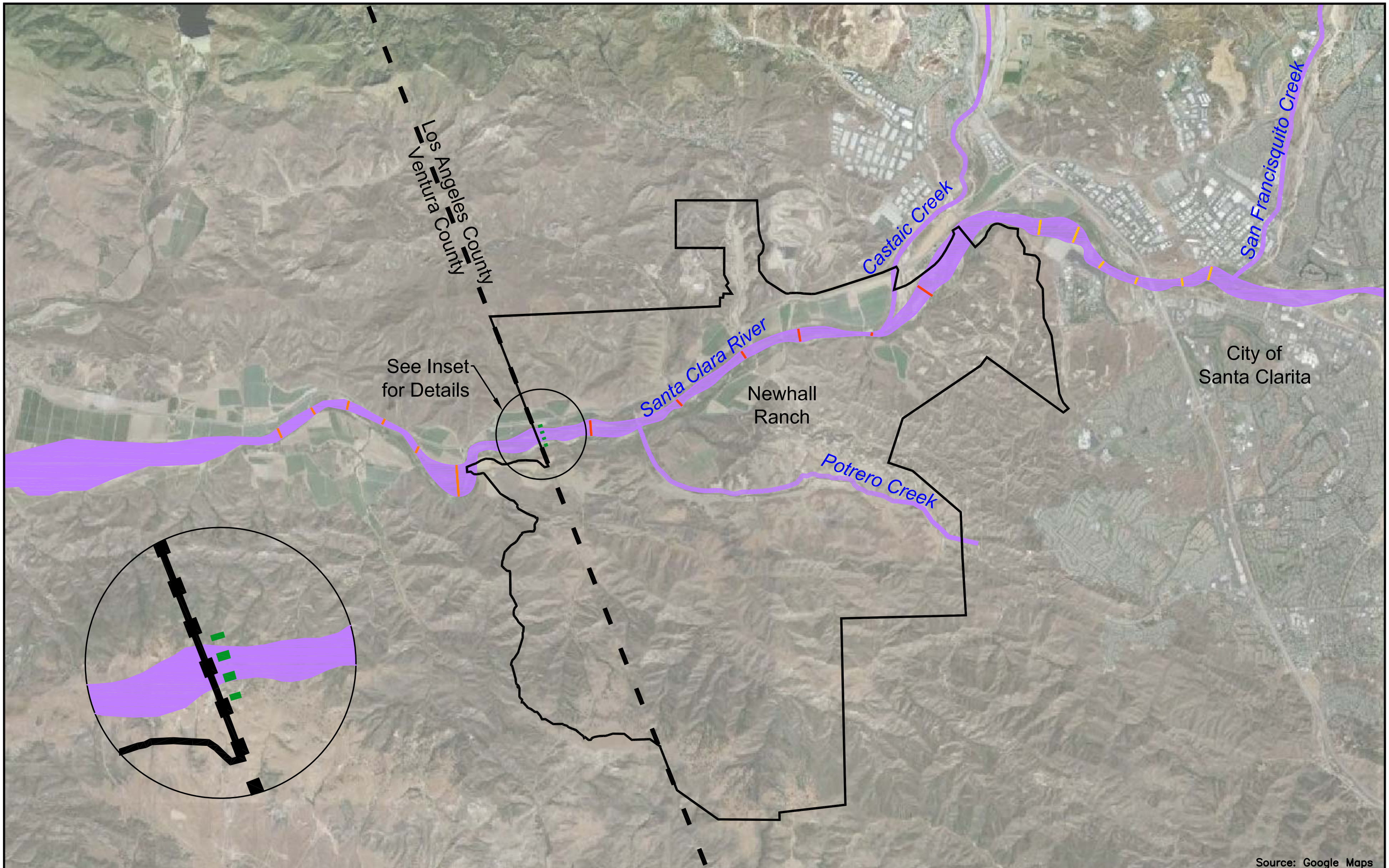

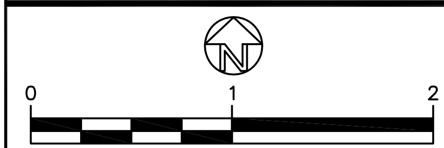

LEGEND

- Project Boundary
- Los Angeles–Ventura County Line
- Creek/River
- Approximate Location of Historic Cross–Section
- Potential Downstream Sampling Location
- Potential Project Reach Sampling Location
- Potential Upstream Sampling Location

Note: Sampling locations are approximate and subject to change.

