Photo: Upper Penitencia Creek

Study of Santa Clara County Steelhead Streams to Identify Priority Locations for Gravel Augmentation and Large Woody Debris Placement

Santa Clara County, California

Prepared for: Santa Clara Valley Water District

The health of our waters is the principle measure of how we live on the land
- Luna Leopold

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Prepared by: Balance Hydrologics

In collaboration with: EOA inc. and HELIX Environmental Planning

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A REPORT PREPARED FOR:

Santa Clara Valley Water District
Judy Nam, P.E.
5750 Almaden Expressway
San Jose, California, 95118
(408) 630-2747
JNam@valleywater.org

by

Eric Donaldson, P.G.
Project Manager

PROFESSIONAL GEOLOGIST
ERIC T. DONALDSON
No. 9209
PROFESSIONAL GEOLOGIST
EXP.
STATE OF CALIFORNIA

Barry Hecht, C.E.G., CHg
Principal-in-charge

CERTIFIED HYDROGEOLOGIST
BARRY HECHT
No. 50
STATE OF CALIFORNIA

PROFESSIONAL GEOLOGIST
BARRY HECHT
No. 1245
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Kealie Pretzlav, PhD

With assistance from:
Bonnie de Berry, EOA, Inc.
Tom Keegan, Helix Environmental Planning, Inc.

Balance Hydrologics, Inc.®

Project Assignment: 215152

800 Bancroft Way, Suite 101 ~ Berkeley, California 94710 ~ (510) 704-1000 ~ office@balancehydro.com

The Team would like to acknowledge the following Santa Clara Valley Water District staff for their input and collaboration:

Judy Nam

Melissa Moore

Afshin Rouhani

Sunny Williams

Scott Akin

Leslie Layng

Carole Foster

Jason Nishijima

Sara Duckler

Ripen Kaur

Joe Chavez

Chris Van Amburg

Gabriel Vallin

John Pfister

Samantha Greene

Samina Shaikh

Travis Moore

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EXECUTIVE SUMMARY

Human activities, including construction of dams, and extensive development in Santa Clara County have altered the fluvial systems that drain the mountains surrounding the Santa Clara Valley by effectively modifying watershed hydrology and disrupting natural supply and transport of gravel, sediment and large woody debris (LWD). Reduction in the supply of gravel and LWD has impacted aquatic habitat in Santa Clara County streams. The Santa Clara Valley Water District's (District) objective is to develop a County-wide Gravel and LWD Augmentation Program to increase spawning and rearing opportunities for anadromous Central California Coast and South-Central California Coast Steelhead Trout (SC-CCCST). The Program falls under the voter-approved, Santa Clara Valley Water District (District) Safe, Clean Water Program, Priority D (D4), Fish Habitat and Passage Improvement. This portion of the overall D4 program strives to integrate geomorphic analysis and aquatic ecology principles to increase in-stream complexity in 8 of the urbanized waterways in Santa Clara Valley: Stevens Creek, Los Gatos Creek, Guadalupe Creek, Alamitos Creek, Guadalupe River, Upper Penitencia Creek, Coyote Creek and Uvas Creek. Major tributaries believed to support anadromy are also considered including Pheasant and Hicks, on Guadalupe Creek, Arroyo Aguague on Upper Penitencia Creek, and Little Arthur Creek and Bodfish Creek on Uvas Creek. The eight priority SC-CCCST streams selected by the District, based on the literature and input from various resource agencies. In a future second phase of work, the District plans to apply this Program to the remaining SC-CCCST streams.

In support of this objective, the scope of this study includes developing gravel placement site prioritization criteria, LWD placement site prioritization criteria, identification of appropriate locations based on Program variables (minimum of twenty sites) for both gravel and LWD augmentation.

To meet the programmatic objectives our approach is to integrate existing data and findings on physical process, fisheries and aquatic habitat available for Program streams and develop criteria which can be used to prioritize placement of gravel and LWD. This is challenging, as data are available from many sources, and in general, most previous work was guided by different goals and therefore compiles and presents information in different ways. This report and the programmatic tools developed herein are intended to meet the first goal, by integrating the existing data to the extent practicable, to examine where augmentation of gravel and LWD will likely be most effective. Considerations used to guide site prioritization and feasibility include hydraulic assessments and evaluation of sediment transport, channel stability evaluation including channel history and projected

watershed and channel conditions, channel habitat type and desired channel habitat relative to SC-CCCST, channel dimension and slope, potential to induce flooding, stream site fee and easement identification and stream access for implementation and maintenance, potential gravel and wood source(s), LWD source(s), and volume of placement materials (effective volume of appropriately sized material) i.e., surface square feet and depth.

To meet the above objectives, we developed a multi-criteria decisional analysis (MCDA) matrix, a commonly used programmatic tool used in ecological restoration. The MCDA was based on relevant criteria used to prioritize reaches for gravel and LWD augmentation. The MCDA is specifically structured to stratify stream reaches by feasibility of the gravel and LWD augmentation. From selected priority reaches, 47 high-scoring priority sites were selected for further evaluation and prioritization by the Team and District stakeholders. Of the 47 priority sites 32 were selected for field evaluations. The Team developed a site assessment Standard Operating Procedure (SOP, presented in **Appendix D**) which was used to evaluate the 32 sites. The SOP outlines evaluation steps as well as ecologic and geomorphic metrics to collect and evaluate and is intended to be used for future evaluations within Santa Clara County.

The final project deliverable is a selection of 20 potential gravel or LWD augmentation project sites. In many cases, gravel and LWD augmentation project sites are co-located or proximally located, but are treated as separate projects. The final 20 project sites were selected by scoring the 32 field sites based on ecologic and geomorphic criteria (Presented in Section 3). For the final 20 project sites the Team has developed concept-level design summary sheets (Presented in **Appendix E**), which include the quantitative and qualitative rationale for site-specific project approaches, success criteria, potential monitoring methods and adaptive management recommendations.

Gravel augmentation implemented as part of this Program can and should evolve over the years of the Program, based on an initial 5- to 10-year pilot period. Results of observing and monitoring the site can be and should be applied quickly. We should also recognize that the streams of Santa Clara County are generally smaller, have different dimensions, and are more likely to watershed disturbance by wildfires or other episodic events than are common in other portions of the state, most notably the Central Valley streams which tend to be less incised and have snowmelt hydrographs with gentler rises to and recessions from peak storms. Monitoring of the Santa Clara streams should be promptly evaluated, such that lessons learned applied to later phases of each project.

A combined gravel augmentation and LWD augmentation project on Los Gatos Creek was selected to be implemented under the District Stream Maintenance Program (SMP). The design plans and documentation are to be presented as a separate document.

Concepts were developed for the remaining 18 priority sites, including a design basis document which clearly articulates the existing site conditions, desired site conditions, success criteria, monitoring methods and potential adaptive management actions.

Success criteria and monitoring methods used to evaluate a project should focus on simple, straightforward metrics. Upstream and watershed-scale processes such as episodic debris flows, and changes to upstream bed and banks affect site-specific conditions. To minimize the risk of confusing watershed-scale processes with proposed gravel and LWD augmentation improvements, we recommend straightforward geomorphic indicators such as topographic and bed texture re-surveys be foundational elements of site-specific monitoring plans.

The following related District projects may utilize this Program as the basis for their future implementation:

- Stream corridor priority plans (SCPP)
- Fisheries and Aquatic Habitat Collaborative Effort (FAHCE)
- Stream Maintenance Program (SMP)

The Team coordinated extensively with these programs to accommodate their needs. The Program developed here will provide a consistent and systematic approach in implementation of gravel and LWD augmentation projects in steelhead streams for these related projects and other future projects and programs that share the steelhead habitat improvement objective.

ACRONYMS AND TERMS

Alluvial Fan – A gently sloping fan of sediments deposited by streams issuing from canyons onto a valley floor in arid and semi-arid environments. Alluvial fan sediments are generally loose and unconsolidated and occur because alluvial fans are depositional environments.

Bankfull – The flow or discharge at which water begins to spill over naturally constructed banks and onto adjacent floodplain(s) (Bates and Jackson). Urban streams typically have lost their adjacent floodplains through encroachment and fill placement.

CCCST – Central California Coast Steelhead Trout, a distinct population segments (DPS) federally listed as threatened by the National Oceanic and Atmospheric Administration National Marine Fisheries Service

CEM – Channel evolution model, after Schumm (1963), used to describe the evolution of channels in response to urbanization and reduction of sediment supply.

CDFW – California Department of Fish and Wildlife, formerly California Department of Fish and Game

Coarse Sediment - Coarse sediment, for the purposes of this Program encompasses coarse sand, gravel, cobble and boulder size classes. Gravel is commonly augmented to support salmonid spawning and incubation, however coarse sediment provides important structure, especially in the relatively smaller canyon reaches, where coarse sediment interacts with bedrock, banks, LWD and roots to from desirable complex habitat structures.

CPAD – California protected areas database

CPOM – Coarse particulate organic matter

cy – Cubic yards

District – Santa Clara Valley Water District

DPS – Distinct population segment

Episodicity – Differentiated from chronic hydrologic and geomorphologic process, episodic events, such as major wildfires, large floods, or landslides occur infrequently but do significant, if not temporarily change the process regime and form of stream channels.

FAHCE – Fisheries and Aquatic Habitat Collaborative Effort.

Floodplain – A relatively flat lying area located adjacent to streams and rivers which is covered with water during moderate and large floods. Active floodplains are constructed by the contemporary hydrologic and sediment transport regimes, reflective of present climate. In urban streams it is common to observe two different active floodplains.

Gravel Augmentation – Addition of coarse sediment, potentially including cobbles and boulders, to stream channels.

Hydromodification – The change in the timing and magnitude of runoff, typically associated with urban development and the subsequent loss of pervious surfaces which naturally attenuate stream flow.

Large Woody Debris (LWD) – Large woody debris is instream wood, defined here as wood pieces larger than six feet in length and one foot in diameter, in keeping with District Stream Maintenance Program (SMP) guidelines, and general practice in most places in northern California. LWD is typically used in stream enhancement projects to provide immediate cover habitat for aquatic species, as well as to promote corridor stability, pool development, and sediment storage. More commonly referred to in the contemporary literature as streamwood or large wood, because the term “debris” connotes negative impacts, we use large woody debris here for consistency with the existing permitting language for District SMP activities.

LSA – Lake and Streambed Alteration Agreement. CDFW permit required to significantly alter channel bed and banks.

MAP – Mean annual precipitation

MCDA – Multi-criteria decisional analysis matrix used to prioritize reaches for gravel and LWD augmentation.

Meandering Stream – A stream which exhibits a sinuous shape as defined by the overhead or birds-eye view.

Natural Levee – An embankment of sediment along a stream or river that was naturally deposited during floods due to presence of near-stream vegetation. Areas behind natural levees or back-levee areas typically are characterized by the presence of seasonal wetlands.

NOAA-NMFS – National Oceanic and Atmospheric Administration National Marine Fisheries Service

Program – Countywide Gravel and Large Woody Debris Augmentation Program including Stevens Creek, Los Gatos Creek, Guadalupe Creek, Alamitos Creek, Guadalupe River, Upper Penitencia Creek, Coyote Creek, Uvas Creek, and select tributaries known to be anadromous at the time of contracting.

Reach – For the purposes of prioritizing stream sections, a length of stream generally considered to be similar as defined by similar bed and bank morphology, presence of engineered bed and banks, stream order, presence or absence of a regulatory floodway.

Riparian – Pertaining to or situated on the bank of a body of water, esp. a river (Bates and Jackson, 1984). Streamside vegetation which draws on surface or hyporheic flows is typically known as riparian vegetation.

RWQCB – San Francisco Bay Regional Water Quality Control Board (District 2), or the Central Coast Regional Water Quality Control Board (District 3), if draining to the Pajaro River, including but not limited to Uvas, Llagas, San Benito, or Pacheco Creeks.

Saltate – Movement by jumps of leaps, used to describe a common mode of bed sediment transport in streams.

Sinuosity – Sinuosity is defined by the ratio of the stream length to the valley length (Schumm, 1963). For example, streams which exhibit a strong meandering form will have a relatively high sinuosity.

SCCCST – South-Central California Coast Steelhead Trout, a distinct population segments (DPS) federally listed as threatened by the National Oceanic and Atmospheric Administration National Marine Fisheries Service.

SC-CCCST – CCCST and SCCCST, collectively

SCPP – Stream corridor priority plans

Site – A specific location within a reach of stream that a gravel or LWD augmentation project can be implemented. Typically gravel augmentation and LWD augmentation sites are co-located within the same site.

SMP – Santa Clara Valley Water District Stream Maintenance Program

Water Year – A water year is defined as the period which begins October 1 and ends on September 30 of the named year. For example, water year 2009 (WY2009) began October 1, 2008, and concluded on September 30, 2009.

1 INTRODUCTION

1.1 Purpose

Human impacts, including dams, road building, and development in Santa Clara County have altered the fluvial systems that drain the mountains surrounding the Santa Clara Valley. In addition to the flow regime, human activities have modified the downstream flux of sediment and the modified recruitment and transport of LWD from headwater channels downstream to the San Francisco Bay.

The Santa Clara Valley Water District's (District) objective is to be able to develop a county-wide gravel and LWD augmentation Program (CAS #4669, Program, hereafter) to increase spawning and rearing opportunities for anadromous Central California Coast and South-Central California Coast Steelhead Trout (CCCST and SCCCST, respectively, SC-CCCST, collectively). CCCST and SCCCST are a distinct population segments (DPS) federally listed as threatened by the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA-NMFS).

In support of this, the scope of this study includes:

Programmatic evaluation:

- Gravel placement site prioritization criteria;
- LWD placement site prioritization criteria;
- prioritization of reaches within each watershed for gravel and LWD augmentation based on prioritization criteria; and
- further narrowing priority reaches into 20 potential project sites or based on additional prioritization criteria and field assessment (for both gravel and LWD augmentation.

Program variables used to guide site prioritization and feasibility include:

- Geomorphic and hydraulic assessment including evaluation of sediment transport;
- channel stability evaluation, including channel history and projected watershed and channel conditions;

- channel habitat type compared with desired channel habitat;
- channel dimension and slope;
- potential to induce flooding;
- stream site fee and easement identification and stream access for implementation and maintenance;
- potential gravel and wood source(s); and
- LWD debris source(s), volume of placement materials (effective volume of appropriately sized material i.e. surface square feet and depth.

This project falls under the voter-approved, Santa Clara Valley Water District (District) Safe, Clean Water Program, Priority D (D4), Fish Habitat and Passage Improvement. Portions of D4 resources were allocated to conduct this study to identify priority locations for gravel and LWD augmentation projects in 8 of the major steelhead streams in Santa Clara County: Stevens Creek, Los Gatos Creek, Guadalupe Creek, Alamitos Creek, Guadalupe River, Upper Penitencia Creek, Coyote Creek and Uvas Creek. Major tributaries believed to support anadromy were also included. This Includes Pheasant and Hicks, on Guadalupe Creek, Arroyo Aguague on Upper Penitencia Creek, and Little Arthur Creek and Bodfish Creek on Uvas Creek. North County streams within the Program limits are presented in **Figure 1-1**, and Uvas Creek and tributaries within the Program limits are presented in **Figure 1-2**. The eight priority SC-CCCST streams selected by the District, based on the literature (e.g. Becker and others, 2008) and input from various resource agencies. For the purpose of this report, we refer to these streams collectively as the Program streams. In a future second phase of work the District plans to apply the Program developed herein (possibly upgraded) to the remaining SC-CCCST streams.

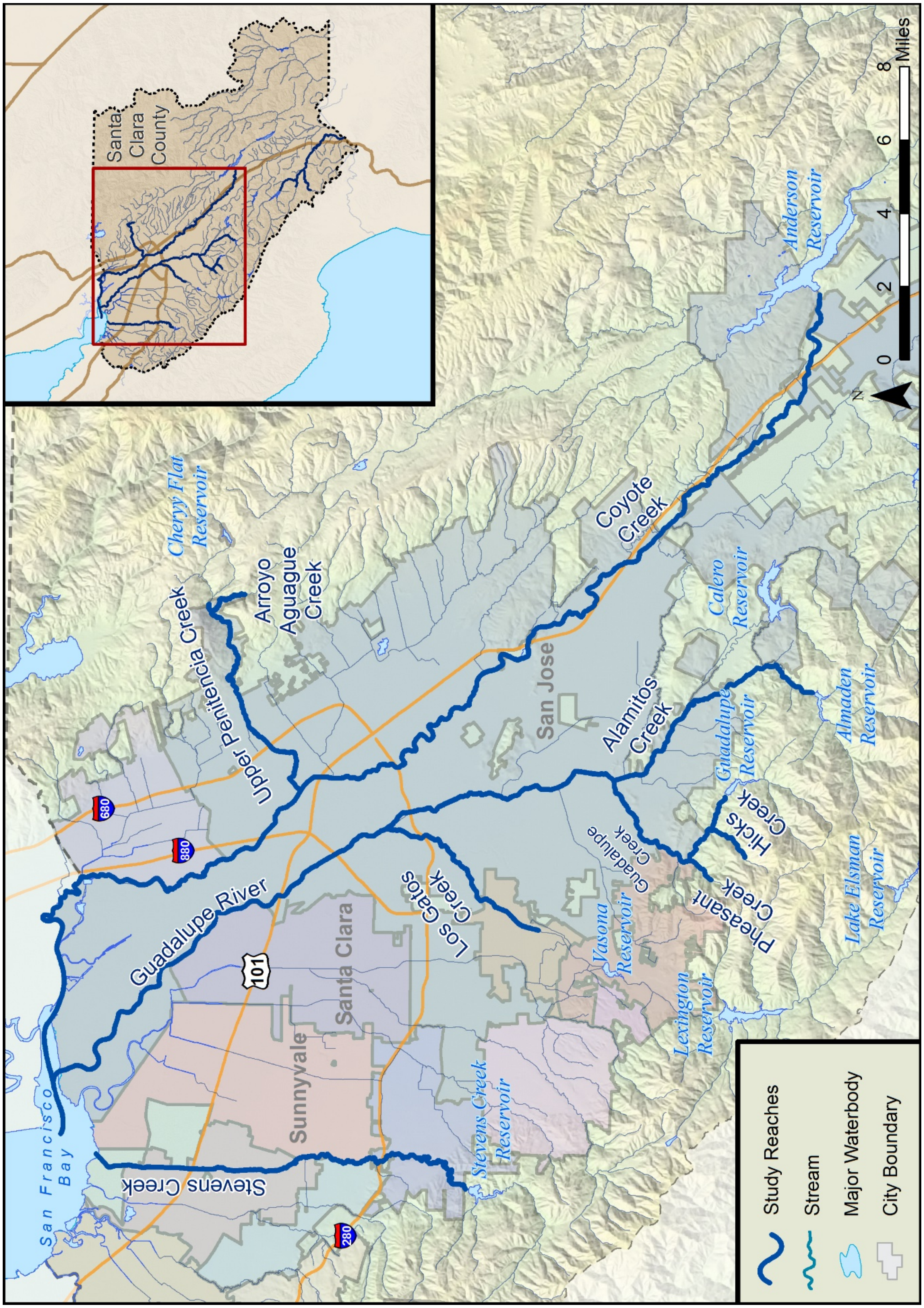


Figure 1-1 Location map of Northern Santa Clara County streams within the Program limits.

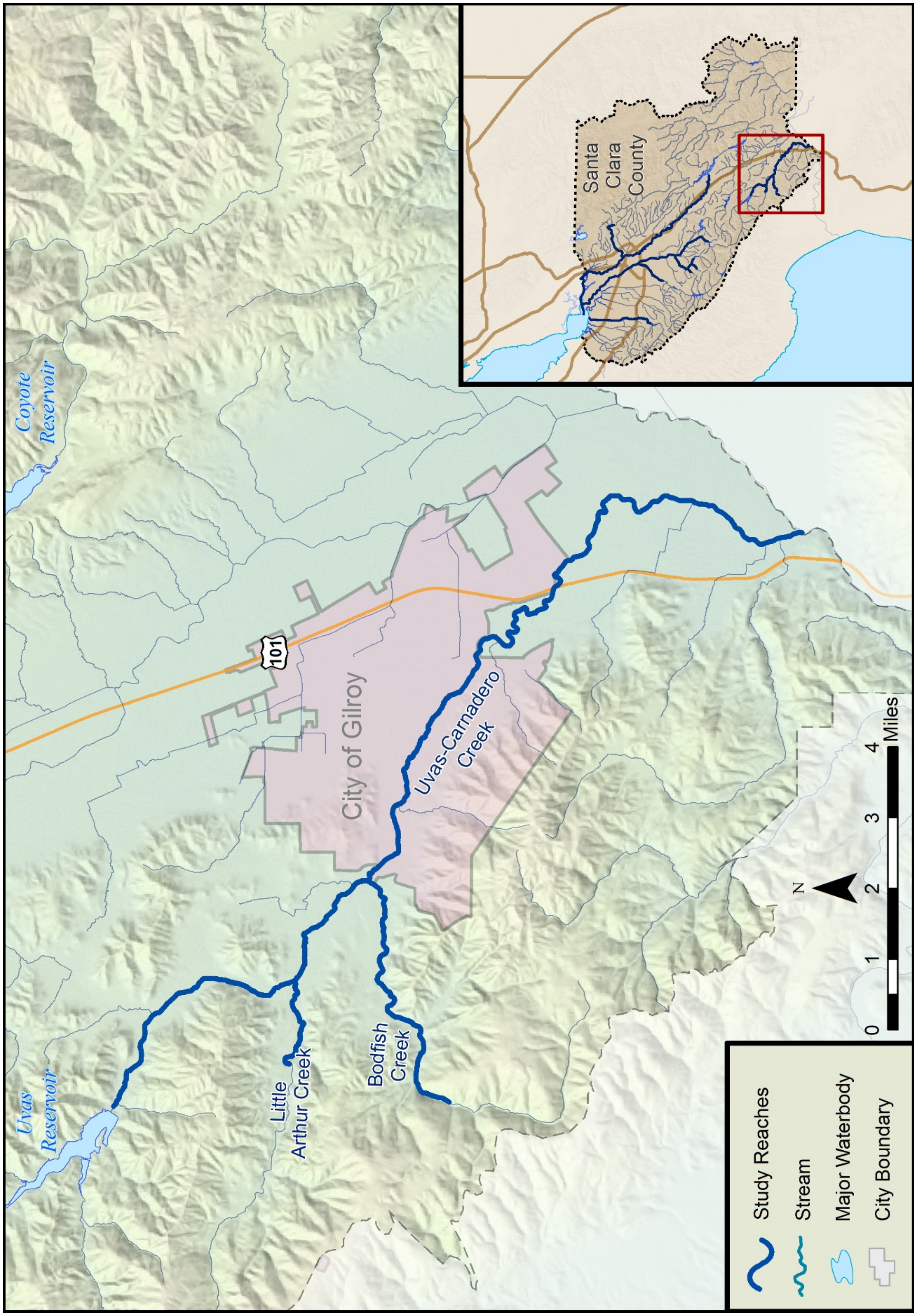


Figure 1-2 Location map of Uvas Creek and tributaries, Little Arthur Creek and Bodfish Creek within the Program limits.

1.2 Program Objectives

Program objectives used to guide development of the programmatic tools and implementation:

- Improve aquatic habitat for anadromous steelhead fish through development of ecologically based programmatic guidance, and;
- implementation of gravel and LWD augmentation projects in streams below dams in Santa Clara County.

To meet the programmatic objectives our approach is to integrate existing data and findings on physical process, fisheries and aquatic habitat available for Program streams and develop criteria which can be used to prioritize placement of gravel and LWD. This is challenging, as data are available from many sources, and in general, most previous work was guided by different goals and therefore compiles and presents information in different ways. This report and the programmatic tools developed herein are intended to meet the first goal, by integrating the existing data to the extent practicable, to examine where augmentation of gravel and LWD will likely be most effective.

To meet the above objectives, we developed a multi-criteria decisional analysis (MCDA) matrix, a commonly used programmatic tool used in ecological restoration. The MCDA was based on relevant criteria used to prioritize reaches for gravel and LWD augmentation. The MCDA is specifically structured to stratify stream reaches by feasibility of the gravel and LWD augmentation. High scoring reaches were evaluated using criteria discussed in **Section 3**, and subsequent field reconnaissance, then reduced to potential project sites.

The final Program deliverable is selection and conceptual-level augmentation plan development of twenty potential gravel or LWD augmentation projects. In many cases, gravel and LWD augmentation project sites are co-located, or proximally located, but are treated as separate projects. For the final twenty project sites the Team has developed concept-level design summary sheets, which include quantitative and qualitative rationale for site-specific project approaches, proposed success criteria, potential monitoring methods and adaptive management recommendations.

1.3 Guiding Fisheries Principles

In this section, we present relevant steelhead background and life history details pertinent to gravel and LWD augmentation. Two Distinct Population Segments (DPS) of Steelhead occur within the streams in Santa Clara County; Central California Coast DPS and South-Central California Coast DPS. The Central California Coast DPS resides in streams that drain to South San Francisco Bay. The South-Central California Coast DPS resides in Uvas Creek, a tributary to the Pajaro River. Both DPS are listed as threatened.

1.3.1 LIFE HISTORY

Steelhead are the anadromous (sea-run) form of rainbow trout. Steelhead populations are divided into Distinct Population Segments (DPS). In this case, both CCCST and SCCCST DPS Steelhead life histories are similar, the following description refers to both. Steelhead are nearly indistinguishable from resident freshwater rainbow trout that also reside in the same streams in which they spawn, with the exception of being larger when hatched (Moyle, 2002). Winter-run steelhead are at or near sexual maturity when they enter freshwater during late fall and winter, and spawn from late December through April, with the peak between January and March. Juvenile steelhead typically rear in freshwater longer than other salmonids, typically ranging from one to three years. Throughout their range, steelhead typically remain at sea for one to four growing seasons before returning to freshwater to spawn (Moyle, 2002). Unlike Chinook and Coho Salmon, steelhead can spawn more than once, returning to the ocean from their natal streams after spawning, though this generally occurs at low rates.

Regionally, steelhead typically return to their natal streams in early winter, however, migrating steelhead may be seen as early as August (Leidy, 2000). Migrating fish require deep holding pools with cover such as undercut banks, large woody material, and boulder edges. Coarse gravel beds in riffle areas are used for egg laying and yolk sac fry habitat once eggs have hatched. Because juvenile steelhead may remain in the creeks year-round for several years while rearing, adequate flows, suitable water temperatures, and an abundant food supply are necessary to sustain steelhead populations. The most critical period is in the summer and early fall, when these conditions may become limiting. Additionally, steelhead require cool, clean, well-oxygenated water, and appropriate gravel/cobble for spawning. Spawning habitat condition is strongly affected by water flow and quality, especially temperature, dissolved oxygen, shade, and silt load, all of which can greatly affect the survival of eggs and larvae (NOAA-NMFS, 2006).

The diet of juvenile steelhead includes emergent aquatic insects, aquatic insect larvae, snails, amphipods, opossum shrimp, and small fish (Moyle, 2002). Steelhead require sufficient fast-water feeding habitat. Good fast-water feeding habitat consists of clean coarse bed material to support benthic macroinvertebrates. Benthic macroinvertebrates, in turn, require sufficient sun and clarity to support algal growth at the base of the food chain (Smith, 2006).

Adult CCCST and SCCCST steelhead are primarily present during in-migration and out-migration periods. Juvenile CCCST and SCCCST Steelhead are often present year-round, where temperature and water quality permits.

Steelhead can spend an extended time in freshwater streams before they smolt, especially at the southern extreme of their territory, therefore, rearing habitat is sought.

During floods, juvenile steelhead seek refuge from the high velocity, highly turbulent flood waters in the interstitial space between immobile cobbles and boulders. Additionally, cobbles and boulders provide cover from predators and hosts numerous benthic macro-invertebrates, which constitute the primary food source for juvenile steelhead trout. Reiser and Bjornn [1979] compiled the findings of many studies and found that cobble and boulder channel beds are the most productive areas in stream channels for benthic macro-invertebrates. Gravel augmentation can include augmentation of coarse material where it is lacking. LWD can also supplement coarse sediment in providing velocity refuge and cover.

1.3.2 Threats

The largest factor limiting growth of this species within Santa Clara County is the placement of migration barriers that prevent access to spawning habitat (NOAA-NMFS, 2007). The quantity and quality of summer rearing habitat with fast-water feeding habitat, cool water pools and extensive cover for older juvenile steelhead are considered limiting factors. Other local threats to steelhead include agricultural operations, historic gravel extraction, illegal harvest, streambed alteration, unscreened or substandard fish screens on diversions, urbanization, water pollution, climatic variation leading to drought, flooding, and predation (NOAA-NMFS, 2007).

1.3.3 Limiting Factors and Application to This Program

Limiting Factors Analyses (LFAs) were originally presented as the definitive and (nearly) exclusive organizing concept for management of salmonid populations throughout coastal California. And, in fact, they were key to understanding how habitat in individual streams within a region (such as South Bay) may differ from each other – an important improvement over the assumed similarity of constraining conditions which prevailed in the 1970s through early 2000s. Nonetheless, LFAs may not be a sufficient or resilient enough paradigm to base management actions planned with a lifetime of a decade or two. To a great degree, LFA is an approach imported from wetter environment with larger and less dynamic streams in Idaho, Oregon, and the northwestern counties of California. In contrast, in the streams of Santa Clara County, habitat quality may be more seasonal, and year-to-year differences may be magnified, thus there is a greater likelihood that limiting factors may change from year to year and decade to decade. Hence, LFAs – with their assumptions that LFAs are static at the multi-year or decadal scale – can help guide the choice or locations for augmenting LWD and gravel, but must be articulated along with expectations of geomorphic change.

1.4 Implementation Framework and Related District Projects

The list of steps below outlines our recommended framework for implementing gravel and LWD augmentation projects. The steps incorporate lessons from previous works (e.g. Wheaton and others, 2004 and Roni and others, 2013) and restoration projects implemented in Santa Clara County:

1. Preliminary Planning, evaluation of history and existing knowledge to develop prioritization criteria;
2. selection of projects based on the criteria;
3. preliminary design documentation and concept development;
4. final Design selection and refinement, design basis report, and regulatory permitting;
5. construction;
6. post-project evaluation; and
7. long-term monitoring and adaptive management.

This Program is intended to complete the first 3 steps of this framework. In addition, the Program implements two pilot projects as part of this work, which will be taken through Step 5 of the framework under District Stream maintenance program (SMP) while partially satisfying the Safe Clean Water (SCW) Priority D4 Key Performance Indicator (KPI) number 5 of completing one project in each major watershed. Through the final design and refinement process, proposed 20 projects from Step 3 may be significantly adjusted, upon further analysis and evaluation during successive steps.

The following related District projects may utilize this Program as the basis for their future implementation:

- Stream corridor priority plans(SCPP)
- Fisheries and Aquatic Habitat Collaborative Effort (FAHCE)
- Stream Maintenance Program (SMP)

The Team coordinated extensively with these programs to accommodate their needs. The Program developed here will provide a consistent and systematic approach in implementation of gravel and LWD augmentation projects in steelhead streams for these related projects and other future projects and programs that share the steelhead habitat improvement objective.

1.5 Limitation of Liability

To the extent possible, the sections above describe our understanding of landscape dynamics in the region, and the assumptions embedded in the evaluations and calculations to help augment freshwater life stages of anadromous fish in Santa Clara County streams. The data are presented for the sole purpose of this project and should not be used for other purposes without the express consent of the Santa Clara Valley Water District and the authors of this report.

Gravel and LWD augmentation are complex, and stream restoration is an emerging field. Thus, all restoration projects are experimental to varying degrees. We have made efforts to incorporate sound science developed by prior workers, and evaluations completed as part of this project. However, recommendations for priority LWD and gravel augmentation may need to be refined or modified as a result of discoveries made during subsequent project-by-project design concept development processes and as the applied fields of gravel and LWD augmentation evolve.

2 PHYSICAL SETTING

2.1 Unique Attributes of Santa Clara County Streams Relating to Gravel and Large Wood Augmentation

The Santa Clara County has somewhat unique attributes that set this project apart from many other LWD and gravel augmentation programs, including:

- Near absence of coniferous woodlands (Uvas excepted) that are now part of the hydrographic net accessible to salmonids.
- Smaller than nearly all other viable salmonid systems, and drier, resulting in absence of examples in comparable settings.
- Complex geology devoid of rock types for which many preceding large-scale gravel augmentation plans have been developed.
- All the complexity of channel management associated with dams, but without the yields or releases that large dams can support.
- Historic land subsidence further complicates patterns of incision and deposition along many of the Program streams.

Because of the complexities posed by the above attributes, adaptive management plays an important role in ensuring success of gravel and LWD projects.

2.2 Regional Geology

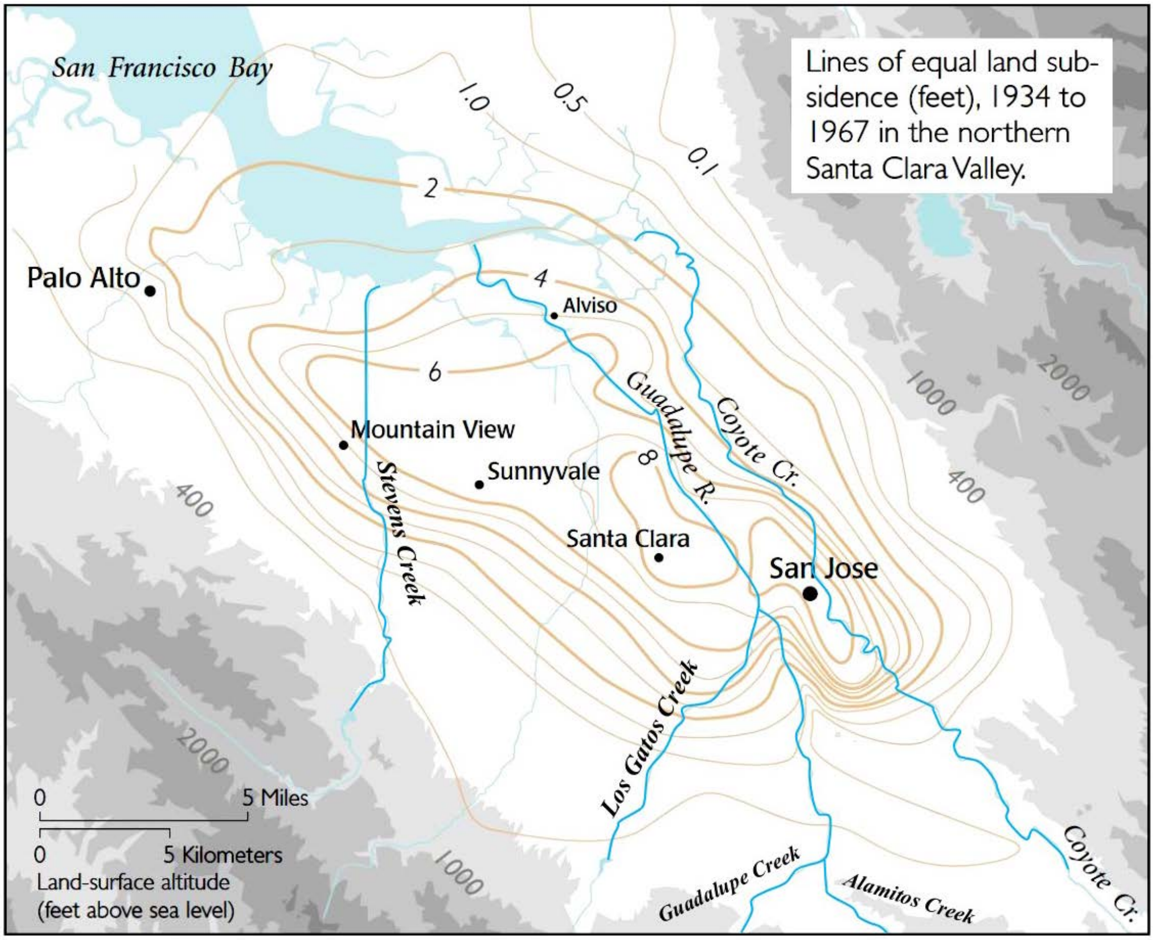
A thorough understanding of the regional geologic processes are key to developing a region-appropriate gravel and wood augmentation Program and is critical in guiding site-specific implementation plans. This section presents a brief overview of the regional geology and key factors influencing design objectives.

The Santa Clara Basin is situated in the northern part of the Central Coast Ranges, which extend southward from San Francisco for about 200 miles. The Coast Range landscape is characterized throughout its length by a series of rugged, sub-parallel, northwest-trending mountain ranges and intervening valleys. Located in one of the most seismically active areas in the world, the Santa Clara Basin is nestled between the northwest-trending Santa Cruz Mountains and the San Andreas Fault to the west and the Diablo Range and the Hayward and Calaveras Faults to the east. Although the geology of the area is complex, the overall picture is straightforward. The Santa Clara Valley is a large trough that has been filled by sediment (gravel, sand, silt and clay) eroded from the adjacent mountain ranges. The structure of the area is controlled by faulting, the trend of which is predominantly in a northwesterly direction as is so commonly the case in California (Lindsey, 1974).

The geologic formations of the Santa Clara Basin are of two kinds—the hard rocks of the mountain borders and the unconsolidated or semi-consolidated materials of the valley fill (Clark, 1924). Most of the Program streams drain metamorphic Franciscan and Great Valley Complex rocks, which tend to break down into clays rather than sands, as many of the younger Tertiary sedimentary rocks do. Thus, much of fine sediment fraction in the Program streams are dominated by silts and clays rather than sands, which can contribute to diminished steelhead habitat. The marked exception to this is Los Gatos Creek, which drains both sides of the San Andreas Fault. Those sediments are currently impounded by Lexington Reservoir, however we expect higher sand fractions from material mined from the banks through the Program reaches, as well as coarse sediment acquired from Lexington Reservoir, or the smaller Elsman and Williams Reservoirs, or other upstream impoundments.

Knudsen and others (2000) have refined the depiction of surficial geology of the San Francisco Bay Region, including Santa Clara County, by mapping the distribution of late-Pleistocene to recent geologic units and their relative susceptibility to liquefaction. These maps articulate the relationship between ancient Pleistocene and Holocene alluvial deposits left by the modern channel systems. Jenkins (1973) identified at least two extensive late-Pleistocene lakes which impounded water in the southern Santa Clara Valley up to elevation 400-feet, which flooded the entire anadromous reach of Uvas Creek, Little Arthur Creek, and the lower portions of Bodfish Creek.

Land-surface subsidence caused by past withdrawal of groundwater has been a dominant driver of geomorphic channel adjustment in areas where subsidence occurred most severely during the 20th century. Maximum land subsidence due to the rapid draw-down of groundwater in the early 20th century is centered north of downtown San Jose (**Figure 2-1**), likely exacerbating incision on the upstream side of the subsidence cone along Stevens, Los Gatos, and Upper Penitencia Creeks, and Guadalupe River. The centroid of subsidence extends to the Bay fringe. Subsidence has largely been arrested due to groundwater recharge efforts since the late 1960s, and thus the channel has largely completed its adjustment to changes in baselevel, though the relict incised channel and meander patterns still exist and must be considered when evaluating site-specific design approaches.



Modified from Galloway and others, 1999, original mapping by Poland and England, 1988

Figure 2-1 Map of subsidence in northern Santa Clara County between 1934 and 1967.

Mediterranean climates are prone to fires. Fires can generate large sediment and wood pulses that can last for several decades, although 3- to 6-years is most common. Gravel and LWD augmentation should acknowledge the occurrence of fire. This largely takes the shape of adapting success criteria and monitoring to a) be adaptable to large episodes (hydrologic, debris flow, fire or seismic) and b) establishing a monitoring program that permits evaluation of such events. Monitoring approaches are discussed in subsequent sections.

2.3 Regional Hydrology

Water is the primary agent of work which forms the rivers and watersheds of Santa Clara County. An understanding of the regional hydrology helps inform geomorphic processes which we rely upon here to guide gravel and LWD augmentation. This section presents an overview of the regional hydrology used to help frame the geomorphic processes which are at play in Santa Clara County streams. More detailed watershed-specific evaluations of localized hydrologic concerns are presented in subsequent sections.

Santa Clara County streams are driven by the regional Mediterranean climate, characterized by warm, dry summers and cool, wet winters. More than 85 percent of annual rainfall takes place between November and April in a typical year. Precipitation is most intense in and around the high peaks which drain to the channel headwaters, and the highest storm and annual rainfall accumulations typically occur in the southwestern flanks of the Santa Cruz Mountains (Nahn and Sa'ah, 1988). Year-on-year rainfall is highly variable. Droughts of 3- to 7-years occur with regularity, most recently during water years (WY) 2012[1] through 2015. Conversely, wet years occur sporadically, and within those wet years, storm tracks can affect variability in rainfall accumulation and intensity over a storm, or a season.

Annual average rainfall amounts vary significantly due to topography. Portions of the basin headwaters in the Santa Cruz Mountains receive 40- to 60-inches per year, while the central Santa Clara Valley receives on average 13- to 14-inches near downtown San Jose. In recent years, major floods have struck regionally in 1952, 1955, 1982, 1986, 1995 1998, and 2005, among other years.

To varying degrees, the conversion of the Santa Clara County from the natural communities, to orchard, and more recently, urban and suburban development has had a variable effect on the stream hydrology. As urbanization and development takes place, more and more of the ground surface is covered with asphalt, concrete, and roofs. The additional impervious area and drainageways cause a greater percentage of rainfall to rapidly move into stream channels, impervious surfaces preventing surface water from soaking into the ground and slowly traveling through the subsurface. Historically, the decreased infiltration and increased runoff associated with urbanization has caused the size of peak floods to increase, however the District works with the cities, and the county to minimize such impacts.

[1] A water year is defined as the period beginning October 1st of any year and ending September 30th the following year; for example, Water Year 1983 is the period from October 1, 1982 through September 30, 1983.

Water supply reservoirs, when not full, buffer watershed responses within their catchments and tend to mute or delay the response to rainfall events. When reservoir storage is filled, however, stream flow can be quite high, with lengthy and sustained high-flow conditions.

During the summer, the District operates the reservoirs for conjunctive use making releases to recharge the groundwater aquifers. Stored water is used to recharge both instream and off-stream in percolation ponds. The reservoirs are also operated to comply with provisions of the Lake or Streambed Alteration Agreements (LSA) issued by CDFW for the diversion facilities located downstream. Cold water released from the bottom of reservoirs means that reaches just downstream of reservoirs are typically cold and less productive for steelhead, while downstream reaches are typically warmer, though with less reliable flows.

Temperatures in the Santa Clara Basin tend to be mild, and rarely drop far below freezing in the valley flat. Although snow is not uncommon in the mountainous portion of the basin in winter, it does not last long. North of San Jose, the hottest summer temperatures are rarely higher than the 90°F, although south of San Jose both summer and winter extremes are somewhat greater.

2.4 Guiding Geomorphic Principles

The following sections serve to introduce key geomorphic principles that lay the foundation for both the site prioritization process and site design selection process.

Riverine ecosystems are built by geomorphic processes which can be characterized by the interaction of hydrologic energy and geologic properties. Riparian vegetation also plays a role in this interaction, primarily through root strength and natural wood recruitment. Geomorphic processes provide the structure which controls stream and riparian ecology, and therefore impacts the abundance and distribution of stream-dependent biota, including SC-CCCST.

2.4.1 Sediment and Wood in Rivers

Rivers transport sediment both along the streambed as coarse bedload which saltates down the channel bed at high flows, and as fine-grained suspended sediment which is transported in the water column. Depending on myriad factors, the size of sediments within streams can vary widely spatially and temporally. The Wentworth scale (Wentworth, 1922) is typically used by scientists to describe and classify sediment sizes.