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Geomorphological Monitoring and Management Study Area Map

Newhall Ranch

Scale 1:1	PROJECT No.	Figure No.	DATE
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2 Description of Project Area and Santa Clara River Watershed

This chapter provides a description of the physical setting of the Project Area including the geology, hydrology, and geomorphology of the Santa Clara River.

2.1 Newhall Ranch Specific Plan Area

The Newhall Ranch Specific Plan Project Area is located within northwestern Los Angeles County, between the city of Santa Clarita to the east and the Los Angeles County/Ventura County line to the west (Figure 1). The Project Area consists of approximately 19 square miles and the developed portion will encompass approximately 8.5 square miles. The Project includes commercial and residential development as well as the establishment of several conservation areas to preserve and protect sensitive biological resources within the Project Area. The Project Area is a subset of the Study Area shown on Figure 2. Figure 2 includes upstream and downstream areas and also shows tributary reaches within the Study Area.

2.2 Study Area

The Study Area consists of three study reaches, as follows:

> Upstream Reach – The upstream reach extends from Castaic Creek upstream to approximately San Fransiquito Creek and will be used to monitor conditions upstream of the Project;

> Project Reach – The Project reach situated between the upstream and downstream ends of the proposed Project development to characterize and monitor conditions within the Project area; and

> Downstream Reach – The downstream reach situated between the downstream end of the Project reach and approximately 4 miles downstream to characterize and monitor conditions downstream of the Project.

The exact boundaries of the Study Area will be defined during the first phase of the Monitoring and Management Program. The Study Area and associated reaches are shown in Figure 2.

2.3 Santa Clara River Watershed

2.3.1 Overview

The Santa Clara River Watershed encompasses 1,626 square miles in Ventura and Los Angeles counties and flows approximately 83 miles from its headwaters in the northwestern San Gabriel Mountains to the Pacific Ocean near Oxnard, California. The watershed ranges in elevation from sea level to 8,832 feet above mean sea level (msl), and is one of the largest watersheds in Southern California. Major tributaries to the Santa Clara River include Santa Paula Creek, Sespe Creek, Hopper Creek, Piru Creek, Castaic Creek, San Francisquito Canyon Creek, and Bouquet Canyon Creek as well as several barrancas and ephemeral creeks. The watershed also includes several dams that serve to modify the natural flow regime. These dams consist of Santa Felicia Dam and Pyramid Dam on Piru Creek, Castaic Dam on Castaic Creek, and Bouquet Canyon Dam on Bouquet Canyon Creek. The presence and operations of these dams is a feature of the Baseline Condition.

2.3.2 Climate and Precipitation

The Santa Clara River is situated in a Mediterranean climate characterized by hot, dry summers and variably wet winters, with the majority of precipitation falling between November and March. As such, the

Santa Clara River and its tributaries experience high annual flow variability, including extreme seasonal flooding and multi-year droughts. The climate and precipitation is a feature of the Baseline Condition.

2.3.3 Geology and Soils

The Santa Clara River watershed is located within the Transverse Ranges Province of California which consists of major ridges and intervening valleys that trend east-west as opposed to the northwest-southeast trend of the surrounding Coast and Peninsular Ranges (Stillwater Sciences 2011). The Transverse Ranges are relatively young in geological terms and are tectonically active with recent uplift and erosion. The geology of the watershed consists of areas of highly erodible and highly resistant formations, resulting in broad alluvial sub-basins alternating with areas of incised bedrock (USGS 1968).