Table 2-1 Sediment grain-size categories and functional descriptions

Size classification *Wentworth*	**Particle size** *mm*	**Functional description**
Boulder	>256	Coarse bed material, can comprise overwintering habitat
Coarse Cobble	128-256	
Fine Cobble	64-128	Approximate range of salmonid spawning gravels
Very Coarse Gravel	32-64	
Coarse Gravel	16-32	
Medium Gravel	8-16	
Fine Gravel	4-8	
Very Fine Gravel	2-4	Can degrade spawning and rearing habitat
Sand	0.0625-2	
Silts and Clays	<0.0625	

Gravel augmentation, for the purposes of this report includes augmentation of gravel-sized material, and also coarser material. The reasons for this are two-fold:

- Spawning gravels typically fall within the gravel size-class but also include larger cobble to boulder material (e.g. Reiser and Bjornn, 1979, Kondolf and Wolman, 1993);

- Juvenile steelhead utilize interstitial spaces in coarse streambed material greater than 128 millimeters in diameter (e.g. Bjornn and Reiser, 1991, Donaldson, 2011) and gravel augmentation downstream of dams is expected to improve SC-CCCST habitat and increase survivorship.

Without exception, the Program streams historically transported coarse and fine sediment from headwater tributaries in the Coast Ranges and out to San Francisco Bay (or Monterey Bay in the case of Uvas, Bodfish and Little Arthur Creeks). Prior to widespread development and the construction of dams, sediment supply, transport, storage and delivery were in relative equilibrium which maintained stream morphology.

Gravel is commonly augmented to support salmonid spawning; however, coarse sediment provides important structure, especially in relatively smaller canyon reaches, where coarse sediment interacts with bedrock, banks, LWD and roots to form desirable complex habitat structures.

Excessive fine sediment can impair salmonid habitat, primarily by smothering gravels, thus reducing availability of high quality habitat, and embedding larger cobbles and boulders, reducing available cover for juveniles. By volume and weight, the vast majority of sediment transported by Central California rivers is fine-grained suspended sediment. Sometimes, an assumed value that suspended sediment amounts to 95 percent of all sediment is used (i.e. bedload is commonly assumed to be 5% of the overall sediment loads), however it can vary widely, with values of 40 percent or less being report for comparable-sized salmonid streams (e.g. Chartrand, 2011; Knudsen and others, 1992). Limited supply of bedload sediment supply can often result in extreme bed grainsize bimodality where finer bedload-sized particles are transported and a coarser armored bed surface forms (e.g. Buffington and Montgomery, 1999). Fines can subsequently settle into the interstitial spaces, increasing grain embeddedness, and potentially reducing the percentage of the bed surface useable for spawning.

LWD, for the purposes of this Program is defined as pieces of wood longer than 6 feet (1.82 meters) having a diameter greater than 12 inches (30.5 centimeters), in keeping with the definition of LWD for the District SMP. Within the literature LWD is defined as wood that is likely to do geomorphic work. Based on a survey of relevant literature Máčka and others (2011) define LWD to be wood pieces with a minimum diameter of 3.9 inches (10 centimeters) and a minimum length of 3.28 feet (1 meter). However, LWD augmentation typically employs wood pieces larger than 12 inches in diameter and 6 feet in length, due to reduced cost-benefit ratios for implementing LWD projects with smaller wood pieces. LWD is more likely to provide long-term bed structure when a piece's length is equal or greater to channel width, often called bankfull width (Cramer, 2012). Larger diameter pieces also tend to be more stable. This is especially true in Santa Clara Valley streams, where along many reaches, sustained summer base flows support a vigorous riparian "fence" at the edge of the low-flow channels which tend to recruit LWD and wood jams (**Figure 2-2**).

Figure 2-2 Riparian "fence" on Los Gatos Creek.

LWD provides myriad geomorphic and hydrologic functions which support SC-CCCST including sediment storage, scouring pools, and increasing hyporheic flow. Other important geomorphic and hydrologic functions include channel width modulation and side channel formation, grade control, and increased recharge. Many of these functions are summarized in USBR-USACE (2016).

2.4.2 Channel Slope and Stream Morphology

In most circumstances, creek and river form and structure follow a downstream succession of alluvial stream channel types. Alluvial channel types for mountain streams were characterized by Montgomery and Buffington (1997), and are characterized as colluvial, cascade, step-pool, plane-bed or forced pool-rifle, pool-riffle and dune-ripple (**Figure 2-3**). Not all stream types are present in all streams. In the case of Program streams under historical conditions, step-pool, plane-bed/forced pool-riffle, and pool-riffle morphologies dominate.

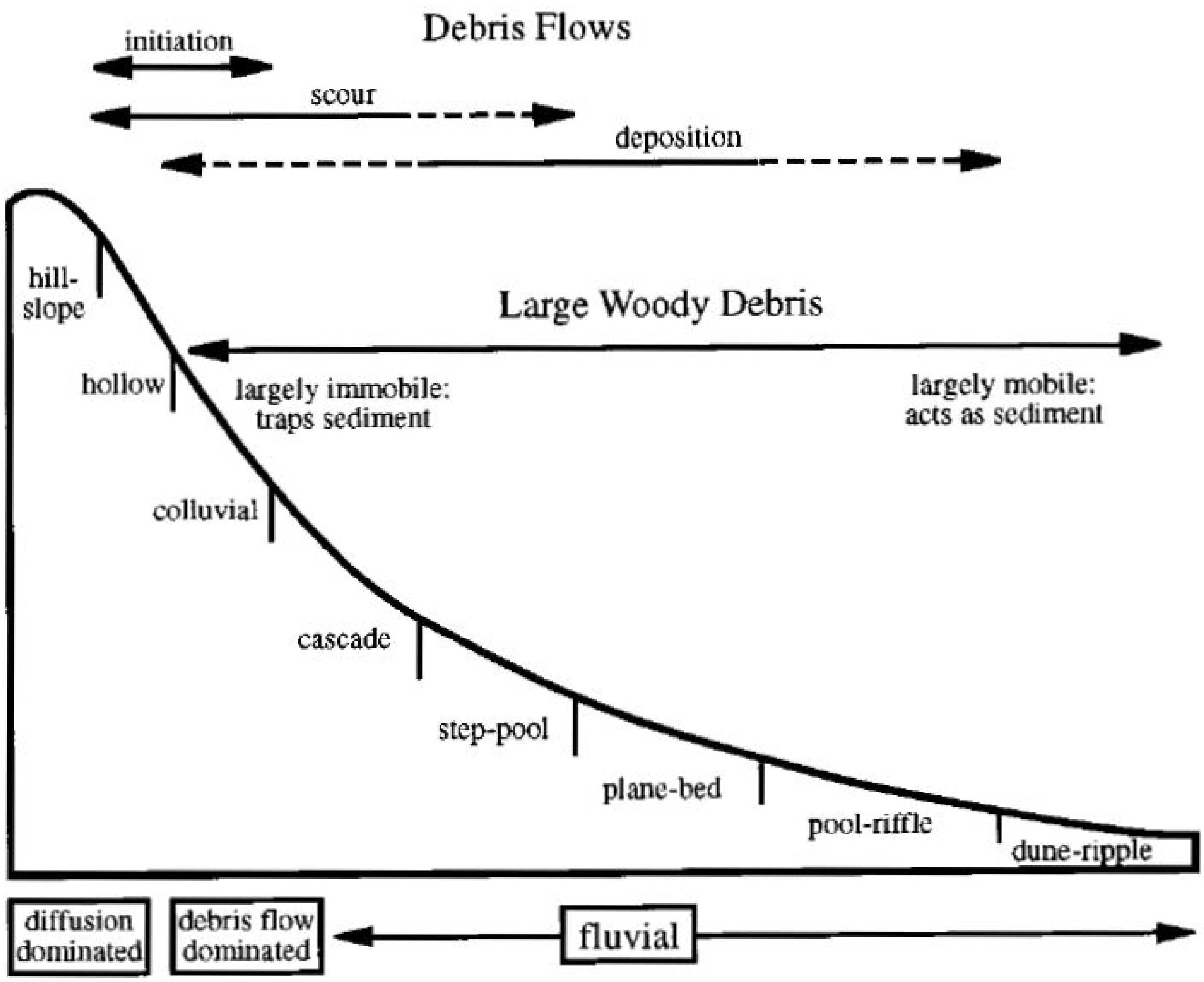


Figure 2-3 **Idealized long profile modified from Montgomery and Buffington (1997).** Compares processes and relative slope of channel types from hillslope and unchannelized hollows downstream through the alluvial channel types. Large woody debris is largely immobile in steeper reaches, which is primarily a function of channel width.

Step-pool channels are characterized by longitudinal steps, typically formed by channel-spanning structural clusters consisting of cobbles and boulders. LWD can also form steps. Step-pool channels typically develop in streams with 3 to 6.5 percent channel slope. Plane bed channels are typified by generally coarse substrate, typically gravel to cobble dominated, range from 1.5 to 3 percent slopes and lack rhythmic bed features like step pool and pool riffle channels. Plane bed channels are less common because they typically require straight channel conditions, and curvature can impart forced pools within a plane bed reach. LWD can also impart pools, steps and riffles, enhancing SC-CCCST habitat. Pool-riffle morphology is typified by an undulating stream bottom consisting of grain sizes between sand and cobble, but typically gravel dominated. Pool riffle morphologies are typical in channels with a slope of less than 1.5 percent. The typical downstream progression of channel types can be interrupted, generally at tributary junctions with smaller channels that may contribute period debris flows, or in areas where landslides occur.

Except for the undammed headwaters of Upper Penitencia Creek, Bodfish Creek, and Little Arthur Creek, as well as the reaches just downstream of the reservoirs on Alamitos and Guadalupe Creek, the Program streams have slopes of less than 1 percent, thus most reaches are within slopes typical for pool-riffle channel types. Prior to being dammed, these reaches were typically used for spawning due to the presence of appropriately sized gravels. Juveniles would have typically migrated upstream where perennial flows support over-summering, and larger cobble-boulder substrates support over-wintering. Because many SC-CCCST streams are cutoff from their headwaters, SC-CCCST have adapted to spawn and rear downstream of dams. Because of the reduced availability of large cobble-boulder habitat, LWD plays an even more critical habitat function which the Program LWD augmentation seeks to support.

2.4.3 Source, Transport and Depositional Zones

Lane (1955) developed a simple conceptual model to help understand the relationship between stream discharge, slope, sediment caliber and quantity, and the tendency for a stream to aggrade or incise. A modified version of the conceptual “scales” from USACE (2013) based on the figure presented by Lane (1955) is presented in **Figure 2-4**. Lane (1955) suggests that, when flow, channel slope, the quantity and the size of sediment and large structural elements like LWD are in balance, a pseudo-equilibrium state will form. Increasing sediment supply, increasing the quantity of LWD, or reducing stream power will result in aggradation while reducing sediment supply, reducing the quantity of LWD or increasing stream power will cause degradation.

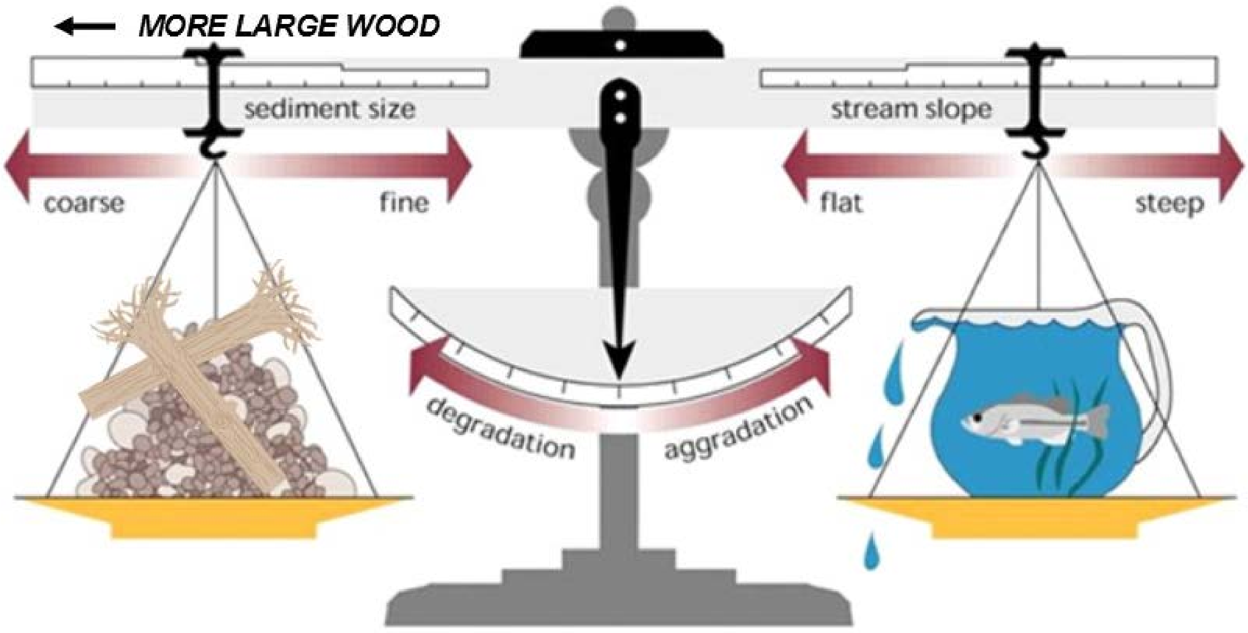


Figure 2-4 **The conceptual scales adapted from Lane (1955).** Conceptual scales balance stream aggradation and degradation or downcutting as a function of the sediment and wood supply and stream power.

Altering the inputs pictured in **Figure 2-4** will drive the stream to a new form. Myriad factors can change the balance, some natural and others human induced. These are discussed below and in the following sections.

Local variability in the size and types of rock delivered to the stream is much greater in the upper erosion and transitional zones. Channels in the canyons, at the base of long, steep slopes, will receive episodic pulses of coarse sediment and LWD, while streams flowing within geomorphic floodplains or older alluvial terraces will be recruiting coarse sediment largely from the collapse of retreating banks. Within the canyons, the main pulses appear to recur at frequencies of 10 to 20 years (e.g. Owens and others, 2003), with large angular rock composing much of the introduced coarse sediment.

Rounder rock, of sizes likely to remain in the channel for many years, is delivered from erosion of floodplain benches and Pleistocene alluvial terraces; where deposits are positioned between the slopes and channels, the terraces absorb and attenuate the greater, less-frequent pulses of soil and LWD from the canyon slopes. With larger drainage areas, smaller wood, and finer bedload, the lower portions of the creeks in the depositional zone are affected less by episodic sediment and LWD delivery than the depositional zone. Sediment pulses are far more attenuated and LWD tends to be transported in generally smaller (and hence more predictably-moved) pieces than those in the erosional and transportation zone. Recruitment of conifers, longer lasting and generally more resistant to decomposition, is primarily limited to the canyon reaches. Placement of LWD and spawning-sized and larger material in downstream segments of the channel on the floor of the valley can be usefully assessed by simulations using averaged and steady-state assessments of LWD and coarse sediment (e.g. USACE and others 2013).

2.4.4 Natural Episodic Inputs of Sediment and Wood

Much of the gravels in the streams of the southern Santa Cruz Mountains enter the channel during events such as major floods, or storms following watershed-scale wildfires, large landslides, and droughts. During these epicycles, sediments accumulate in the channel, filling pools, and accumulating to depths of (often) several feet, with much of it being sand (Hecht, 1994). The sands and gravels are gradually depleted in the latter stages of the epicycle, with the bed becoming progressively coarser as the episode-induced pulse of sediment is gradually and progressively depleted during successive years. This duration is long relative to the life cycle of salmonids, hence it makes sense to include management provisions for epicyclic recovery, because watershed conditions can vary substantially, and limiting factors for SC-CCCST can vary with these cycles.

There is little to be gained by augmenting gravels during years when the channel is likely to be saturated or even choked with 'episodic gravels'; adding sediment at such times can fill pools and delay recovery. Conversely, the greatest benefit can be achieved by augmenting gravels during years between such events, during which intervals channels may be gradually depleted of gravels suitable for spawning, incubation or rearing. Similarly, LWD tends to enter the channels in the Santa Cruz Mountains in pulses associated with large episodic events, such as floods, wind storms, the rare snow storms, landslides, or during storms following wildfires and droughts, such as the current episode recovery period following the very wet WY2017. Thus, we recommend episodicity be addressed in developing project success criteria, monitoring methods and adaptive management plans. These concepts are presented in greater detail in **Section 4.5**.

2.4.5 Human Impacts

Most Program streams flow into reservoirs which do not pass coarse sediment, from varying areas of the channel headwaters. The variable influences of the reservoirs and urbanization on hydrology have changed the balance of flow and sediment supply, which has led to changes in morphology and riparian ecology. Examining **Figure 2-4,** increases in peak flows due to urbanization, and a lack of sediment being transported to these channels from their headwaters tips the Lane's (1955) scale toward degradation. The stream processes have eroded, and in some cases, continue to erode the bed until a new equilibrium slope and form are reached. Though not a part of the Program at this phase, the Llagas Creek system is presented as an example of this process since extensive data exist, because the available data present a striking result, reflected in the Program streams. **Figure 2-5** (Hecht and others, 2012) historic long profiles of Llagas Creek from 1915 and 1955 compared to a more recent 2002 survey. These data show channel incision varying from about 8 to 12 feet, with the most incision occurring at downstream reaches. Similar magnitudes of incision are present in streams, countywide.

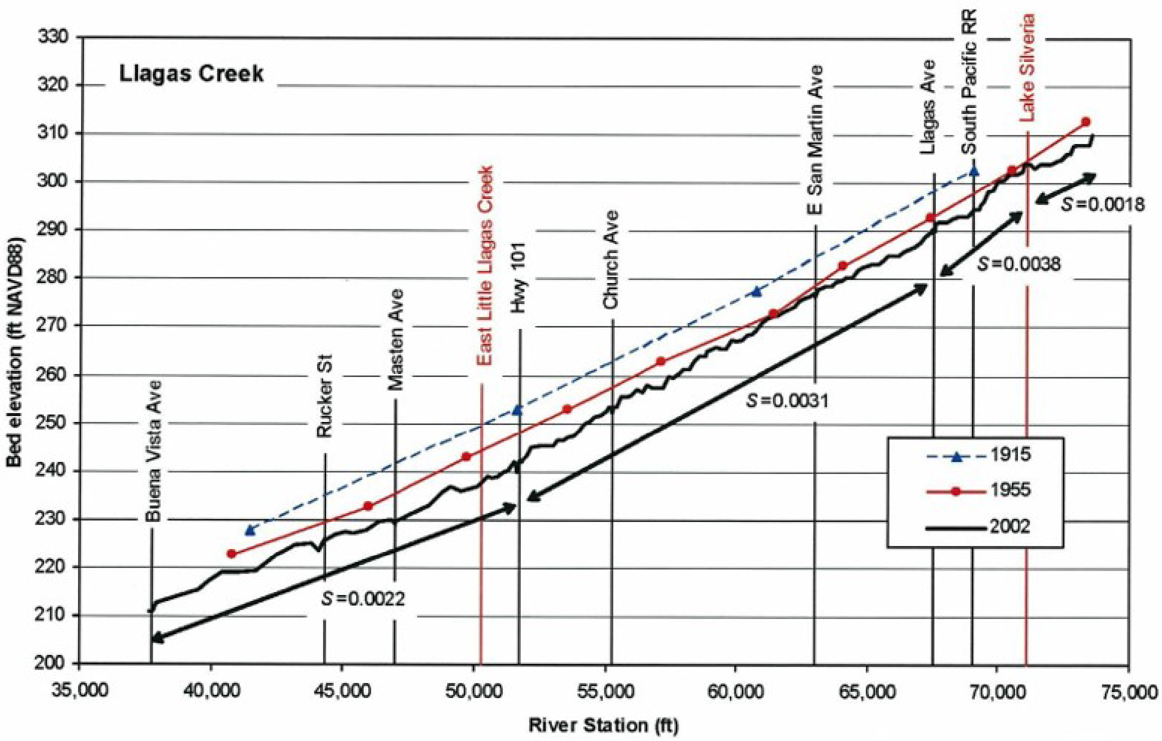


Figure 2-5 **History of incision on Llagas Creek.** Comparison of longitudinal profiles from topographic maps published by USGS in 1915, 1955 and surveys from 2002. Though Llagas Creek is not a Program stream, the comprehensive stream profile data illustrate the magnitude of incision common throughout the Program streams. Modified from Noble and NHC (2008).

Degradation, or streambed incision, toward a new equilibrium condition is not desirable for numerous reasons including:

- Extirpation of in-channel gravel bars, and subsequent creation of long mid-channel pools (**Figure 2-6**) and reduction in functional aquatic habitat;
- exposure of grade control structures which can result in fish passage impediments;
- degradation of stream banks, which, in lower reaches, can introduce ancient fine-grained sediment to channels, reducing habitat value;
- undermining adjacent infrastructure; and
- de-watering of the banks and loss of groundwater stored in the alluvial aquifer.

Figure 2-6 Example of a long mid-channel pool on Uvas Creek just downstream of Uvas Dam (Program Reach 1-1). Channel incision has high transport capacity relative to available sediment load, and has armored the channel bed, and washed out bars and riffles.

During Program site concept development, we recommend comparison of observed conditions to a well-documented channel evolution model (CEM) paradigm (**Figure 2-7**, Schumm and others, 1984; Simon and Rinaldi, 2006) that depicts alluvial systems in several stages of degradation and recovery as associated with disturbance by land-use activities. Once these stages and the trajectory of channel response are identified, appropriate restoration and management strategies can be developed.

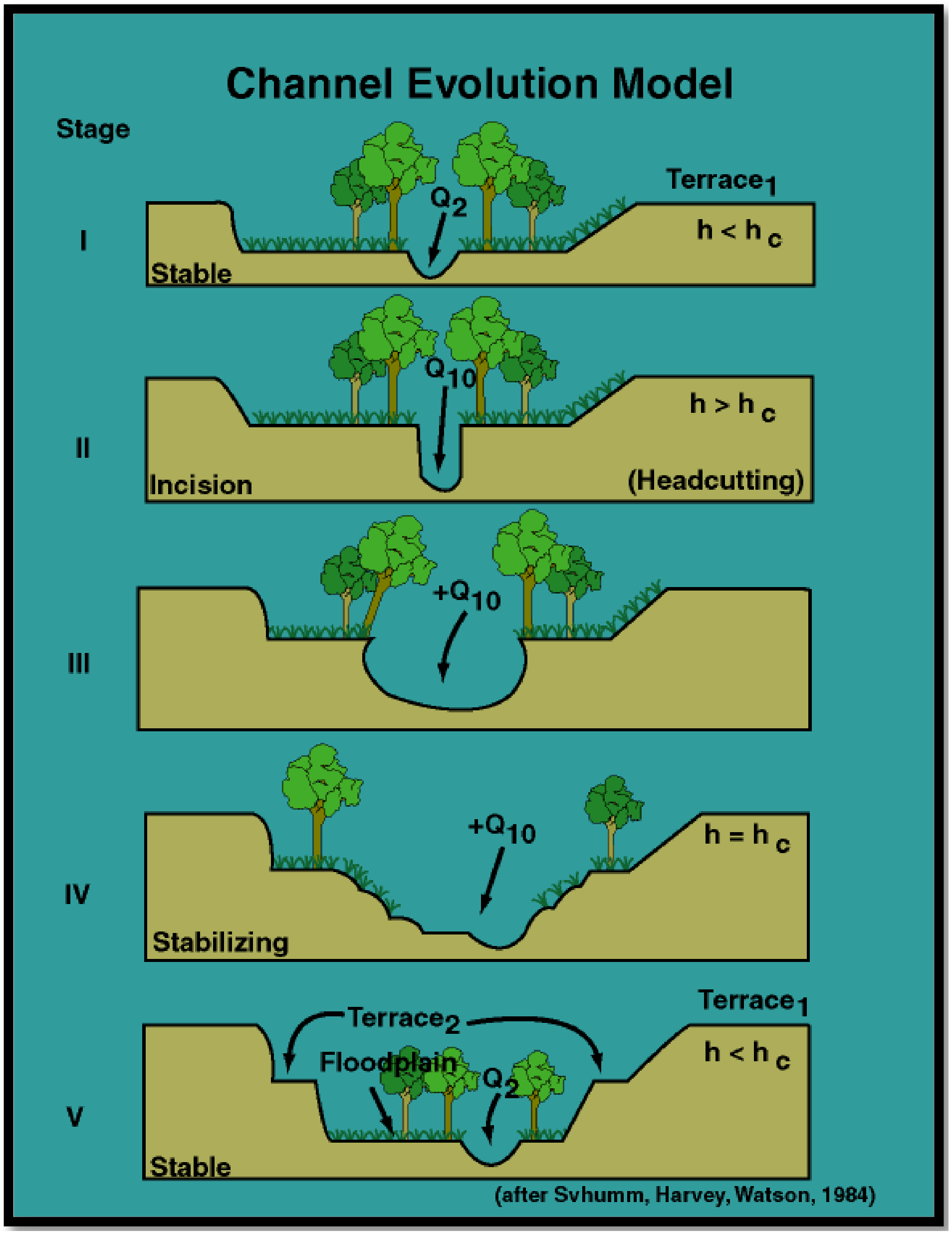


Figure 2-7 Theoretical channel evolution model for alluvial systems. Various stages of channel evolution are observed in many Santa Clara Valley streams within the limit of anadromy and can be used to evaluate restoration principles.

Based on the CEM (**Figure 2-7**), channel changes can be viewed in both a temporal and spatial context. First, the temporal viewpoint is best ascribed to channel incision initiated by watershed changes or direct disturbances that affect hydrology, channel form, and/or sediment transport processes presented above, in which a new equilibrium may take decades or even centuries to achieve (Fischenich and Morrow, 2000), but follow 5 basic stages of evolution. Typically, there is no need for rehabilitation of Stage I reaches, as these reaches show little sign of degradation and are considered stable. Rehabilitation of floodplains and habitat should be evaluated with caution if channel conditions are characteristic of Stage II and Stage III, as an actively incising or widening channel may cause some restoration elements such as augmented LWD to fail unless future channel deterioration is carefully considered. Note that during these phases, larger and larger flows (**Figure 2-7**) are contained within the channel, which increases bed shear and a positive feedback which drives further incision and widening. Advancement through Stage IV and toward Stage V is a critical component of establishing a new, quasi-equilibrated or equilibrated and relatively stable state.

Spatially, stages of degradation typically migrate up the watershed. Ultimately, incising channels can create a disconnect between active flow in the channel and its connectivity with its floodplain surfaces leading to habitat loss or deterioration.

It is often appropriate to follow a restoration strategy that identifies the equilibrated Stage V geometry, and advances through Stages III and IV, so that stability is more rapidly achieved, and sediment sources are addressed, however along much of the Program streams advancement to Stage V geometry would require significantly wider channel corridors and development precludes such actions. Thus, many Santa Clara Valley streams are stuck in Stages II-IV, perpetuating instability, as a result significant grade controls and bank protection features are common. Nearby grade controls, especially those downstream of potential project sites need to be evaluated, and if deemed necessary, project plans should incorporate design or adaptive management contingencies if those grade controls were to fail and propagate a knickpoint upstream.

Augmentation of gravel and wood can arrest further incision, by “tipping the scales” back toward aggradation, however the hydraulic regime in Stage II-IV results in increases in faster, deeper flows which increase bed shear. The subsequent increase in frequency, intensity and duration of higher-shear events make placement of gravel and wood more challenging.

Bankfull hydraulic geometry relationships are that correlate drainage area to bankfull height, bankfull width, and bankfull cross-sectional area. Bankfull, commonly correlated to the 1.5 or 2-year recurrence flows, however for the Program streams it is important to point out that to varying degrees, topographic channel shape is not a reflection of equilibrium self-formed channel dimensions, as otherwise summarized by the concept of a bankfull channel (e.g. Leopold and others, 1964). Hydromodified streams typically exhibit two or more hydraulic geometries reflective of the multiple historic recurrent flow regimes. For this reason, we recommend conducting field studies of nearby reference reaches and measuring the channel cross-sectional geometry and taking detailed geomorphic observations at least 2-3 locations to inform the potential variability and channel evolution trajectories to inform LWD placement and gravel augmentation.

2.4.6 Gravel Augmentation

Gravel augmentation – the deliberate placement of coarse sediment in channels to enhance aquatic habitat or improve suitability for salmonids – is needed because changes in flows and sediment supply have sharply altered where sufficient gravels are available to support SC-CCCST spawning, rearing and other ecological functions for the reasons demonstrated in previous sections.

In low gradient channels, augmented spawning-sized gravels provide three-fold benefits: a) When used in conjunction with installed stream complexity elements such as LWD, the activation of bed sediment will facilitate new complex bedforms quickly b) natural bars will form quickly which can increase spawning and fast-water feeding opportunities, and (c) augmented gravel will typically transported downstream, encouraging development of bars outside the project reach, a benefit to other stream locations.

In steeper streams, augmentation of coarse material greater than 128 millimeters in diameter can reduce the embeddedness of existing coarse bed material and support the restoration of plane-bed and step-pool morphologies which can increase the carrying capacity for SC-CCCST.

Successful gravel augmentation requires systematic development toward site- and channel-specific objectives and constraints during planning and implementation. Though numerous projects have been implemented in California and elsewhere, gravel augmentation is a young science and there are significant uncertainties. Many uncertainties were presented in Harvey and others (2005) and more recently for the Guadalupe River by USACE and others (2013). Local geologic, geomorphic and hydrologic restrictions specific to each river must be considered. Specific challenges include predicting flushing flows (magnitude and frequency), evaluating quantities and the management of gravel sources, evaluating the desired gravel quality (size, angularity, pathogens, contaminants and organics), and selecting effective sediment placement techniques.

2.4.7 LWD Augmentation

LWD controls many of the functional and structural properties of smaller streams in wooded areas. Mainly, LWD in channels absorbs and deflects energy, creating a complex channel configuration within which fish can find shelter and cover from high velocities and from predators, as well as faster water within which they can feed. The LWD within the channel or lining the banks often form deeper pools, an essential component of salmonid habitat in the small- or mid-sized steep channels typical of the Santa Clara Valley, adults, downstream-migrating salmonid smolt, and summer-resident fish use the pools to rest and cover as well as home territory from which they can dart into faster water to feed.

LWD affects channel form by inducing formation and stabilization of pools, gravel bars, and undercut banks. LWD influences sediment routing through formation of depositional sites, bars and islands. Jams or interlocking accumulations of LWD can deflect high flows into banks or bars, occasionally causing a channel to change course, or ‘avulse’, leading to secondary changes to the stream course downstream from the wood structure, with associated risks of flooding or new channel formation. Wood jams or LWD ploughing its way downstream can also be important factors in turning over the bed, releasing accumulated fine sediment, coarsening and freshening the bed to provide long-term improvement in bed conditions.

LWD retains coarse particulate organic matter (CPOM, e.g. Raikow and others, 1995), which both increases terrestrial carbon storage (e.g. Wohl and others, 2017, Battin and others, 2008), and supports the aquatic food web (Muotka and Laasonen, 2002). Muoka and Laasonen (2002) suggest that adding LWD to gravel augmentation projects can help counteract the losses of aquatic mosses and other aquatic flora that are typically absent immediately after gravel augmentation.

2.5 Watershed Physical Descriptions

Watershed parameters including anadromous stream length, watershed area, watershed area impounded by reservoirs, range of mean annual precipitation (MAP), highest elevation, and percent protected area (CPAD, 2016) are presented in **Table 2-2**. Long profiles for the Program streams and significant anadromous tributaries are presented in **Figure 2-8**, **Figure 2-9**, **Figure 2-10**, **Figure 2-11**, **Figure 2-12** and **Figure 2-13.**

Table 2-2 Summary of Program stream characteristics

Creek Name	Watershed Area (sq. mi)	Watershed Area Impounded by Reservoirs (sq. mi)	Limit of Anadromy (total barrier)	Stream Length Downstream of Anadromy Limit (mi)	Highest MAP[1] inches (mm)	Lowest MAP[1] inches (mm)	Highest Elevation (ft)	CPAD-Percent Protected (%)	Dominant Bedrock Geology[2]
Stevens Creek	38	17	Stevens Creek Reservoir	10.0	52 (1313)	16 (400)	2,900	41%	Franciscan assemblage: graywacke sandstone and greenstone, Tertiary sandstones and shales
Los Gatos Creek	55	42	Camden Drop Structure	5.7	53 (1336)	16 (399)	3,790	34%	Franciscan assemblage: graywacke standstone
Guadalupe Creek	15	6	Guadalupe Reservoir	5.9	49 (1250)	17 (437)	3,480	73%	Franciscan assemblage: graywacke standstone
Alamitos Creek	38	12	Almaden Reservoir	7.6	53 (1336)	17 (437)	3,790	55%	Franciscan assemblage: greenstone and melange
Guadalupe River	170	60	n/a	15.7	53 (1336)	15 (379)	3,790	32%	Franciscan assemblage: graywacke sandstone, greenstone, and melange
Coyote Creek	350	133	Anderson Reservoir	16.2	28 (711)	17 (421)	3,640	43%	Franciscan assemblage: sandstone, shale, and melange
Upper Penitencia Creek	24	2.4	Natural cascade	7.4	24 (617)	15 (393)	3,330	59%	Franciscan assemblage: graywacke sandstone, shale, and melange
Arroyo Aguague	13	0	Natural cascade	1.3	24 (611)	19 (483)	2,990	71%	Panoche Formation: clay shale or sandstone and conglomerate
Uvas Creek	89	16	Uvas Reservoir	17.2	51 (1289)	20 (499)	3,790	16%	Franciscan assemblage: graywacke standstone and greenstone
Little Arthur Creek	9	9	Irrigation Dam	1.5	40 (1007)	27 (692)	2,490	23%	Franciscan assemblage: graywacke standstone
Bodfish Creek	7	7	Natural cascade	4.2	37 (940)	27 (677)	1,890	41%	Franciscan assemblage: graywacke standstone and greenstone; Marine sedimentary rocks: clay shale

Notes

[1] Mean annual precipitation (MAP) data was collected from the PRISM 30 year (1980-2010) normal annual precipitation

[2] In most cases, upstream of major reservoirs

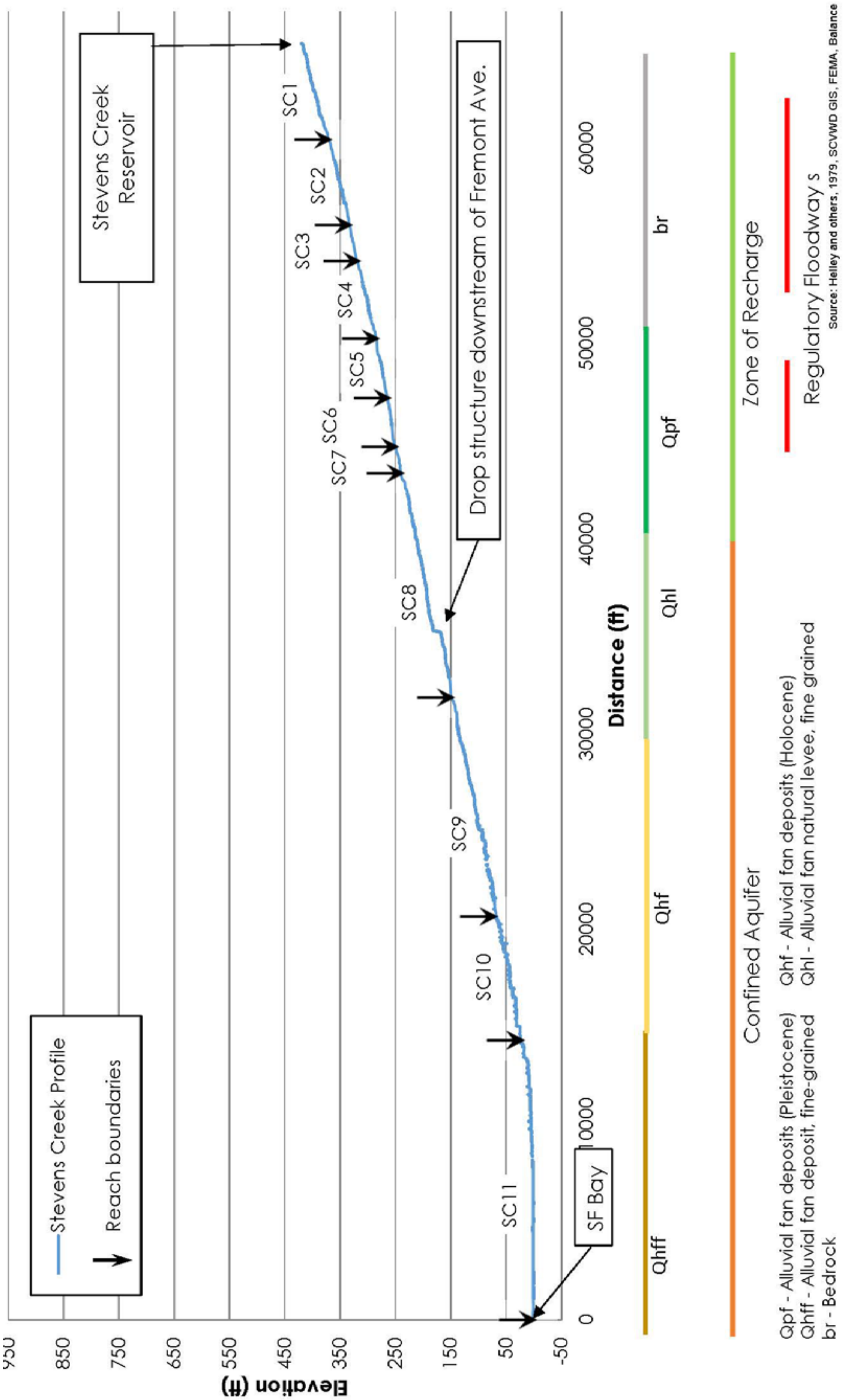


Figure 2-8 Long profile of anadromous reach of Stevens Creek.

Long profile data are correlated with underlying and adjacent Quaternary deposits (following Helley and others, 1979), location of confined and unconfined aquifers and locations of FEMA regulatory floodways.

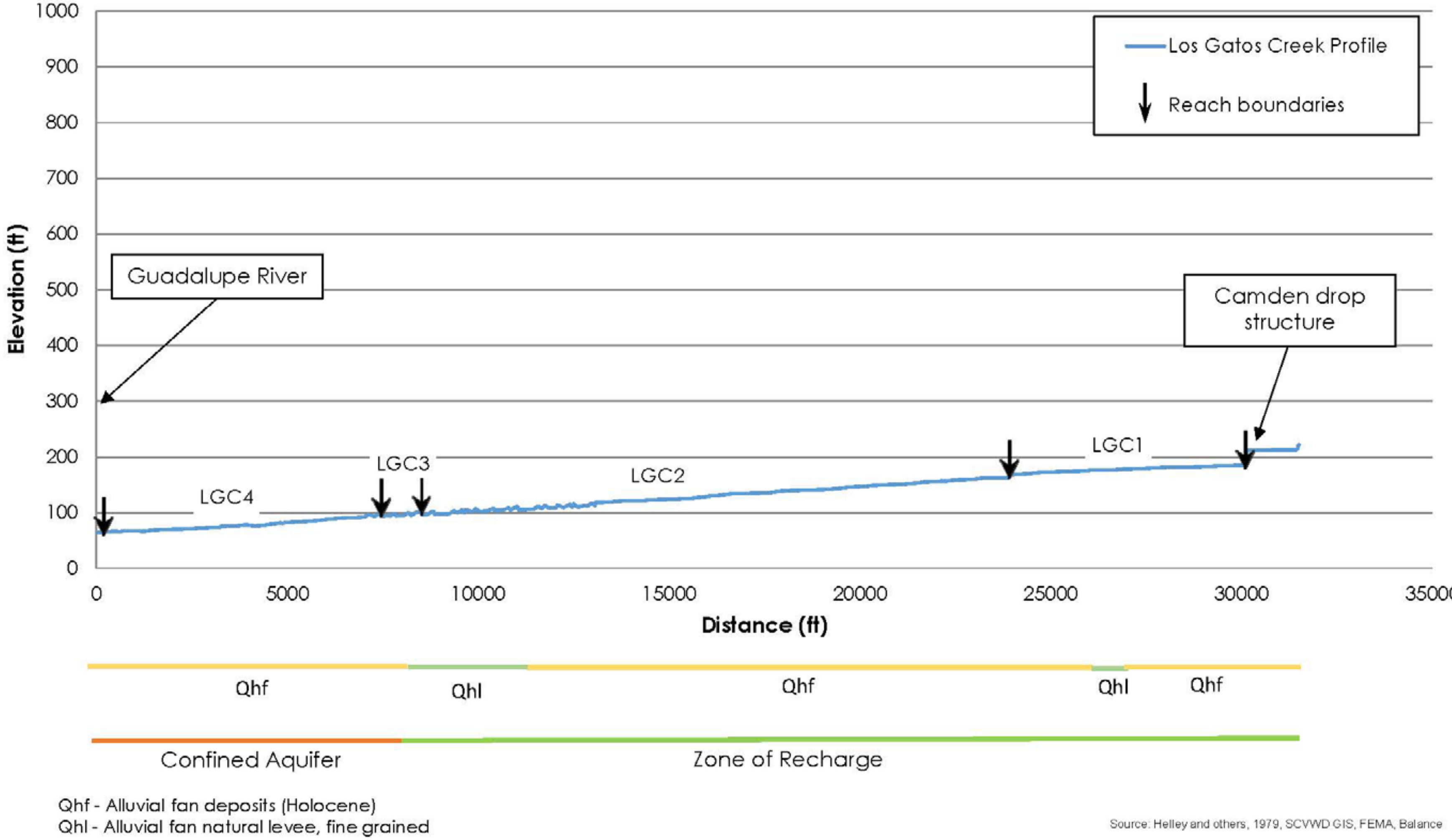


Figure 2-9 Long profile of anadromous reach of Los Gatos Creek.

Long profile data are correlated with underlying and adjacent Quaternary deposits (Following Helley and others, 1979) There are no FEMA regulatory floodways on Los Gatos Creek.

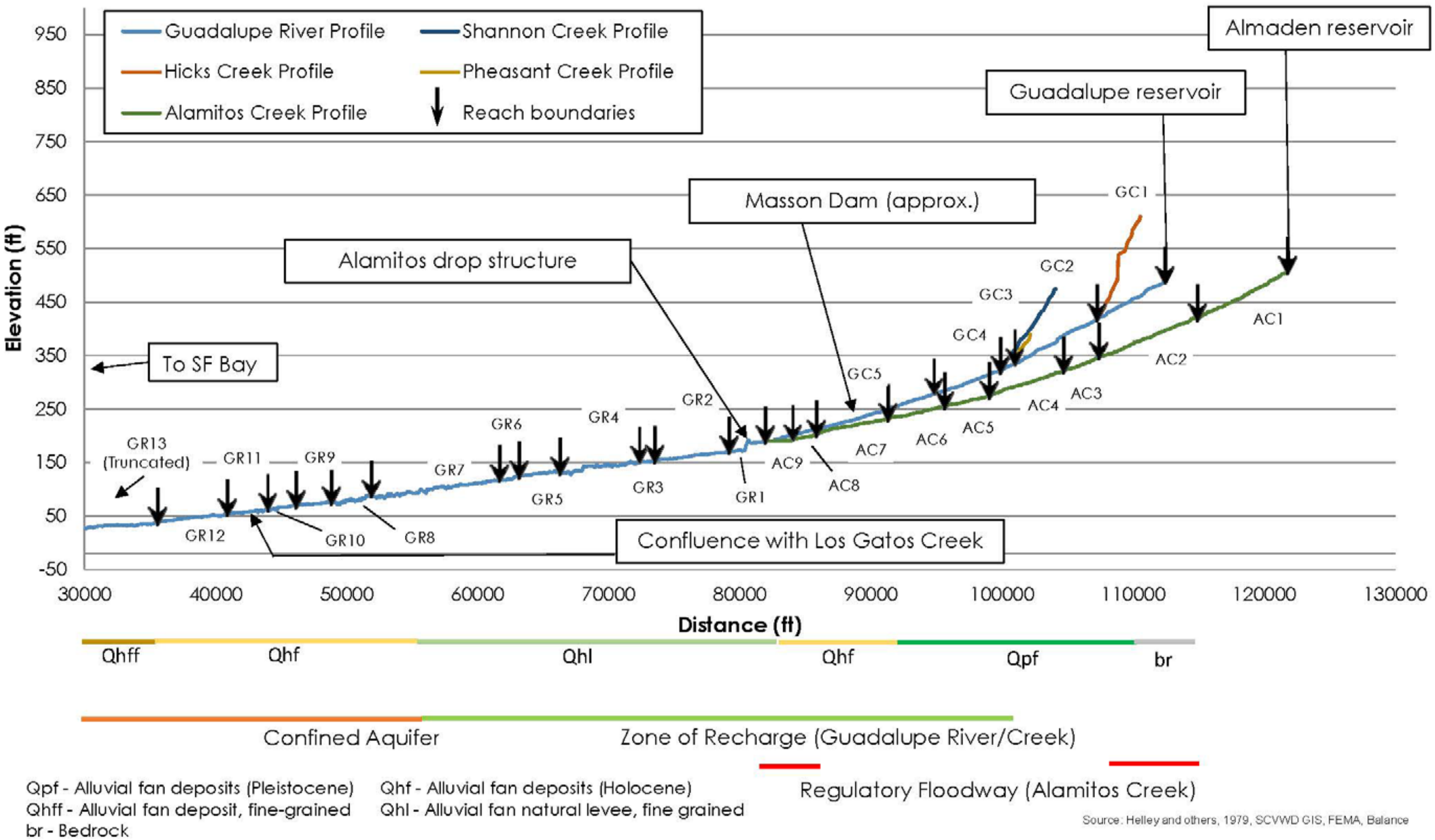


Figure 2-10 Long profile of anadromous reach of Guadalupe River, Guadalupe Creek and Alamitos Creek.