Due to the active seismicity in the region, highly deformed, fractured, and faulted rock types are found across the watershed – specifically, a mixture of geologically old igneous and metamorphic rocks (granite, anorthosite, and schist) and younger sedimentary and volcanic rocks (claystone, sandstone, conglomerate, volcaniclastic sediments). The igneous and metamorphic bedrock group is primarily situated in the uplands of the northern and eastern portions of the watershed, while the sedimentary bedrocks are found in and around the Santa Clarita Basin and the Santa Clara River Valley. Taken together, the relatively young and erodible sedimentary rocks that are subject to fractures, deformation, and faulting make these units especially susceptible to land sliding and erosion (Stillwater Sciences 2007). The geology and soils are a feature of the Baseline Condition.

2.3.4 Hydrology

The hydrology of the Santa Clara River watershed is characterized as flashy with highly variable and episodic flows. The watershed experiences highly variable annual rainfall and stream flows that, during the rainy season, can increase, peak, and subside rapidly. Severe flooding can occur during saturated or near-saturated watershed conditions and the flow can vary from a continuous base flow to the ocean in wet years to disconnected flow in dry years. During the dry season, flows along the river are intermittent, supported by wastewater treatment plant effluent or in some reaches flow is absent. Winter flows within the Santa Clara River watershed vary according to decadal-scale patterns of wet and dry periods. Between 1953 and 1996, annual flow at the Los Angeles/Ventura County line gage ranged between 253,000 acre-feet in 1969 and 561 acre-feet in 1961. Peak daily flows during the same time period ranged from 68,800 cfs in 1969 to 109 cfs in 1960.

Stream flows also vary due to anthropogenic sources (i.e. dam releases on Piru and Castaic creeks) or areas of rising groundwater (Stillwater Sciences 2011). Artificial stream flows in the Project Area are derived from runoff from agricultural fields, discharges of treated effluent from two existing water reclamation plants, and releases from Castaic Lake and Lake Piru. The amount and seasonality of this runoff are variable. The hydrology is a feature of the Baseline Condition.

2.3.5 Geomorphology

The Santa Clara River is characterized by high sediment loads, high bank erodibility (due primarily to flow impinging upon the banks), and intense and intermittent flows. The river morphology primarily consists of braided channels that migrate laterally within the floodplain margins. The river within the Project Area is relatively flat with slopes ranging from 0.5 to 5%, and the streambed substrate primarily consists of non-cohesive sands. While some gravels and cobbles occur within the channel, most of the sediment moved by the Santa Clara River is fine material, with less than 5 percent of transported material being greater than 0.25 millimeters in diameter (Brown and Hecht 2005).

Extreme events dominate the sediment transport processes in the Santa Clara River, with the majority of the discharge occurring during high-intensity low-recurrence storm events (Williams 1979, Stillwater 2008). Analysis of long-term channel adjustment indicates that riverbed degradation is more prevalent in the upstream portion of the Project Area while the downstream portion appears to be more stable or fluctuating around a mean elevation. This result is likely due to the relatively steep, confined areas within upper part of the Project Area and the relatively flat, wide, and braided nature of the river in the downstream portion of the Project Area (USACE 2010).

The morphology, stability and character of the Santa Clara River are largely determined by “reset” events caused by large precipitation events that occur in the watershed every 10-15 years. A “reset” event refer refers to the effects of large storm events on the stability of a local channel geomorphology and riparian vegetation. The channel generally maintains a constant planform during drier years, while large storm events can significantly modify the channel. The channel does not maintain the typical riffle-pool sequence of the standard alluvial river, as high flows result in significant shifts in planform and channel cross-section (Stillwater 2008). In the Santa Clara River, the “re-set” event is related to the 10-year recurrence interval flow; that is a flow that has a probability of occurring once every 10 years. Table 1 shows the average flows for storm events of different recurrence intervals at the upstream end of the Project area under existing conditions.

Table 1 Existing Santa Clara River Flows Through the RMDP/SCP Area

	Discharge for Different Return Events (cfs)					
Location	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
Upper end of the RMDP/SCP area, but downstream of Castaic Creek	2,527	8,232	14,942	24,157	41,141	58,207
Downstream end of the RMDP/SCP area at County line	2,600	8,480	15,400	24,900	42,400	60,000

Source: USACE 2010

Figure 3 consists of a cross-section across the Santa Clara River near the Los Angeles/Ventura County line. The figure shows the channel geometry of the cross section after wet years over the last 80 years, and demonstrates that the baseline conditions are characterized by significant variability. The geomorphology is a feature of the Baseline Condition.