Long profile data are correlated with underlying and adjacent Quaternary deposits (following Helley and others, 1979), location of confined and unconfined aquifers and locations of FEMA regulatory floodways.

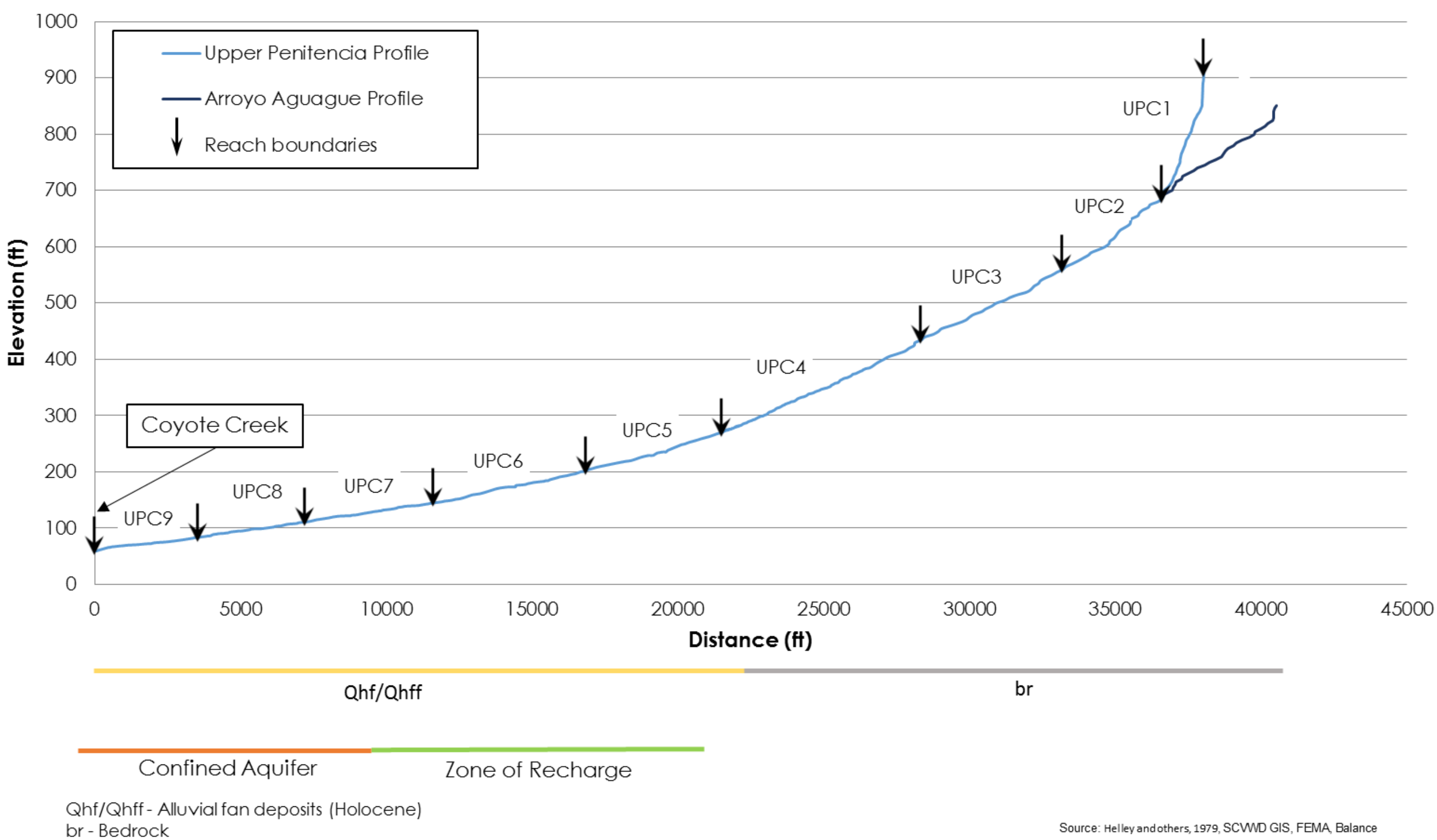


Figure 2-11 Long profile of anadromous reach of Upper Penitencia Creek.

Long profile data are correlated with underlying and adjacent Quaternary deposits (following Helley and others, 1979), location of confined and unconfined aquifers. There are no FEMA regulatory floodways on Upper Penitencia Creek.

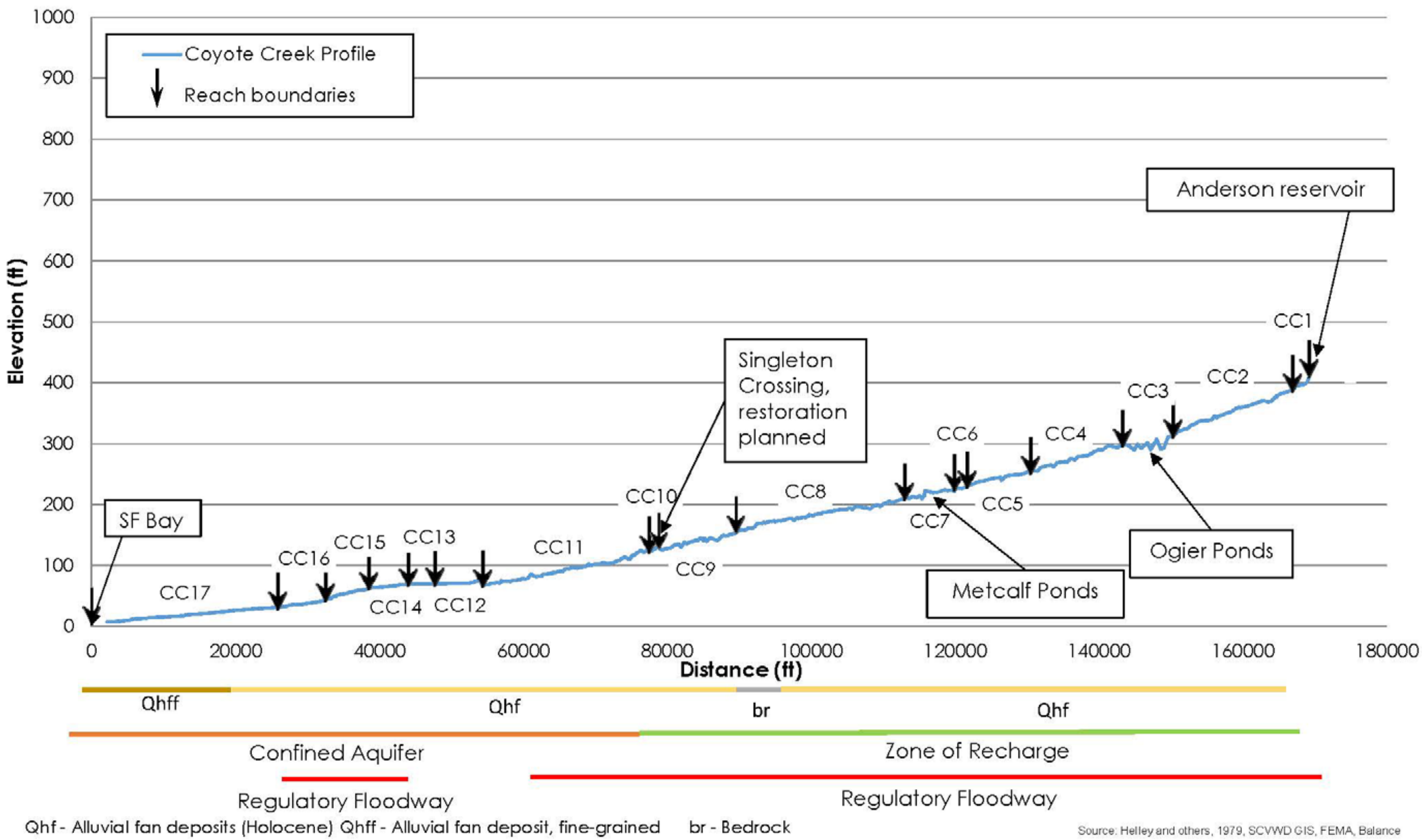


Figure 2-12 Long profile of anadromous reach of Coyote Creek.

Long profile data are correlated with underlying and adjacent Quaternary deposits (Following helley and others, 1979), location of confined and unconfined aquifers and locations of FEMA regulatory floodways.

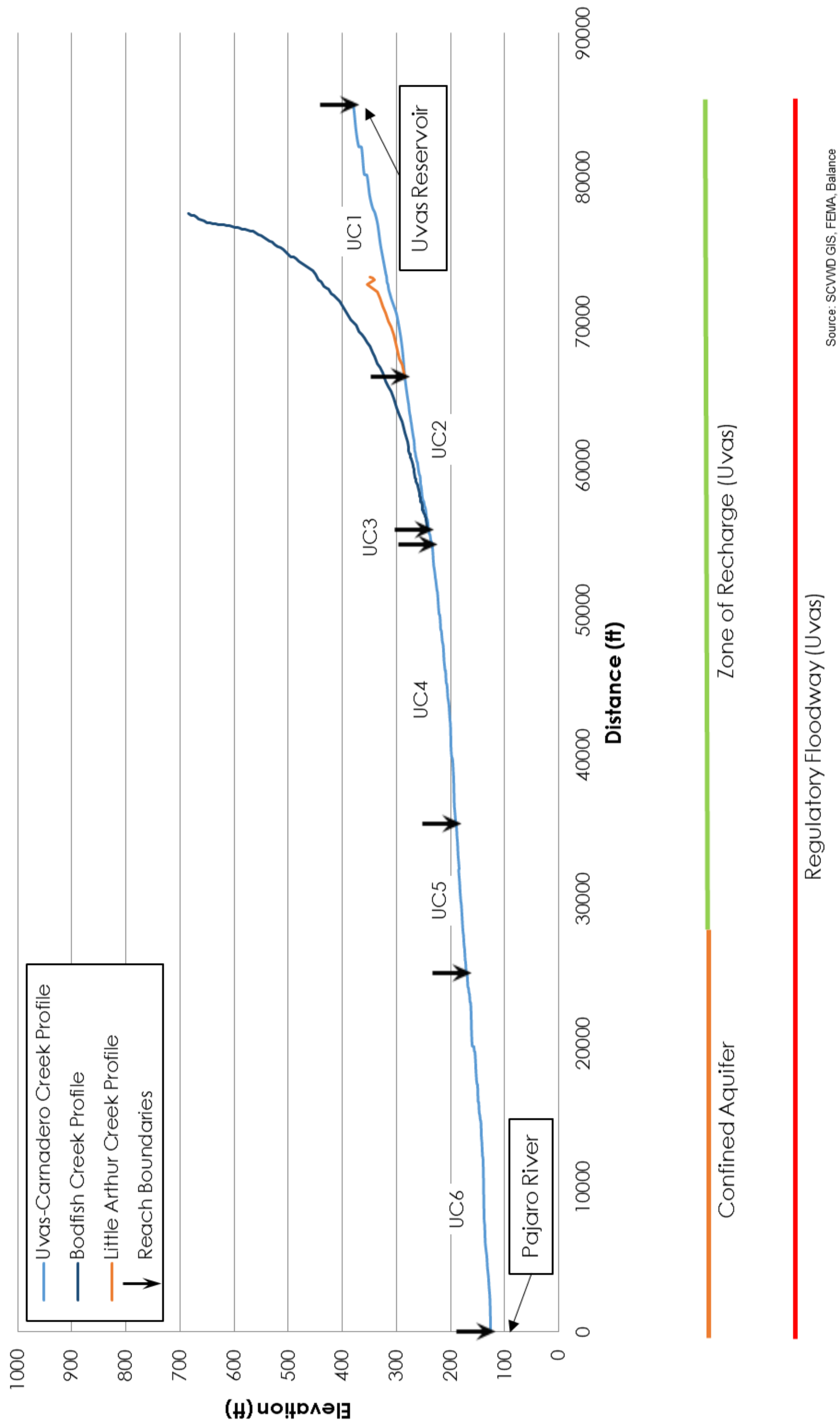


Figure 2-13 Long profile of anadromous reach of Uvas Creek.

Long profile data are correlated with the location of confined and unconfined aquifers and locations of FEMA regulatory floodways.

2.5.1 Stevens Creek

Although located in a highly urbanized region, Stevens Creek originates in the Santa Cruz Mountains. The upper watershed follows the San Andreas Fault traversing southeast before turning north where the creek is impounded by Stevens Creek Reservoir. Downstream of Stevens Creek Reservoir, Steven Creek receives runoff and sediment from hillslopes and side channels that drain the Santa Clara Formation and older Pleistocene terrace deposits (**Figure 2-8**), a potentially good source of gravel and other coarse sediment.

Stevens Creek Reservoir is the limit of anadromy. Stevens Creek Reservoir was constructed in 1935 and impounds 17.3 square miles of the watershed. The total watershed area is 37.7 square miles. Creek flows through the Program reaches are highly regulated by the Stevens Creek Reservoir. Streamflow downstream of the dam is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Gage No. 5044, operated by the Santa Clara Valley Water District).

Stevens Creek is unusual in that there appear to have been few if any large fires within this watershed. Substantial additional flows following a large fire would perhaps place additional stress on the bed, as the fire-related coarse sediment would likely be retained in the reservoir.

Long reaches of Stevens Creek are within FEMA regulatory floodways (**Figure 2-8**).

2.5.2 Los Gatos Creek

Los Gatos Creek is one of several major streams that drain the east side of the Santa Cruz Mountains to the San Francisco Bay, originating at an elevation of about 3,500 feet (SCBWMI, 2003), with a contributing area of approximately 55 square miles, 13.9 square miles of which is downstream of Lexington Reservoir. The limit of anadromy is the Camden drop structure just downstream of the Vasona Reservoir recharge complex. The anadromous reach is underlain by alluvial sediments (**Figure 2-9**). Before the mid-1850s, there was no defined channel connecting Los Gatos Creek to the Guadalupe River (Beller and others, 2010), and instead the confluence was characterized by an un-channelized wet meadow grove at the edge of Willow Glen, an historic expanse of willows. The wet meadows and wetlands formed on top of thick, inter-bedded clay-rich sediments, deposited at the distal alluvial fan edge. This type of channel terminus morphology was prevalent throughout the South Bay prior to settlement and land conversion (e.g. Grossinger and others, 2006).

Since the 1850s much of the lower watershed area has been developed and includes more than 40 percent of impervious cover (SCVWD, 2006). In addition, channel modification since the late 1800s has been extensive, with 31 percent of the channel hardened below Lexington Reservoir (SCVWD, 2006). As is the norm for similar streams that cross the Santa Clara Valley, Los Gatos Creek has incised dramatically since the late 1800s. Upstream flow regulation has transformed a braided, ephemeral creek into a perennially flowing, single-threaded system.

Flows in Los Gatos Creek are highly regulated by upstream reservoirs. Lake Elsman was built in 1948 in the upper watershed to capture surface water runoff. Its original capacity was about 6,200 acre-feet, but it is now largely sedimented and has little holding capacity (SCVWD, 2006). Lexington Reservoir was built in 1952 and is also located in the upper watershed. Its capacity is about 20,000 acre-feet. Streamflow downstream of Vasona Reservoir is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Gage No. 5059, operated by the Santa Clara Valley Water District). Streamflow from the middle of the anadromous reach is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Gage No. 5050, operated by the Santa Clara Valley Water District).

Flow regulation in Los Gatos Creek affects both winter and summertime flow regimes. For example, beginning about 15 years ago, summertime flow regulation began with prescribed outflows from Vasona Reservoir, resulting in daily flow variations of between 1.5 and 4.0 cfs, as measured at the District Lincoln Avenue Stream Gage Station 50 (Owens and others, 2010). Prior to this flow regime change the creek was typically dry during summer months (Owens and others, 2010).

There are no FEMA regulatory floodways mapped along Los Gatos Creek (**Figure 2-9**).

2.5.3 GUADALUPE CREEK

Guadalupe Creek drains the Santa Cruz Mountains, and travels north to the confluence with Alamitos Creek, where the two become the Guadalupe River. Guadalupe Reservoir was built in 1935 and captures flows and releases water to the channel to encourage recharge through streambed percolation and percolation ponds. Guadalupe Reservoir is the limit of anadromy. Guadalupe Creek, like Alamitos and Uvas Creeks, is dammed upstream of the range-front, and therefore has a number of unregulated tributaries which contribute water and sediment. In addition, Guadalupe Creek has a long, canyon source/transport reach before it emerges into the Santa Clara Basin.

Historic mercury mining within the watershed requires consideration, both about the implications of sourcing sediment from the watershed for augmentation, as well as disturbing calcines and mercury laden sediments. The RWQCB has implemented a Total Maximum Daily Load (TMDL) for mercury which establishes mercury releases from the stream to the San Francisco Bay. Program actions should consider disturbance to existing calcines and methylated mercury laden sediments. Calcines are a byproduct of the mercury refinement process and are primarily a concern in Guadalupe Creek and Alamitos Creek.

Streamflow downstream of Guadalupe Reservoir is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Gage No. 5017, operated by the Santa Clara Valley Water District).

There are no FEMA regulatory floodways mapped on Guadalupe Creek (**Figure 2-10**).

2.5.4 Alamitos Creek

Alamitos Creek originates in the Santa Cruz Mountains at an elevation of about 3,790 feet and is a tributary to the Guadalupe River. Almaden Reservoir, with a capacity of 1,780 acre-feet, was built in 1935, and is the limit of anadromy.

Alamitos Creek, like Guadalupe and Uvas Creeks is dammed upstream of the range-front, and therefore has a number of unregulated tributaries which contribute water and sediment. In addition, Guadalupe Creek has a long, canyon source/transport reach before it emerges into the Santa Clara Basin.

Historic mercury mining within the watershed requires consideration, both about the implications of sourcing sediment from the watershed for augmentation, as well as disturbing incipient calcines and mercury and methylmercury laden sediments.

Alamitos Creek is regulated downstream of Almaden Reservoir by prescribed outflows from the reservoir. Streamflow releases from the dam are documented at a stream gaging station, Alamitos Creek Gage No. 5016, located downstream of the dam, and are made available to the public via the Santa Clara Valley Water District website[2].

Alamitos Creek drains into Lake Almaden prior to joining Guadalupe Creek, where all coarse sediment transported by Alamitos Creek is deposited.

Select reaches of Alamitos Creek are within FEMA regulatory floodways (**Figure 2-10**).

2.5.5 Guadalupe River

The Guadalupe River originates at the confluence of Alamitos and Guadalupe Creeks. Other tributaries including Canoas and Ross Creeks join Guadalupe River downstream of the confluence.

Historically, the Guadalupe River originated in the Willow Glen Neighborhood, 4 miles downstream of the current confluence of Alamitos and Guadalupe Creeks, in a broad area of seep and spring wetlands colonized with willows and sycamores. Through the later part of the 19th century and into the 20th century the channel was excavated and channelized.

Like elsewhere, land use change and urbanization, in combination with reservoir construction, have caused channel incision. No coarse sediment currently bypasses Lake Almaden on Alamitos Creek. However, it is our understanding the Alamitos drop structure (**Figure 2-10**), which controls water levels in Lake Almaden, but also backwaters the downstream-most portions of Guadalupe Creek may be a partial sediment transport barrier. Flashboards are installed between May and December to avoid high-flow periods. Per the District's LSA with CDFW, they are permitted to remove up to 50 cy of sediment from the Alamitos drop structure to facilitate annual placement of the flashboards, however it is understanding that the sediment removal is rarely performed. Thus, sediment transport is likely to occur across the Alamitos drop structure, less the amount of sediment that is deposited at the outlet of Lake Almaden.

Maximum land subsidence due to the rapid draw-down of groundwater in the early 20th century is centered north of downtown (**Figure 2-1**) San Jose and the confluence of Los

[2]http://www.alert.valleywater.org, Gage No. 1544

Gatos Creek, likely exacerbating incision on the upstream side of the subsidence cone. The centroid of subsidence extends to the Bay fringe.

Streamflow near the top of the alluvial reaches of the Guadalupe River is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Almaden Expressway Gage, Gage No. 5023, operated by the Santa Clara Valley Water District).

The entire length of Guadalupe River is within the limit of Anadromy.

No FEMA regulatory floodways are mapped on Guadalupe River (**Figure 2-10**).

2.5.6 Upper Penitencia Creek

Upper Penitencia Creek drains the Diablo Range from an elevation of about 3,300 feet. The shape of the watershed is strongly controlled by the Calaveras and associated faults. Prior to the 1800s, Upper Penitencia Creek did not connect with Coyote Creek. At some point in the early 1900's, the reach downstream of the range-front, Upper Penitencia Creek was permanently diverted to drain directly into Coyote Creek within a confined corridor that typifies the current condition at the project site. This modification coupled with intensified settlement of the lower basin defines much of the present-day basin hydrography. Upper Penitencia Creek watershed drains approximately 24 square miles, 22 of which occur within predominantly un-urbanized canyon within the Diablo Range. Cherry Flat Reservoir is a small facility impounding 2.4 square miles upstream of Aguague Creek, the watershed's main tributary. Thus, Upper Penitencia Creek has a significantly unimpaired coarse sediment supply.

The District diverts flows to Upper Penitencia Creek via a pipeline to promote enhanced recharge of local alluvial aquifer. The pipeline introduced water to Upper Penitencia Creek near the head of the alluvial fan at the percolation pond facility near Noble Avenue. Most of this water is sourced from the Sacramento/San Joaquin Delta through the South Bay aqueduct.

Streamflow near the top of the alluvial reaches of Upper Penitencia Creek is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Piedmont Gage, Gage No. 5001, operated by the Santa Clara Valley Water District).

The limit of anadromy are two natural cascade barriers on Upper Penitencia Creek and Arroyo Aguague Creek, upstream of their confluence.

No FEMA regulatory floodways are mapped on Upper Penitencia Creek (**Figure 2-11**).

2.5.7 Coyote Creek

Coyote Creek drains a significant portion of the southern Diablo Range. It originates at approximately 3,640 feet. Two reservoirs, Coyote and Anderson, regulate flows to lower Coyote Creek. Coyote Dam was constructed in 1934 and Anderson Dam was constructed in 1950. Large portions of the upper watershed have been minimally disturbed and are largely undeveloped. A large portion of the upper watershed is within Henry Coe State Park. Operations of the two reservoirs to optimize yield and downstream recharge have changed the hydrology downstream since the 1950s. Water is directed out of Anderson Reservoir through outlet works and (occasionally) a spillway. Immediately downstream of the dam there is a diversion canal, which is no longer in use, however it occasionally captures water, as was the case in 2017. In addition, two in-line percolation facilities, Ogier and Metcalf ponds (**Figure 2-12**) trap transported coarse sediment. Anderson Dam is the limit of anadromy.

Twenty tributaries join Coyote Creek downstream of Anderson Dam. Historically, the portion of Coyote Creek tributaries did not connect (or infrequently connected) to Coyote Creek through a channel, but rather terminated in backwaters and arroyos along the natural levees created by Coyote Creek. Channelization of tributaries in the 19^{th} and 20^{th} centuries increased the flashiness of the watershed, very substantially exacerbating incision.

Streamflow downstream of Anderson Reservoir is documented and made available to the public via the Santa Clara Valley Water District's homepage on the World Wide Web (Madrone Gage, Gage No. 5082, operated by the Santa Clara Valley Water District). Streamflow and stage are also reported at other stations along Coyote Creek.

Many reaches along Coyote Creek are within FEMA regulatory floodways (**Figure 2-12**), which poses significant challenges to implementing gravel and LWD augmentation. Coyote Creek also flows through area of land subsidence, previously discussed in connection with Los Gatos Creek.

2.5.8 UVAS CREEK

Uvas Creek Drains mountainous areas of the mid- to south portions of the Santa Cruz Mountains. Uvas Reservoir impounds flows before the creek traverses the valley floor toward Gilroy. Much of the channel between Uvas Reservoir and Gilroy is nestled between farms, orchards and ranches, however there is very little land within District Fee or Easement. Uvas Reservoir, an early 1960s structure, is the limit of anadromy.

Prior to construction of Uvas Reservoir in 1957, the Program reaches were predominantly braided (Kondolf and others, 2001). Gravel mining has occurred extensively within this reach. Changes in releases from Uvas Reservoir appear to have increased the vigor and density of riparian vegetation along many of the Program reaches. The valley floor configuration – including the extent of woody riparian vegetation – has frequently changed ("been re-set" in response to peak flow events.

Uvas Creek, like Guadalupe and Alamitos Creeks is dammed upstream of the range-front, and therefore has a number of unregulated tributaries which contribute water and sediment. In addition, Uvas Creek has a long, canyon source/transport reach before it emerges into the Santa Clara Basin.

Bodfish Creek has a long anadromous reach. The channel extends into the Santa Cruz Mountains along Hecker Pass Road to natural cascade barriers on Bodfish Creek and a number of unnamed tributaries. Much of the Program reach is directly adjacent to private property, with the exception of Mount Madonna County Park.

Anadromy extends 1.5 miles up Little Arthur Creek to a historic diversion dam. It is our understanding the coarse sediment can pass the diversion dam and reach Uvas Creek. Much of the Program reach is directly adjacent to private property. Little Arthur Creek was identified in the 1982 Pajaro Basin Habitat Enhancement Plan as having substantial restoration potential.

Through Gilroy, a levee has been constructed to contain flood flows. The entire anadromous reach of Uvas Creek is within FEMA regulatory floodways (**Figure 2-13**), however major anadromous tributaries Little Arthur Creek and Bodfish Creeks are not mapped as regulatory floodways.

2.6 Hydrology

2.6.1 WATER QUALITY CONSIDERATIONS

Section 303(d) of the Federal Clean Water Act requires the identification of waterbodies that do not meet, or are not expected to meet, water quality standards. The affected waterbody, and associated pollutant or stressor, is then prioritized in the 303(d) List for development of a Total Maximum Daily Load (TMDL). TMDLs are action plans to restore clean water. The current list, approved by the EPA, is the 2010 303(d) List. **Table 2-3** lists each of the waterbodies included in the Program and associated 303(d) listings.

Table 2-3 Current (2010) EPA 303(d) water quality listings for Program streams

Creek	303(d) Listing
Alamitos Creek	Mercury
Arroyo Aguague Creek	None
Coyote Creek	Diazinon, trash, toxicity (proposed in 2016)
Guadalupe Creek	Mercury
Guadalupe River	Diazinon, mercury, trash
Hicks Creek	None
Los Gatos Creek	Diazinon
Pheasant Creek	None
Stevens Creek	Diazinon, water temperature, toxicity, trash
Upper Penitencia Creek	None
Bodfish Creek	None
Little Arthur Creek	None
Uvas-Carnadero Creek	Low dissolved oxygen, turbidity

The following bullet points summarize the relevant findings from the **Table 2-3**:

- Many of the creeks draining to San Francisco Bay are listed for diazinon. Diazinon has been found to disrupt antipredator and homing behaviors in salmonids (Scholz and others, 2000). This potential pollutant is being addressed by the Diazinon and Pesticide-Related Toxicity in Urban Creeks TMDL which became effective in 2007.

- Trash loads from municipal separate storm sewer systems (MS4s) are being reduced through provisions in the San Francisco Bay Regional Municipal Regional Stormwater NPDES Permit (MRP) and the Statewide Trash Amendments to the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries (adopted in 2015).

- The Pajaro River Basin Nutrient TMDLs (adopted in 2015) address nitrate and low dissolved oxygen in waterbodies draining to the Pajaro River.

- The Guadalupe River Watershed Mercury TMDL (adopted in 2008) and San Francisco Bay Mercury TMDL together address mercury from sources such as the mercury mining and atmospheric deposition. The considerations for legacy mercury mining on gravel augmentation are potentially significant, and we present a more detailed discussion in **Section 4.2**.

For the purposes of the Program, we consider water quality to be primarily an issue of contaminants, rather than turbidity or temperature (discussed below). For example, our experience, and the experience of the District staff, suggest that restoration in support of CCCST recovery is desirable on Alamitos Creek, even though mercury mining was centered in the watershed, with legacy calcine deposits widespread, and methylated mercury a concern. For example, where disturbing calcine deposits is a primary concern, an approach that minimized bed and bank erosion may be warranted. Thus, we have not utilized the presence of contaminants, or 303(d) listing status as a site prioritization criterion.

2.6.2 Climate Change Considerations

Based on review of the IPCC climate change models, we anticipate that the predicted county-wide variability is not significant enough to justify use as a reach prioritization tool. However, climate resiliency is a potential factor to consider when developing design concepts and subsequent adaptive management planning. Projections of mean annual surface temperature and total annual precipitation are used to understand differences in climate projections over spatial and temporal scales, and how these projected changes may differ seasonally.

Climate projection data is explored through 2050, with the years 2020 and 2050 as benchmark years, with a 20-year historical average centered around 1995 as the baseline for historical comparison. Projection data is derived from SimCLIM, a climate change analysis application and database that can spatially represent and build databases of climate projections for a variety of pertinent parameters. SimCLIM uses 40 of the latest global circulation models (GCMs) run as part of the 2012 climate change assessment completed by the IPCC (CMIP5 generation of modules), published in 2013, at a 0.5° x 0.5° model resolution. The 40 GCMs represent a range of climatological conditions, and some GCMs predict certain regions or variables better than others. Therefore, all 40 GCMs were used in this analysis as an ensemble average representing the most statistically reliable results.

The model is downscaled to a 1km x 1km grid cell resolution using a pattern-scaling method (Li and Ye, 2011). The greatly reduced grid cell size was the primary reason for selecting the SimCLIM dataset over other available climate change projections, such as Cal-Adapt. Santa Clara County has a wide-range of topographic variation which leads to a wide-range in mean annual precipitation and so the higher-resolution data provides more accurate representation of climatological processes.

SimCLIM allows for selection of one of four Representative Concentration Pathway (RCP): 2.6, 4.5, 6.0, and 8.5. A RCP is a projection for greenhouse gas concentration trajectories, which were updated in 2014. The 8.5 RCP will act as the “worst” case scenario in this analysis. While the 2.6 RCP is the best-case scenario for emissions, achievement of this pathway requires aggressive removal of atmospheric carbon (Van Vuuren and others, 2011). Because many experts question whether it will prove possible to achieve RCP 2.6, we are using the 4.5 RCP as the “best” case scenario.

Climate projections are not uniform over all Santa Clara County and vary spatially as well as temporally and seasonally. The following figures explore these long-term trends and these results are summarized as follows:

- **Spatial variability:**

  Figure 2-14 and **Figure 2-15** show increases of total annual precipitation across the entire Santa Clara Valley for all scenarios. Precipitation is expected to increase most for the Stevens Creek watershed, by about 3-5 percent by 2050, for RCP 4.5 and 8.5, respectively. **Figure 2-16** and **Figure 2-17** show that mean annual temperatures (°C) in the Santa Clara Valley are projected to increase by less than 2 percent by the year 2050, representing a maximum increase of only 0.3 C° (2050, RCP 8.5). Warming is expected to occur slightly more rapidly in the eastern part of the Valley. Precipitation in the Coyote Creek and Guadalupe River watersheds to the south and east is expected to increase by a smaller amount than for Stevens Creek, the extent of which is dependent upon the year analyzed and RCP.

- **Temporal and seasonal variability:**

  Figure 2-18 shows the long-term trends in average air temperature and total monthly precipitation averaged over Santa Clara County for each season: January, February, March (JFM); April, May, June(AMJ); July, August, September (JAS); and October, November, December (OND). Seasonal trends show that total monthly precipitation (**Figure 2-18 a-b**) will likely stay relatively consistent, but that precipitation in JFM are projected to increase by approximately 0.7 – 1.0 inches by the year 2050 for RCP 4.5 and RCP 8.5, respectively. Trends also indicate that precipitation may decrease slightly during the OND months, but expected changes are a smaller magnitude than the winter increases. Conversely, long-term averaged air temperatures are likely to increase at a consistent rate in all seasons, with slightly higher average air temperatures expected for the worst-case RCP 8.5 than for RCP 4.5.

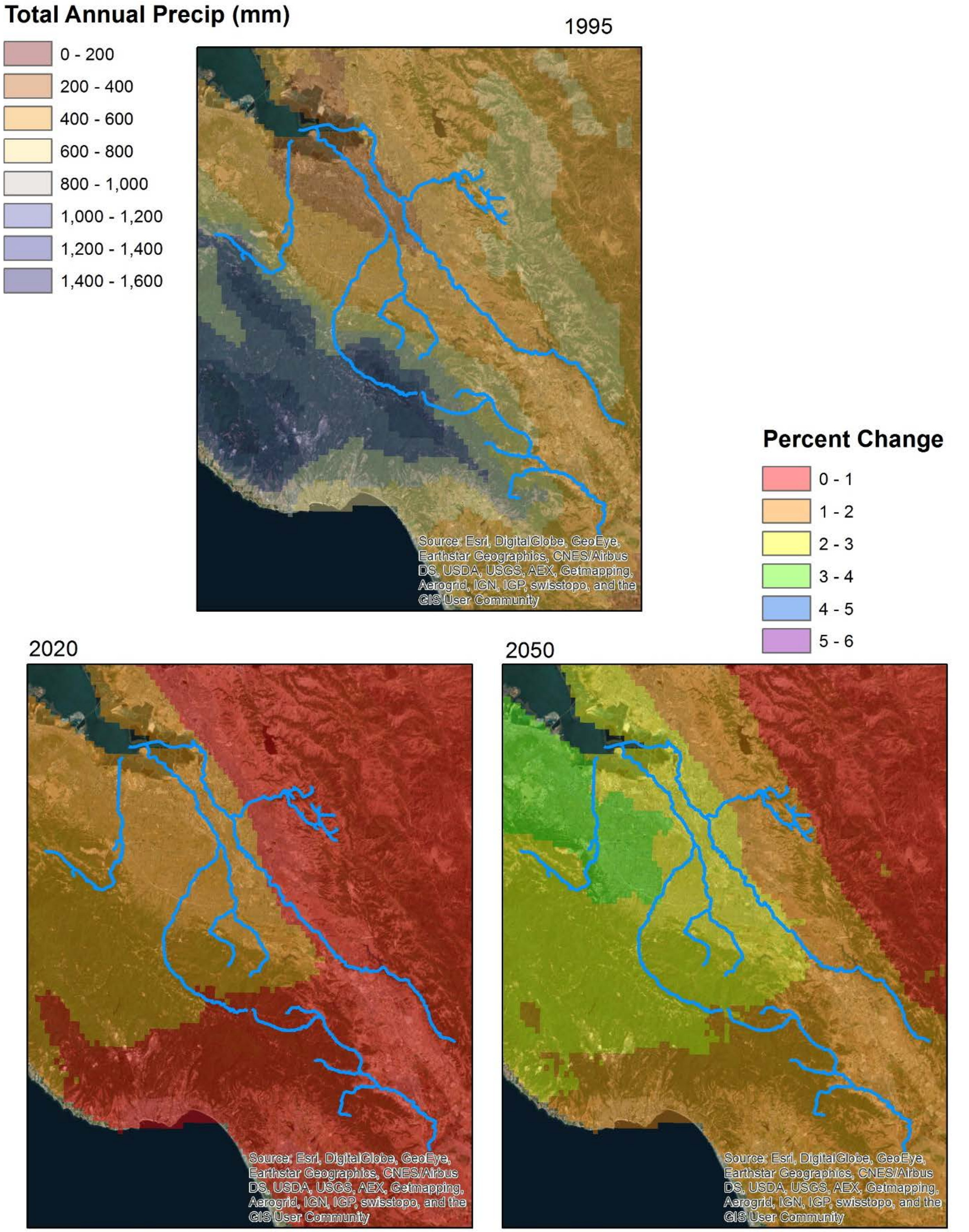


Figure 2-14 Predicted percent change in total annual precipitation from 1995, RCP 4.5 "best-case Scenario", for years 2020 and 2050.

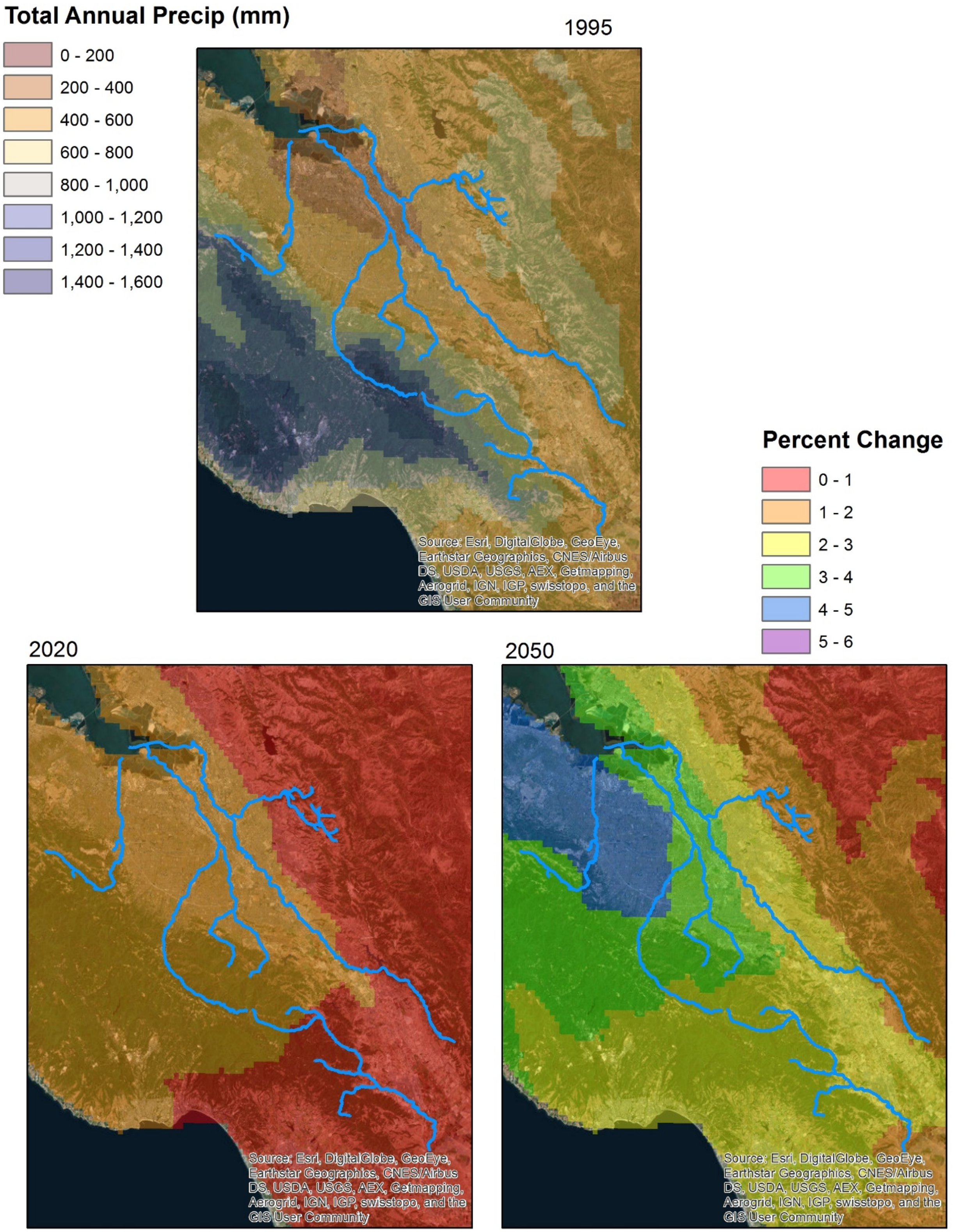


Figure 2-15 Predicted percent change in total annual precipitation from 1995, RCP 8.5 "worst-case scenario", for years 2020 and 2050.

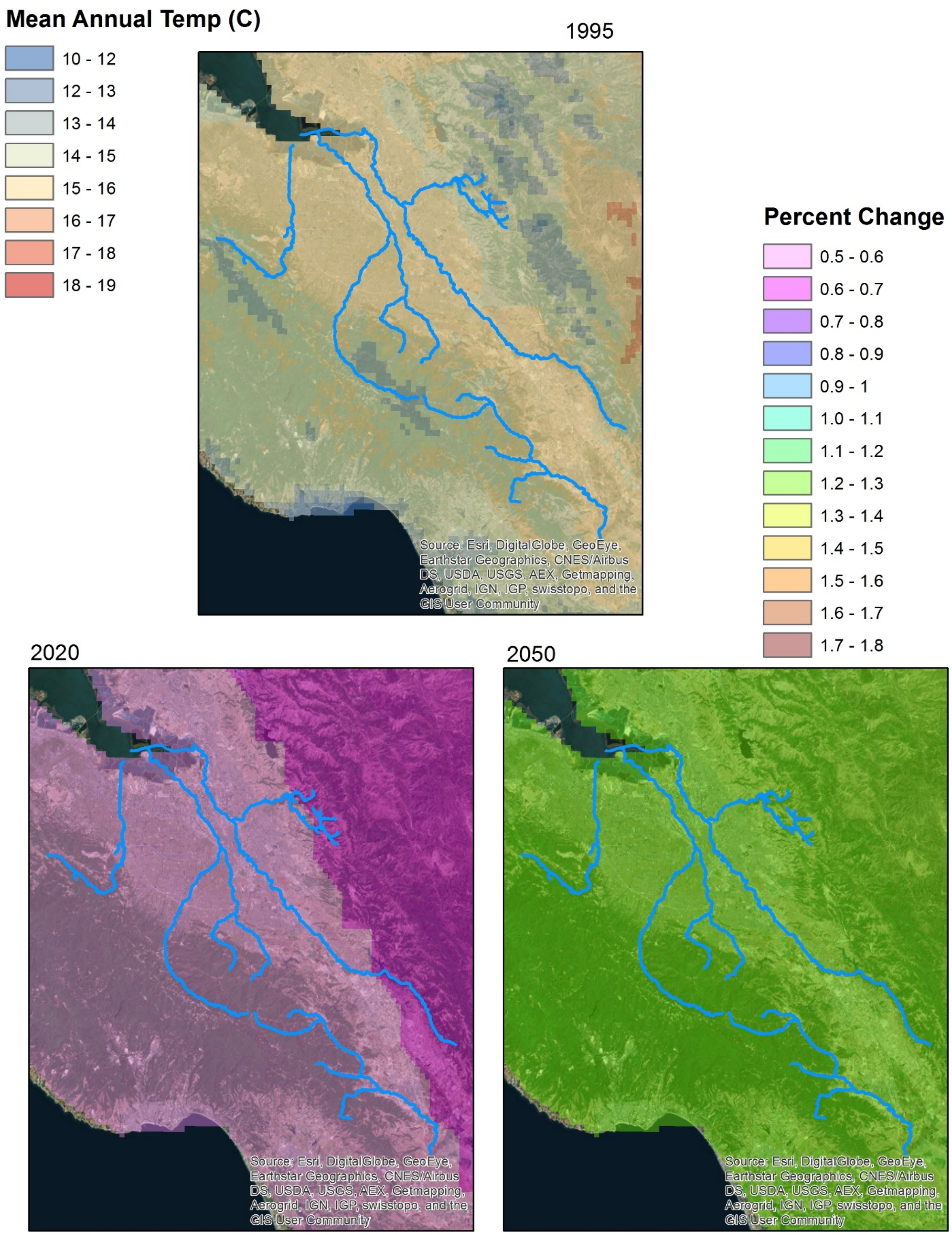


Figure 2-16 Predicted percent change in mean annual temperature from 1995, RCP 4.5 "best-case scenario", for years 2020 and 2050.