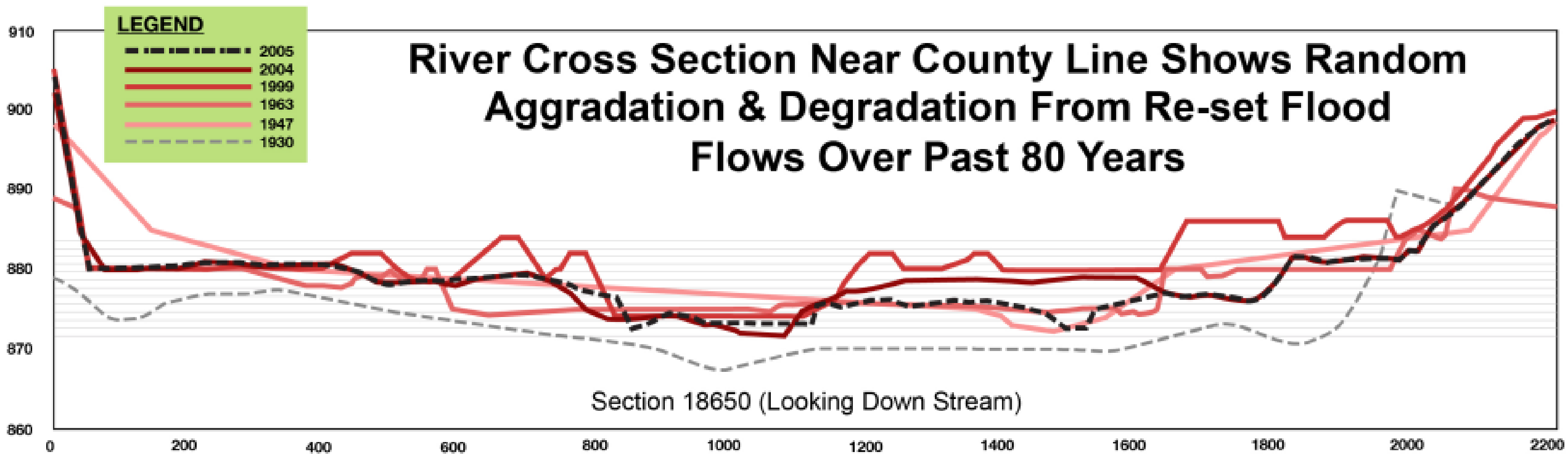

Figure 3 **River Cross Section near County Line over 80 Years**

3 Monitoring and Management Program Scope and Methods

This section describes the Study Area, scope of work, and methods for the Monitoring and Management Program. In accordance with Condition 27 of the WDR, the Monitoring and Management Program will be led by Dr. Tormey or other geomorphologists, with expertise in flashy and sandy rivers like the Santa Clara River.

3.1 Scope of Work

The Monitoring and Management Program consists of the following three elements:

> Establishment of Baseline Conditions. This element consists of determining the historic range in natural variation of the Santa Clara River within the Study Area including topography, aggradation and erosion, and any downstream impairments and flow regimes; and establishing pre-development conditions within the Study Area.

> Annual Geomorphic Monitoring. This element consists of performing annual monitoring of specified geomorphic indices within the Study Area to evaluate potential effects.

> Additional Action (if warranted). This element consists of implementing additional action if the annual geomorphic monitoring results indicate if triggers or action levels are exceeded as a result of RMDP activities.

These elements are described in further detail below.

3.2 Establishment of Baseline Conditions

3.2.1 Desktop Analysis

A desktop analysis will be conducted to review available information on the physical characteristics of the Santa Clara River within the Study Area. This information will include previously prepared reports related to the Project, reports prepared Los Angeles and Ventura Counties, the City of Santa Clarita, the California Coastal Conservancy, and other peer-reviewed literature. In addition, the analysis will include a review of current and historic aerial imagery and photographs, remote sensing data, and topographic data. The Coastal Conservancy has developed a comprehensive visual compilation of this type of data, which will form a starting point for this portion of the desktop review.