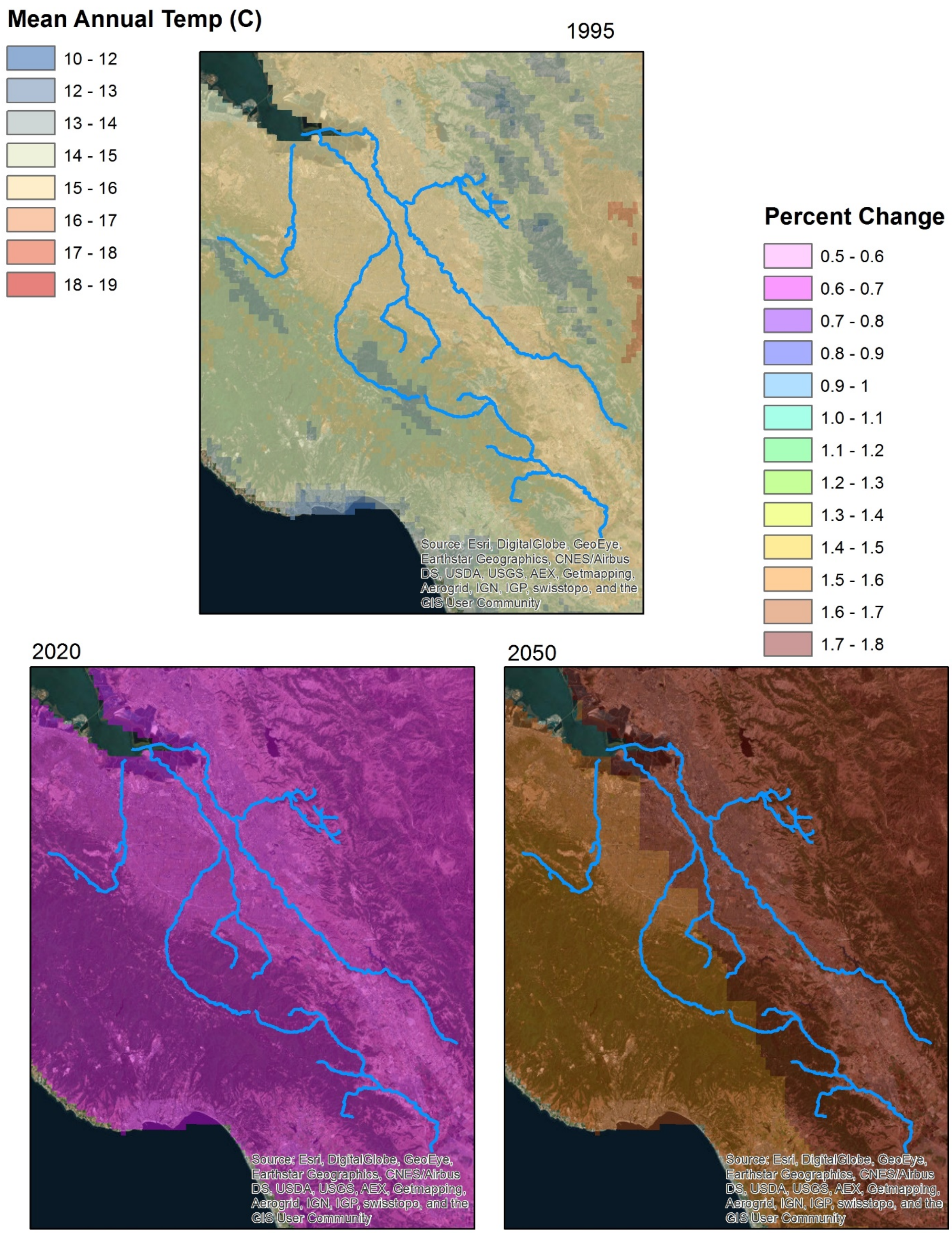


Figure 2-17 Predicted percent change in mean annual temperature from 1995, RCP 8.5 “worst-case scenario”, for years 2020 and 2050

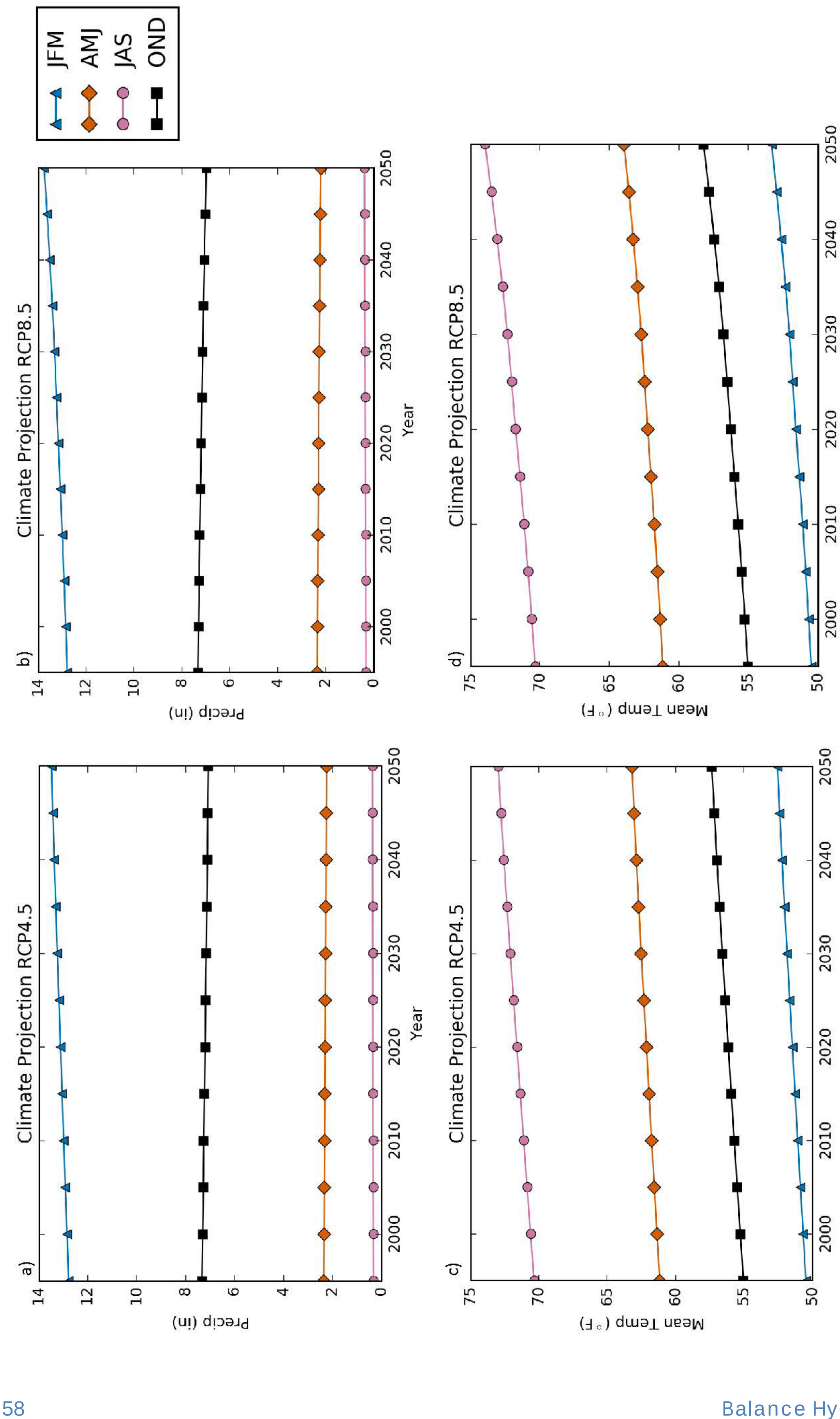


Figure 2-18 Projected long-term average precipitation and temperature for Santa Clara County.

a) projected precipitation for RCP 4.5, b) projected precipitation for RCP 8.5, c) projected mean air temperature for RCP 4.5, d) projected mean air temperature for RCP 8.5.

Climate change models provide long-term trends in average precipitation and temperature and are not detailed or precise enough predict individual storm events or precise timing of droughts. As a result, the expected increase in hydrologic variability (e.g. droughts and extreme precipitation events) is not directly analyzed. However, analysis and interpretation of these models has led the climate science community to agree that the frequency and magnitude of precipitation events and droughts will increase over time (e.g. Hagos, 2016, Pelletier, et al., 2015). Gravel and LWD augmentation are likely to reduce the potential erosive impacts of the predicted increase in the magnitude and frequency runoff events by contributing to roughness and effectively slowing flows, as well as reducing the effects of “hungry” sediment starved flood flows on bed and bank erosion. Precipitation is expected to change most dramatically within the northwest portion of the County, particularly in the Stevens Creek watershed, and the Guadalupe River watershed, including tributaries (**Figure 2-14** and **Figure 2-15**). Droughts are expected to become more common, however for the purposes of this Program we assume that baseflows will continue to be managed by District reservoir operators. In watersheds with no District reservoir, channels are expected to be drier more frequently. Augmented gravel may increase hyporheic flow, and therefore reduce connectivity of surface flows in extreme conditions. LWD is expected to have similar effects during droughts by creating pools and increasing sediment storage. In those streams, a practical approach to addressing climate change is to include appropriate additional factors of safety to address potential increases in sheer stress over the engineered lifespan of projects. Monitoring should consider the effects of climate change before making adaptive management decisions.

We anticipate that FEMA mapping policies and practices will change to address climate change. When new policies are developed and implemented by FEMA, the Program may need to be adapted.

2.6.3 Low-flow Conditions

Stream channels with perennial flow generally provide better salmonid rearing habit, however in Mediterranean climates, downstream reaches can seasonally lose flow through percolation into underlying aquifers. Such reaches do not provide good summer rearing habitat but may provide critical passage to migrating fish during spawning migration and smolt out-migration.

Within the Santa Clara Valley there are two primary factors which affect the low-flow conditions in the Program streams, and thus the expected habit usage.

- Pools and shelter areas in the zones of erosion and transport are usually closely linked to groundwater levels. However, the incised channels in the zone of deposition are not only unusually disconnected from the adjoining aquifers but are also water-bearing gravels capable of sustaining pooled surface water through most dry seasons.

- Most of the Program reaches have major range-front reservoirs that are designed to release water slowly throughout the year to recharge the valley aquifers. As a result of the altered hydrology, many Santa Clara County streams flow longer into the dry season or flow year-round, under normal hydrologic conditions[3]. In most locations this appears to have increased the length of potential rearing habitat downstream of where it historically may have extended (e.g. Uvas Creek, see Becker and Reining, 2008).

We have identified passage or rearing reaches based on Becker and Reining (2008) and Leidy and others (2005) estimate of spawning and rearing habitat on the Program streams. To confirm that reaches where previous workers have identified good rearing habitat, we worked with District staff to evaluate data collected by the District which estimates the drying-front for major creeks in Santa Clara County (Dry-back location). District staff extracted dry-back location data for June 1, and September 30 for a water-years 2003, 2005, 2006 and 2010-2015, which span a breadth of hydrologic conditions, including multiple normal, wet, dry, and extended drought years. **Appendix A** presents dry-back data provided by the District.

The District dry-back location suggest that nearly all reaches identified by Becker and Reining (2008) and Leidy and others (2005), have perennial flows, and that most passage reaches have perennial flows under normal hydrologic conditions. One exception to this is Stevens Creek, which the data suggest dries out regularly in the vicinity of Fremont Avenue, leaving reaches SC8-SC11 dry in many years. Additionally, the data suggest that Uvas Creek dries in the lower reaches UC5 and UC6 with some regularity, though not as frequently as Stevens Creek.

Notably, during the severely dry water years 2014 and 2015 during the recent record-breaking regional drought, most streams went dry earlier, and the wetted front retreated further upstream. We are more interested in the prevailing near-normal conditions and have focused on those years, and we anticipate new rule curves planned for Stevens

[3] Future reservoir habitat releases are subject yet-to-be-finalized FAHCE agreements.

Creek, Guadalupe River, and Coyote Creek will likely change the extent and timing of seasonal dry-back.

Nonetheless, we suggest that consideration be given to the effects of more extreme conditions that can be expected, and evaluate scenarios which may encourage use of augmentation in particular reaches or streams, or to consider how augmentation might be used to mitigate for habitat losses which may be (a) of particular concern, (b) amenable to “shovel ready” funding, or (c) considered in conjunction with episodic or ongoing geomorphic events. Examples, respectively, might be (a) post-fire action plans at Stevens Creek, which has not experienced a watershed-scale fire for quite some time, (b) fires whose effects might extended or intensified by sudden oak death, or (c) integration into the mitigation or final-step planning for reaches affected by ongoing SCVWD planning, such as reaches just downstream from the Anderson Dam spillway. There are opportunities here to maximize both funding resilience and to build teams that can be agile in recognizing and implementing opportunities which arise.

Low-flow dry-back data will be used to evaluate a) whether a particular gravel and/or LWD augmentation project b) has the opportunity to improve hyporheic flow, and c) whether augmentation may increase the likelihood of premature seasonal drying and potential smolt or fry stranding due to the expected localized increase in sub-surface flows.

2.6.4 Suitable Water Temperature

The Santa Clara Valley, and Central- to Southern-California Coast, in general is at the southern extent of anadromous salmonid habitat. One of the constraining factors at the southern limit of anadromous salmonid habitat is stream temperature. Sub-lethal and lethal thermal limits from various literature sources, including cited references in FAHCE (2003), Stillwater Sciences (2004 and 2006) and Moyle (2002) suggest 20°C and 24°C for sub-lethal and lethal limits, respectively. However, temperature thresholds are subject to considerable variation. As examples, in nearby Santa Cruz County, fisheries biologist Don Alley has used considerable field data to support a single threshold of mean daily temperature of 25°C for 7 consecutive days. In San Diego County, USFWS biologists (Lang and others, 1998) identified 29°C as a lethal temperature in a very similar rolling bedrock and small valley landscape, although genetic strains of steelhead are different.

In general, we find that summer temperatures are most suitable in the upstream reaches, which makes intuitive sense, because those reaches either receive water from District bottom-release reservoirs year-round in most years, or in the cased of undammed systems, the upstream canyon reaches are generally “gaining” reaches which receive water from adjacent aquifers. Though it varies across the Program streams, downstream reaches tend to have less suitable summer stream temperatures, which is generally less concerning because those reaches are used by SC-CCCST during cooler months for passage upstream to the more suitable spawning and rearing reaches.

We surmise that gravel and LWD augmentation projects are likely to benefit SC-CCCST on both streams with suitable water temperatures and unsuitable water temperatures. Temperature data will be used to evaluate the conceptual design approach. For example, in reaches where temperatures are unsuitable or border line suitable, gravel and LWD can be augmented in such a way to improve hyporheic exchange, or to create deeper, cooler holding pools.

To guide gravel and LWD augmentation we have used the District reach evaluations based on Smith (2006). These data integrate stream temperature and other habitat metrics to classify reaches by fisheries functions and values. These data are described in more detail in **Section 3**.

3 GRAVEL AND LWD AUGMENTATION SITE PRIORITIZATION

3.1 Program Strategy

The Program strategy is to systematically identify highest priority gravel and LWD augmentation projects with the goal of habitat improvements. The Project Team carefully considered methods to specially discretize the channels and potential project sites to identify feasible projects with high potential for project success. This is a multi-step process that begin with a Multi-Criteria Decisional Analysis (MCDA) tool to prioritize channel reaches independently for both gravel and LWD augmentation projects. Next, project sites are identified with the top scoring reaches and further prioritized in a series of steps including desktop analysis and field surveys.

The Program goes through several iterative steps of prioritization, with differing levels of effort executed at each stage and on a subset of reaches or sites. To clarify each of the products for each step 1 through 3, below, the terminology used is highlighted in bold, with definitions in the footnotes:

1. Conduct a desktop analysis to score and prioritize stream reaches using a multi-criteria decisional analysis (MCDA) matrix. The MCDA process employs geomorphic, hydrologic, biologic, and regulatory criteria to prioritize reaches in a number of criteria. The deliverable from this step is a score for both gravel augmentation and LWD augmentation for each reach in the stream. From these scores, the highest priority reaches4 are identified.
2. Evaluate existing information and spatial data sources to identify and prioritize study sites within the highest priority reaches for gravel/LWD augmentation. Selection of priority sites should be carried out in concert with a geo-spatial desktop analyses. The deliverable from this step is a list of priority sites5 for gravel or wood projects. These priority sites may be further refined to include set of priority field sites6 depending on scope and budget allocated.

[4] **Priority reaches** are reaches that score high in either the gravel or large wood augmentation categories.

[5] **Priority sites** are sites located inside a priority reach that have been identified as ideal locations for gravel or wood projects, based on criteria listed in Step 1. There are approximately 40 priority sites.

[6] **Priority field sites** are a subset of priority sites for which Steps 2 and 3 will be carried out. Steps 2 and 3 may not be carried out for all priority sites due to time or resource constraints. There were approximately 30 priority field sites.

3. Conduct channel and habitat surveys within the priority field site(s).

4. Select conceptual design sites[7].

Each of these steps is detailed below. More detail is also given about the selection of the priority field sites in the attached Standard Operating Procedures (SOP).

3.2 Selection of Priority Reaches

3.2.1 Reach Delineation

To prioritize locations which will be selected for evaluation in the field using criteria presented in **Appendix B Table B1** (Gravel augmentation) and **Table B2** (LWD augmentation), we have first defined reaches using geomorphic, hydrologic, biologic and regulatory criteria. Reaches will be scored and prioritized using the MCDA. A stream reach is typically defined as a length of stream channel that is reasonably uniform with respect to discharge, depth, cross-sectional area and slope. Definition of stream reaches for desktop analysis has been designed to balance previous work (i.e. the Limiting Factors Analyses on Stevens and Upper Penitencia Creeks), and reach definitions defined here. For reaches defined here, the concept is to define sections of each creek that are geomorphically similar, have a similar drainage area (i.e. major tributaries would define a reach break), and account for varying anthropogenic considerations. Due to the inherently complex influences that affect stream morphology and habitat, and the variety of data sources available across the Program streams, one single reach definition scheme will not fit all inputs and selection criteria perfectly. The criteria used to define reach boundaries within the eight study streams are as follows:

1. Reaches are defined only below the limit of anadromy. Limit of anadromy is defined by natural waterfalls or barriers, water supply reservoirs, and in the case of Los Gatos Creek, the Camden Drop Structure.

2. Reach boundaries start and end at major changes in stream properties:

    a. Major stream network attributes, such as;

[7] **Conceptual design sites** are sites that have been selected for further advancement of project conceptual designs. These sites are a subset of the priority field sites. There are approximately twenty conceptual design sites. Gravel and large wood concept design sites by be designed together, or directly next to each other, depending on site-specific conditions.

i. tributary confluences, generally those involving named streams, and have the potential to effect geomorphic or hydrologic change downstream of the confluence,

ii. downstream position in the channel network or hierarchy ("stream order"[8]) and,

iii. depth to groundwater during ecologically important times of years, such as summer rearing, or support for riparian vegetation.

3. Reaches are also delineated by the status of bed and banks as designated in the Santa Clara Valley Water District Watershed Asset Management Report published by GHD Ltd. (GHD) for the District in 2016. The categories used to designate reaches include Natural, Natural Modified, Rock-lined, and Concrete. GHD (2016) channel type descriptions are presented from their report here:

   a. Natural: Undefined, though we interpret the term, for the purposes of their report, to mean channels that have not been straightened or modified, for flood control, flow conveyance, or drainage improvement.

   b. Natural Modified: Natural Modified channels are natural, earth-lined channels that have been modified (typically straightened) for flood control, flow conveyance, or drainage improvement.

   c. Rock-lined: Rock-lined channels are constructed with rocks or boulders, designed to stabilize eroded banks and control flow runoff.

   d. Concrete: Concrete-lined channels are constructed under the District's capital improvement program and are usually constructed to increase channel capacity.

   e. Other asset types (e.g. levees, weirs) used by GHD were not utilized for reach delineation because they are generally redundant to the definitions above for the purposes of this study, or too short to consider for defining workable reach lengths.

4. Reaches defined by previous workers such as the limiting factors analyses performed on Upper Penitencia Creek and Stevens Creek, as well as the USACE reaches defined on Guadalupe River. In all cases, these reaches were

[8] Generally, "Strahler orders" are used, as is usually the case in most habitat-hydrology science (c.f., Gordon and others, 1992, p. 102-107).

evaluated based on changes to the creeks, primarily restoration projects that have been performed since the publishing of those reports. In the case of the USACE reaches defined for Guadalupe River, reaches were lumped by restoration status, for example.