The literature review, in conjunction with the imagery, will be used to develop and describe a comprehensive understanding of the range of pre-project variation of the river system through the Study Area. The desktop baseline evaluation will focus on determining the natural, historic range of the following key variables; river contours, elevations, aggradation and erosion and any historic impairments of the river downstream for the Newhall Ranch Project Area.

3.2.2 LiDAR Acquisition and Image Analysis

Aerial data will be generated for the Study Area using light detection and ranging (LiDAR) technology that enables detailed topographic and geomorphic observations to be made on spatially extensive landforms, including channel network features. The acquired image will then be extracted to form a high-resolution digital elevation model (DEM). The DEM will be exported to GIS for image analysis.

For the baseline study, the DEM will be used to support the field reconnaissance, assist in transect selection, and serve as a quantitative snapshot of the entire Study Area for use in determining Project-related impacts and potential triggers for further action.

3.2.3 Field Reconnaissance and Selection of Study Sites

Following the desktop review and collection of LiDAR data, a preliminary field reconnaissance survey of the Study Area will be conducted to ground-truth the gathered information and to further assess and characterize current channel conditions. The purpose of the initial site survey will be to visually characterize general channel conditions such as substrate within the channel, planform, and other geomorphic features, as well as to accurately identify the banks. This allows for accurate measurement of channel width and bank elevation and accurate measurements of subsequent changes along the river. This geometry can be used to compute the net sediment contribution from stream banks. Field measurements are necessary as the LiDAR data can contain ‘‘lumpy’’ false water surfaces as a result of poor reflectivity. As such, a consistent bankfull water surface longitudinal profile provides more accurate measurements of channel gradient.

During the field reconnaissance survey, permanent photo points will be established to more precisely track variability over time. The photo sites will be selected to include a representative sample of variation in the key variables (e.g. river contours, elevations, aggradation and erosion) throughout the Study Area. The number of photo sites will be determined based observations and best professional judgment during the initial site visits. Permanent photo points will be established at each photo site and its coordinates will be recorded using a GPS unit (accurate to at least 1 meter). Initial photographs will be taken at each photo point to visually record the representative baseline condition. The field reconnaissance and photo documentation will also be a component of the annual observations and monitoring.

This type of evaluation, combining an overall survey based on the best professional judgment by a geomorphologist knowledgeable in systems like the Santa Clara River, and documented by consistent photo-documentation, ensures that all of the Study Area will be evaluated, not only areas of detailed study such as the channel transects. The combination of reconnaissance observations by an experienced practitioner paired with the quantitative measurement is a powerful combination to make comprehensive observations supported by the necessary quantitative basis for calculating the magnitude and variation in effects (Spina and Tormey 1994). This method allows flexibility to take into account current site-specific attributes of the river system within the Study Area, and enough qualitative information to make comparisons between years.

3.2.3.1 Channel Transect Selection

During the site reconnaissance survey, the location of channel transects will be determined. It is anticipated that six transect locations will be selected within each of the study reaches (Upstream, Project, and Downstream) for a total of 18 transect locations.

The transect locations will be selected based on the following criteria: representativeness to overall character of study reach, representativeness of physical geomorphic features of interest within study reach, proximity to the Newhall Ranch development areas, and other areas expected to be sensitive to change. In addition, accessibility and safety will be key considerations when selecting study sites. These criteria will be evaluated by the desktop study, the LiDAR survey, and the field reconnaissance.

3.2.4 Channel Transect Measurements

Once the transect locations are identified, the following data will be collected to characterize the existing conditions during the year that the transects are surveyed. The determination of existing conditions will augment the description of historic range of channel morphology and the LiDAR image to describe overall baseline conditions.

3.2.4.1 Data Collection

Cross-section and longitudinal profile surveys will be conducted at each study site to quantitatively characterize existing conditions of the channel geometry. Cross-section surveys will be conducted at each transect location, and one longitudinal profile will be surveyed at each study site. The surveys will be conducted during low flow conditions when the channel can be safely accessed and traversed.

The cross-sections will be measured from left bank to right bank, looking downstream, and will be surveyed to the elevation of the floodprone width, using a total station and prism or an engineer's level and rod. Permanent cross-section stakes (headpins) will be placed inland from the bankfull discharge level along the channel at each transect location. Ground elevations will be surveyed using an engineer’s level and stadia rod. Elevation measurements will be recorded at the headpins and at approximately one to two foot intervals along the transect cross-section within the active channel and at a broader spacing within the floodplain basin primarily on significant slope breaks or change in geomorphic features. Elevations of each transect within each study site will be tied to a common datum and these will be used to calibrate the LiDAR data.

The longitudinal profile will be surveyed over a distance of approximately 10 times the bankfull channel width and will include the channel thalweg and water surface elevation at each survey point. The survey will be conducted using a total station and prism or an engineer's level and rod. During the survey, the channel geomorphic/habitat feature (i.e., pool, riffle, run) at each point will be recorded.

The bankfull level at each transect will be determined based on evidence of lichens, high water staining, debris accumulations, topographic breaks in bank slope, the rooting elevation of perennial woody riparian vegetation, elevation of bank undercutting, significant changes in particle size of the bank material, and the height of depositional features within the active channel, such as unvegetated bars (Harrelson, Rawlins, and Potyondy 1994). Preference will be given to the top of toe bank and the active channel. Streambanks upstream and downstream of each cross-section will be carefully examined to establish continuity of the bankfull indicators. The bankfull level corresponds to the channel-forming flow because of its significance to the sediment transport characteristics of the active channel (Wohlman and Miller 1960, Leopold et al. 1992).

3.2.4.1.1 Pebble Counts

Sediment characteristics at each study site will be analyzed by conducting a pebble count of the bed surface particle size. The pebble count will follow the modified Wolman (1954) pebble count method. Particles will be randomly selected across the bankfull channel using the “first blind touch” method. Each particle will be measured on the intermediate axis (b-axis) using a ruler. The substrate categories defined by this study, modified from Platts et al. (1983), will be as follows:

> Fine sediment (sand and smaller particles, <2 mm),

> Gravel (2 to 64 mm),

> Cobble (64 to 256 mm), and

> Larger substrate types (boulder and bedrock, >256 mm).

The pebble count data will be used to prepare cumulative particle size distribution curves, and the final classification of dominant particle size (i.e., sand, gravel, cobble, or boulder) for each study site will be determined by calculating the most frequent particle size class present (as represented in the frequency histograms). The pebble count data will be collected at the same time as the cross-section and longitudinal profile surveys under low flow conditions when the channel can be safely accessed and traversed.

3.2.4.2 Data Analysis

The data analysis procedures described here are based on determining a baseline condition of the Study Area. As described in the next phase of the program, these channel transects will be measured again in the year following the occurrence of flows in excess of the 10-year recurrence interval flow (approximately 15,000 cfs). The additional data will be compared to prior data to quantify changes in change in channel form. The channel substrate type and grain sizes will also be used to evaluate differences in channel characteristics. Analyzing the collected data will include plotting cross-sectional data, calculating indices of channel form, and conducting statistical analysis.

3.2.4.2.1 Plotting Channel Cross-Section Data

Channel bed elevation data representing the existing condition will be plotted such that future changes in channel form can be evaluated and illustrated. The visual depiction of the channel form will be used in estimating the extent of change within the channel, and, if a change is observed, whether it is confined to a specific area or more broadly distributed across the transect.

3.2.4.2.2 Indices of Channel Form

Three indices will be calculated to monitor channel form and depth to represent existing conditions. The indices calculated will include the cross-sectional depth, the width/depth ratio, and the absolute change in area. The cross sectional depth is the mean vertical distance from the bankfull discharge level to the channel bed across the channel. The width/depth ratio (w/d) will be used as an index of channel shape. Width is the length of the cross-section and depth is the mean cross-section depth. The difference in the w/d ratio after reset events will be calculated. Since the width will be fixed by permanent transects, changes in the w/d ratio will reflect a change in depth. The absolute percent change in area will be used to quantify change in the cross-sectional area, since degradation and aggradation occurring along the channel could balance-out, resulting in no net change. Absolute change in area will be calculated using the equation:

$$\Delta A\% = \left[\sum_{i=1}^{n} \left| \left(X_{i\,before} - X_{i\,after} \right) \right| \Big/ \left(\sum_{i=1}^{n} X_{i\,before} \right) \right] x\ 100$$

In this equation, X*i* refers to the vertical distance from a horizontal line between cross-section transect markers to the streambed and streambank at the *i*th point along the transect, while n is the number of X*i* values.

3.3 Annual Geomorphic Monitoring

The establishment of baseline conditions will occur during the first year after the Workplan is approved by the LARWQCB and annual monitoring will be conducted each year thereafter. If annual flows do not exceed the 10-year recurrence interval of 15,000 cfs, then annual monitoring will consist of a reconnaissance survey by a qualified geomorphologist (identified for this project as Dr. Daniel Tormey) knowledgeable in flashy hydrologic systems such as the Santa Clara River, and photo-documentation of conditions, from the established locations. If annual flows exceed the 10-year recurrence interval, then, in addition to the reconnaissance survey and the photo-documentation, the baseline measurements (channel transects and LiDAR imagery) will be repeated.

3.3.1 <u>Flows Less than the 10-year Recurrence Interval</u>

If annual flows do not exceed the 10-year recurrence interval flow of 15,000 cfs, then the annual monitoring will be conducted primarily through visual observations and photo evaluation. Observations will be compared semi-quantitatively to the established baseline conditions. During the site visit, qualitative observations about the general condition of the river system as well as about the condition of each study site will be recorded. This method allows flexibility to respond to site-specific attributes of the study stretches, building on the professional experience, judgment, and knowledge of the geomorphologist.

More specifically, the practitioner will observe the river system in general and the specific study sites, focusing on river contours, elevations, aggradation and erosion, and any downstream impairments to the flow regimes in the Study Area, as well as any changes in other alluvial geomorphic features. These data will then be used to evaluate whether there are any significant changes outside of natural, historic baseline ranges.

In addition to general observations, the survey team will visit each of the photo sites established during the initial baseline surveys. The general condition of the photo site will be noted using a field form and an updated photo will be taken at each established photo point.

3.3.2 Flows Greater than the 10-year Recurrence Interval

If annual flows exceed the 10-year recurrence interval, then the stream power is such that there can be significant change to channel morphology. As such, the LiDAR imagery and channel transect measurements will be repeated as described in Section 3.3. Data from the LiDAR and the channel transects will be compared to the baseline measurements to assess change relative to the baseline conditions.

In addition, as with flows that are less than the 10-year recurrence interval, we will visually inspect the Study Area and take photos at each photo location using the methods outlined in the previous discussion.

3.4 Additional Action (if warranted)

The data collected during the annual monitoring will be used to evaluate geomorphic changes in Study Area. For attributes where changes are detected, an assessment will be conducted to determine if the change is outside of the historic baseline range and whether such change is significant. If it is determined that the change is within the historic baseline range of natural change, then no further actions are required. However, if it determined that the change is significantly outside of the baseline range, then a root-cause analysis will be conducted to identify the reason for the change and determine if the change is related to the Newhall Ranch Project or can be attributed to some other perturbation in the Santa Clara River watershed.

The root-cause analysis will be largely dictated by the nature and extent of the change that is observed or measured. If the root-cause analysis reveals that the change is most likely Project related, then an action plan will be developed to address the issue and restore the attribute of the river channel to within the baseline range. The action plan will be specific to the Project-related impairment, but may include channel restoration, bank restoration, and/or other actions. The results of the root-cause analysis and the action plan will be submitted the LARWQCB for review and approval.

Within 90 days after annual monitoring, RWQCB will be notified of any potential departures from baseline. The preliminary root-cause analysis will be completed within 180 days.

3.5 Reporting

A report will be prepared and submitted to the LARWQCB to document baseline conditions and present annual monitoring results. The contents of the report will include a description of scope of work, methods, results, figures and tables, and a discussion of the results. The discussion will focus on observed trends and their significance with respect to Project related effects. The report will identify whether any triggers for further action were identified during the field and data analysis activities.

In the event that the Annual Report identifies a trigger for further action, one or all of the following reports may be prepared:

1. If triggers for further analysis are identified, then the determination of whether the change is significantly outside baseline and whether it is Project related will be presented to the LARWQCB in a Change Investigation Report.

2. If a significant adverse Project-related change is identified in the Change Investigation Report, then an Action Plan will be prepared for submittal to the LARWQCB.

At the conclusion of the work described in the Action Plan, an Action Completion Report will be prepared for submittal to the LARWQCB.

4 Quality Assurance/Quality Control Plan

The quality assurance/quality control plan (QA/QC) associated with the Monitoring and Management Program is presented below.

4.1 Objectives

The primary objective of the Quality Assurance/Quality Control Plan (QA/QC Plan) is to provide procedures to obtain representative data, which can be used to meet the goals of the assessment. In general, quality and representation of the data are assured by adherence to formalized and standardized field and laboratory procedures performed by trained, qualified personnel.

4.2 Project Organization and Responsibilities

The data collection and monitoring will be performed by a geomorphologist knowledgeable in the Santa Clara River geomorphology (see Appendix A), a California Professional Geologist, and additional environmental scientists working under his supervision. All personnel involved with this project will be aware of their individual responsibilities, as described in the following subsections, and understand that QA must be applied throughout the duration of the project.

Procedures will be implemented to avoid data gaps and sampling errors, and to maintain a high quality of data collection and analysis. These involved procedures for documentation of field data, monitoring channel bed and elevation over time, and performing statistical analysis.

4.2.1 Documentation of Field Data

All field data will be recorded on standardized data sheets. Site number, time-of-day, and date will be recorded on the data sheets. Field data sheets will be reviewed by the field team leader at the end of each survey at a particular transect before leaving the location to avoid data gaps. Field data will be entered into a computerized database. A computerized printout of the data will be cross-referenced with field data sheets to verify the data were entered in the database correctly.

4.2.2 Measurement of Channel Cross-Sections

It is important that cross-section markers remain in place during the course of our monitoring study, since repeated surveys will be performed at the same location over time. Movement of cross-section markers between sampling periods may bias measurements and cause errors when evaluating channel form over time. Transect markers (headpins) will consist of rebar and will be driven deep into the stream bank, placed inland and at bankfull discharge level, to increase the likelihood that cross-section markers remained in place during our monitoring period. The headpin locations will be identified using a GPS and photo-documented.

The distance along the transect will be recorded for each cross-section survey. This information will be used when revisiting a site for repeated measurements to occupy the same measurement location. This will be important since measurements taken at different locations along the transect may cause errors in evaluating channel form over time, and decrease the validity of statistical tests.

4.3 Calibration Procedures and Frequency

All equipment and instruments used in the investigation will be maintained and calibrated to operate within the manufacturer's specifications so that the required sensitivity and QA/QC parameters are upheld.

Operational procedures for all field equipment will be followed to ensure that the equipment is operating properly and data are valid and traceable to a particular instrument. These procedures may include:

> Operation theory
> Functional operational checks
> Routine maintenance
> Calibration procedures
> Simplified operational instructions
> Special environmental conditions or interferences
> Deactivation and storage procedures.

Calibration and maintenance requirements of the field equipment will follow the manufacturer's specifications.

4.4 Corrective Action

During the course of the project the Project Manager will be responsible for ensuring all of the specified sampling procedures are followed and data meet prescribed acceptance criteria. The field and analytical procedures will be reviewed if QA/QC problems or deficiencies requiring corrective action occur. If a problem is discovered, prompt and prescribed action will be taken to correct the problem. Corrective action may be initiated based upon QC data or audit results.

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Workplan for Geomorphological Monitoring and Management Program

APPENDIX A

QUALIFICATIONS OF DR. TORMEY