5. We have defined reaches based on the presence or absence of a FEMA regulatory floodway.

6. In a few cases Program Team geomorphologists and planners further divided the streams into reaches based on inferred or observed geomorphic change from aerial photo reconnaissance and review of District fee and easement maps.[9]

Based on the above six criteria, the Team located reach boundary points along the stream channels and used the delineation boundary points to define reaches. Reaches were delineated in a GIS for the eight creeks and significant tributaries. We employed the six criteria below, marking reach boundaries at locations suggested by the criteria. For example, a reach may be defined at its upstream end by a transition from a regulatory floodway to a stretch of channel that is not a floodway, and at its downstream end by a transition from a natural channel to a concrete lined channel. The resulting reaches are not necessarily similar in length, though most are shorter than a mile. However, the reach delineation scheme allows us to score reaches more easily and accurately because they are defined by factors which will affect the overall effectiveness and feasibility of augmenting gravel and/or LWD. The reaches are presented in plan view on **Plates 1 through 8** and on long profile along with data on Quaternary deposits (Helley and others, 1994), presence of underlying confined or unconfined aquifers, and the FEMA floodway status (**Figure 2-7**, **Figure 2-8**, **Figure 2-9**, **Figure 2-10**, **Figure 2-11**, **Figure 2-12** and **Figure 2-13**). The naming convention for reaches utilizes the initials of a given stream and a numbering system starting at the upstream end (For example, the reach directly downstream of Stevens Creek Reservoir is named SC1, because it is the upstream-most reach on Stevens Creek.

The Team has evaluated the eight Program streams: Stevens Creek, Los Gatos Creek, Guadalupe Creek, Alamitos Creek, Guadalupe River, Coyote Creek, Upper Penitencia Creek, and Uvas Creek. In the case of Uvas Creek, we have included anadromous portions of Little Arthur Creek and Bodfish Creek. On Guadalupe Creek, we have

[9] For example, narrowing and deepening of channels as they flow from lower alluvial fans into ancient lakebed deposits. In the case of Uvas Creek, stream characteristics were so different that the lower reaches has had a different name (Carnadero Creek) since pre-statehood times.

included anadromous tributaries Pheasant Creek and Hicks Creek. Finally, on Upper Penitencia Creek, we have included anadromous portions of Arroyo Aguague.

The District desires at least 1 or more projects in each of the eight study watersheds. The top 2 to 3 scoring reaches for either gravel augmentation or LWD augmentation are considered the priority reaches. In some cases, where more than one reach achieved the same prioritization score, more than 2 to 3 reaches were prioritized within each watershed. Priority reaches are then subject to further desktop evaluation to select key sites within those reaches. The process by which those sites are located is described in **Section 3.3**, below.

3.2.2 PRIMARY CRITERIA FOR PRIORITIZING REACHES

The guiding questions used to score reaches include: Will augmentation improve stream complexity, and therefore improve the functional SC-CCCST habitat? Is adding gravel/LWD the most site-appropriate way of adding complexity?

For the purposes of the Program we assume that, at most locations, there is a deficit of gravel and LWD, and that SC-CCCST spawning and/or rearing habitat will likely improve by restoring geomorphic process through addition of gravel and/or LWD. However, the key purpose of this section is to describe the programmatic approach to prioritizing sites where existing conditions are such that addition of gravel and/or LWD are most likely to improve geomorphic process and therefore increase the amount of functional SC-CCCST habitat.

It should be noted that we have attempted to use the best available data. However, data have been extracted from projects and programs that in some cases have similar goals to this Program. However, in other cases have data for all or nearly all the reaches being evaluated in this Program, but are not collected, categorized and evaluated in terms that are typical for geomorphic studies guiding channel habitat management (e.g. Santa Clara Valley Water District Watershed Asset Management Plan [GHD, 2016]). We have taken the approach of using publicly available data and data previously developed by the District to add value to those data and provide a basis for prioritization that is straightforward and can be implemented in the future on other SC-CCCST streams.

Certain criteria apply to both gravel and LWD augmentation. Under each criterion below we have used subheadings to identify which criteria are applied for gravel, LWD, or both.

Criterion 1: Major Range-front Reservoir?

Gravel and LWD Augmentation Prioritization Scoring

Major water-supply reservoirs have been built along mountain range fronts on most streams. Major range-front reservoirs change stream hydrology and cut off sediment supply to stream reaches downstream of the dam. In Santa Clara County, there are 10 major reservoirs, which were built primarily to manage groundwater supply within county aquifers. The effort – in combination with delivery of water from the Delta, has largely arrested ground subsidence, a major problem through the first half of the twentieth century (Poland and Ireland, 1988, Galloway and others, 1999). A list of District managed reservoirs is listed in **Table 3-1**.

Table 3-1 Santa Clara Valley Water District water supply reservoirs

Reservoir Name	Year Built	Original Storage *(acre-feet)*	Material	Height *(feet)*
Almaden	1935	1,586	Earth	105
Anderson	1950	89,073	Earth & rock	240
Calero	1935	10,050	Earth	98
Chesbro	1955	8,952	Earth	95
Coyote	1936	22,925	Earth & rock	120
Guadalupe	1935	3,228	Earth	129
Lexington	1952	19,834	Earth	195
Stevens Creek	1935	3,465	Earth	120
Uvas	1957	9,935	Earth	118
Vasona	1935	400	Earth	30

In addition to water supply needs, District reservoirs are managed to balance those needs with and optimize fish habitat needs, which is increasingly critical to counteract the regional loss of habitat quality and quantity for SC-CCCST and other species. One of the goals of this Program is to restore fish habitat in response to negative effects of the major range-front reservoirs, including channel incision, bank erosion, lack of stream bed complexity, and overall reduced habitat function within the stream. Channel incision increases shear stress in the channel, which tends to mobilize then wash gravels downstream. As such, spawning gravels, fast-water feeding habit have been identified as limiting factors (e.g. Casagrande, pers. comm. 2016). Placing gravel in these reaches, in tandem with other stream complexity features such as LWD, which can hold gravels in place will likely benefit SC-CCCST. LWD placed downstream of large reservoirs enhances stream complexity and cover. Minor reservoirs which only impound small portions of sediment and wood source areas, such as the City of San Jose operated Cherry Flat Reservoir, have the same impacts, but to a less significant degree, because there are still large areas where sediment and wood reach the channel and can be transported to anadromous reaches.

This criterion is designed to differentiate streams that have major range-front reservoirs and are therefore more likely to benefit from gravel augmentation. Stream reaches were binned and scored according to **Table B1** and **Table B2.**

Criterion 2: Are Source Areas Protected?

Gravel Augmentation Prioritization Scoring

This criterion asks if the coarse-sediment source areas for a given reach are protected, according to the California Protected Areas Database (CPAD). From CPAD's website:

> *The California Protected Areas Database (CPAD) is a GIS inventory of all parks and other open space lands that are owned in fee by agencies or nongovernmental groups for the purpose of maintaining their use as open space resources. CPAD includes neighborhood parks, wildlife refuges, regional and county parks and preserves, some land trust holdings, and state and federal parks, trust lands and forests…*

Similar to evaluating percent urbanized area within a given watershed, this criterion is based on the assertion that protected areas tend to have fewer obstacles (e.g. road crossings and catch basins) to block coarse sediment from entering streams. Open space will generally be managed in a way that preserves more natural sediment regimes (e.g., preservation of natural communities, trail maintenance, more natural surface and groundwater function). Urban areas often have sediment catchment areas at the edge of development to limit the amount of sediment that can enter storm water infrastructure. We posit that reaches with less protected area should be prioritized for gravel augmentation, because they are more likely to be impaired for coarse sediment, and also more likely to have flashier hydrology. Coarse sediment supply above large reservoirs is impounded and does not currently reach the reaches in question; therefore, we have developed an estimate for the percentage of protected area downstream of major reservoirs.

To estimate the percent protected areas that drain to each reach, we calculated the amount of protected area based on the California Protected Areas Database (v. 2016a, CPAD, 2016) in each sub-watershed. Sub-watersheds for each reach were calculated or estimated based on the District sub-watershed GIS shapefile (downloaded on March 23, 2017). For streams with major reservoirs, only areas downstream of the reservoir were evaluated. For similar reasons discussed in previously, Cherry Flat Reservoir was ignored for this evaluation.

Upstream watershed areas and protected areas are calculated by summing the sub-watershed areas upstream of any given sub-watershed in Excel®. It should be noted that, in many instances, the reach boundary for this Program coincided with the Sub-watershed boundary, as defined in the District sub-watershed shapefile. In those instances where the reach boundary did not coincide with the sub-watershed boundary, the GIS analyst used professional judgement to locate the closest watershed boundary.

Based on our review, a moderate proportion of protected areas downstream of the reservoirs are either poorly connected to the streams, or likely managed in such a way (i.e. landscaped urban parks, or narrow river corridor parks where bank erosion is typically arrested to prevent damage to trails or infrastructure) that will not benefit, nor be detrimental to coarse sediment supply. That said, our review of the data indicates the vast majority of protected areas generally include large contiguous pieces of hydrologically connected open space.

Additionally, watersheds with proportionately larger protected areas are generally more likely to support healthier stream ecosystems and are more resilient to predicted climate change variability; here we assume the protected areas will remain relatively static, though that is difficult to predict. The prioritizing tool, though, can be revised and adapted as policies or conditions change.

Stream reaches were binned and scored in accordance with **Table B1.**

LWD Augmentation Prioritization Scoring

LWD was not scored based on protected watershed area because LWD in most Program streams has a low transport rate and is generally supplied locally. It is generally understood most LWD entering the channels is not transported far (Senter, 2017), especially in smaller streams such as most of those in this study, where the active channel width is often less than the canopy height of the riparian forest. Trees closest to the stream channel, that can fall directly into the stream are most important in LWD loading in local streams, especially in alluvial valley floor channels where hillslopes are not present to transport wood to stream channels. Even in the mixed-conifer-hardwood forests of upper Uvas and Bodfish creeks or Stevens Creeks, LWD which falls near the base of the slopes is most likely to reach the stream; trees which require peak flows from several episodes over multiple decades are unlikely to reach the channel system (or even the floodplain) in one piece.

Wood loading in streams varies with age and species of riparian cover, degree of channel incision, time since last disturbance or "episode", and land-use history. We evaluated riparian canopy data collected and presented in the Santa Clara Valley Habitat Plan (2012), which covers all the 8 SHRT streams in this study except for Stevens Creek. Riparian corridors of varying width consist generally of mixed riparian forest and scrub throughout the study reaches. Our review of the Santa Clara Valley Habitat Plan (SCVHP) land cover data (ICF, 2012) suggests that, while impaired in places, nearly all the channels have some type of riparian woodland, and therefore that wood will be delivered to the reaches in the future. We recognize that some reaches have a much broader riparian corridor than others, but all Program streams are incised to varying degrees, and therefore the riparian forest is generally less frequently inundated or subject to episodic flows that incite wood loading. As such, we anticipate that broader alluvial corridors may not be responsible for significantly higher wood loading rates in the future. Stream reaches were binned and scored in accord with **Table B2.**

Criterion 3: Does Sediment Accumulate in the Reach?

Gravel Augmentation Prioritization Scoring

We have reviewed Stream Maintenance Program sediment removal records from 2006 to 2011 to help establish which stream reaches tend to accumulate more sediment. These reaches may be less desirable for gravel augmentation because maintenance needs in areas of aggradation are expected to increase, and sediment removal, while important to protect community resources, has deleterious effects on aquatic habitat, and should be minimized as a routine management practice.

We used the frequency of maintenance within each reach and the volumetric estimates to identify reaches which appear to be most prone to sediment accumulation. Reaches that tend to accumulate sediment most frequently were assigned a negative score in the MCDA. We understand that frequency of maintenance may be the more reliable metric, because emphasis has not been placed on accurate volume calculation during past sediment removal projects. Stream reaches were binned and scored in accord with **Table B1.**

LWD Augmentation Prioritization Scoring

LWD affects sediment transport by either causing scour (and bank retreat), or storing sediment, or both. When designed to do so LWD structures can be installed upstream of reaches that tend to accumulate sediment will temporally reduce sediment flux to those reaches by storing sediment, and convert a maintenance problem into a beneficial use.

Under this criterion for the LWD, the most proximal three reaches upstream of accumulation reaches, as discussed in the above section, should be prioritized for LWD augmentation. Should sites in these reaches eventually be included in the twenty final sites, careful consideration will be made to install wood in such a way to store sediment, as long as other design considerations (e.g. flood risk) do not preclude projects designed to accumulate sediment Stream reaches were binned and scored per **Table B2**.

Criterion 4: Are the Bed and Banks Highly Manipulated?

Gravel and LWD Augmentation Prioritization Scoring

We expect gravel and LWD augmentation to be more technically challenging and less likely to achieve habitat objectives if implemented in reaches that are lined with concrete or rip-rap. GHD prepared the 2015 Watershed Asset Management Plan for the District (GHD, 2016). In their report, they identify stream channel asset types by bed and bank, which we use here to identify reaches with hardened bed and banks, which are not recommended for gravel or LWD augmentation. They did not specifically identify sacked concrete bank protection, which is common in Santa Clara County, but not necessarily laterally extensive in Santa Clara County streams. Should sacked concrete bank protection be identified during field reconnaissance activities, those sites will be identified and avoided.

Stream reaches were binned and scored per criteria presented in **Table B1** and **Table B2.**

Criterion 5: Is the reach downstream of a sediment or wood sink, and therefore deprived of sediment?

Gravel Augmentation Prioritization Scoring

In general, and specifically within Santa Clara County, we anticipate that augmentation of gravel and wood will be most cost effective when implemented in reaches just downstream of major sediment sinks. Sediment from augmentation is expected to transport downstream, and provide habitat benefits downstream of augmentation sites.

For the purposes of this Program, major sediment sinks include major range-front reservoirs, as well as major in-channel ponds downstream of range-front reservoirs. There are three additional major sediment sinks with the Program streams, Ogier and Metcalf ponds on Coyote Creek and Lake Almaden on Alamitos Creek/Guadalupe River. Downstream reaches will benefit from gravel augmentation, as they have been subject to decades of gravel deprivation, and therefore we have included them in the scoring scheme as areas to prioritize for gravel augmentation.

Additional sediment sinks exist within the Program streams, these include Masson Dam, and various flashboard structures that are used to manage percolation facilities. Based on consultations with the District staff, we elected not to include these facilities as sediment sinks. These facilities are typically only operated in the summer, when sediment transport generally does not occur, or in the case of Masson Dam, sediment passes over the dam with regularity

Stream reaches were binned and scored per **Table B1.**

LWD Augmentation Prioritization Scoring

Criterion 5 is not used to evaluate LWD. As the ratio of the length of LWD pieces to channel width ratio approaches unity, LWD does not move frequently (Senter, 2017). Based on reconnaissance level review of mapping data, and spot observations in the field, riparian canopy is generally near, or in many cases taller than the flood-prone channel width of the adjacent channel, therefore we anticipate that naturally recruited LWD will not generally move very far before coming to rest. In addition, based on feedback from the District, we are recommending cabling or ballasting LWD installed as part of this Program. As such, we are not using this criterion to prioritize locations for LWD augmentation directly. However, we are prioritizing reaches for LWD augmentation based on the likelihood of gravel augmentation (or a natural or near-natural sediment transport regime) and therefore, reaches that are downstream of sediment sinks are more likely to be prioritized for LWD augmentation as well.

At present, collecting LWD from reservoirs and passing it downstream each year is not a practice encouraged by resource agencies. It is, in fact, done at other impoundments in the San Francisco District of the Corps of Engineers. We suspect that the practice will spread over the coming decade. If this is consistent with District governance and riparian management practices, it may be that this criterion should be revisited.

Criterion 6: Is the reach upstream of a sink, and therefore augmentation benefits are minimal?

Gravel augmentation prioritization scoring

In general, and specifically within the Santa Clara Valley, we anticipate that augmentation of gravel will be most cost effective and provide the greatest habitat benefits when implemented in reaches well upstream of major sediment sinks. Sediment from augmentation is expected to transport downstream rapidly, as observed at the 2011 Blackberry Farm Phase I restoration project on Stevens Creek, and provide habitat benefits downstream of augmentation sites, and projects located just upstream of major sediment sinks will not yield that benefit, if the sediment is lost in the sediment sink

Criteria for defining sediment sinks are the same as criterion 5. Stream reaches were binned and scored per **Table B1.**

LWD augmentation prioritization scoring

For the same reasons presented above for criterion 5, criterion 6 was not scored for LWD

Criterion 7: District fisheries functions and values mapping

Gravel and LWD augmentation prioritization scoring

The District mapped "Potential Fisheries in Selected Santa Clara County Streams" to support maintenance mitigation strategies. Smith (2006) presents an update of that map based on updated sampling and barrier removals. The maps are intended to emphasize habitat conditions for and distribution of SC-CCCST and Chinook salmon (*Oncorhynchus tshawytscha*). The map breaks streams into eleven categories, Cold Trout, Cold Steelhead, Warm Potential Trout, Warm Native, Mixed Salmon, Mixed Native, Fish Scarce, No Fish Value, No Data, No Data/Likely No Value, and Estuarine. The Team worked closely with District staff to identify stream classification categories that may benefit from the gravel or LWD augmentation, based on work by their fisheries biologists. This includes experience based on past and ongoing collaborations with the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA-NMFS) and the California Department of Fish and Wildlife (CDFW).

Program reaches frequently correspond to reaches defined by Smith (2006), however some do not align, and the Team wanted to capture smaller pockets of reaches with desirable habitat potential, Thus, the Team established scoring criteria where, if at least 25 percent of the reach falls within one or more of the desirable designations of Cold-Steelhead, Warm Potential Trout, Mixed Native-Salmon, and Mixed Native, the reach was scored based on those designations.

Stream reaches were binned and scored per **Table B2.**

Criterion 8: Is the reach likely to have gravel augmentation as part of this Program?

LWD augmentation

We recommend that locations selected for gravel augmentation should also be considered for LWD augmentation. LWD is an excellent tool to help retain gravel, and gravel augmentation is an excellent tool to enhance the function and value of LWD augmentation. Additionally, mobilization and access are costly and can have temporary impacts to aquatic and riparian habitat resources and consolidating mobilizations and access should be considered a priority.

This criterion evaluates for each reach the likelihood that gravel augmentation from nearby sources will be implemented as part of this Program. Stream reaches were binned and scored in accordance with **Table B2.**

3.2.3 Secondary Criteria for Prioritizing Reaches

Criterion 9: Do not increase flood risk

The placement of any additional gravel or wood structures has the potential to increase water surface elevation in a channel reach. To minimize flood risk for constructed features, Criterion 8 was created to examine potential flood risk of enhancements and whether flood regulation may permit channel enhancements with increased base flood elevations (BFEs, or in other words, the predicted water surface during a 100-year recurrence flow event). To determine whether a changing water surface elevation may or may not have adverse effects on the overall success of the Program, this selection criterion uses the following four topics: regulatory floodway status, FEMA (Federal Emergency Management Agency) or the District detailed study status, existing water-surface slope, and channel bank heights.

9a: Regulatory floodways

For channel reaches in a FEMA-designated regulatory floodway, any changes to the channel configuration must be done in a way that will not increase the water surface elevation beyond existing BFEs, irrespective of the proximity to structures, or bank elevations. This restriction may make the design and construction of habitat enhancement more difficult, requiring the production of a "No Rise" certification. Regulatory floodway status is assigned using data from the FEMA map service center[10].

We have experience designing stream enhancement in regulatory floodways, and the existence of a regulatory floodway should not necessarily preclude gravel and LWD augmentation, however there is often more cost associated with constructing in regulatory floodways, and we expect that such projects may require more detailed hydraulic evaluation and may also require more earthwork to meet the "No Rise" certification standards.

Gravel and LWD augmentation are likely to have similar effects on BFEs, and are therefore scored Identically. It should be noted that we expect gravel to be mobilized downstream and therefore we have scored reaches that are just above regulatory floodways lower for this criterion. Stream reaches were binned and scored per **Table B1** and **Table B2.** Scores for Criteria 8a were determined using the following for gravel augmentation:

- -1: The reach is in a regulatory floodway, and the reach directly downstream is not a regulatory floodway
- 0: The reach is not in a regulatory floodway, but the reach directly downstream is a regulatory floodway
- 1: The reach is not a regulatory floodway

Scores for Criteria 8a were determined using the following for wood placement:

- -1: The reach is a regulatory floodway
- 0: The reach is not a regulatory floodway
- 1: Not applicable for this scoring criteria

Scores for gravel augmentation and wood placement were calculating with different criteria based on the assumption that gravel is mobile and augmentation will likely impact flood water levels downstream of augmentation sites, while planned LWD

[10] https://msc.fema.gov/portal

structures will be cabled or ballasted in place and are considered immobile for the purposes of this Program.

Of the total 81 reaches, 27 are in a regulatory floodway. Approximately 33 percent of reaches (by length and count) are in a regulatory floodway.

9b: Existing flood capacity issues

As discussed above, both gravel augmentation and wood placement can decrease channel capacity for flood flows. Existing flood capacity issues could be exacerbated by the introduction of gravel augmentation or wood placement projects. Therefore, reaches with existing flood capacity constraints have lower scores than reaches with sufficient freeboard.

Scores were developed using the FEMA Special Flood Hazard Areas (SFHA) mapped for the 100-year flood event. Reaches score favorably if the 100-year flows stayed in-channel, or if overbank flows occurred in undeveloped areas. Scores for Criteria 9b do not differ between gravel augmentation or wood placement. Stream reaches were binned and scored per **Table B1** and **Table B2.** Scores for Criteria 9b were determined using the following:

- -1: FEMA maps do not show SFHA floodplain out of the channel reach[11]
- 0: Either: FEMA maps indicated break out from channel, but in undeveloped areas[12]; OR flow breaks out of the channel into a developed area but in a subset of the reach[13]
- 1: FEMA maps indicate break out from channel along the entire reach into developed areas

In addition to evaluating the FEMA SFHA, the District Flood Inspection Locations (FIT, **Table 3-2**) were cross-checked against the FEMA SFHA to confirm that known flood capacity issues are captured by the FEMA SFHA. We found no flood capacity issues identified as either medium- or high-priority FIT that were not reflected by overbank flows in the 100-

[11] Includes reaches with no floodplain mapping.
[12] Undeveloped is defined as greater than 30 percent of the channel reach adjacent to structures.
13 Includes any subset of the reach that is not developed.

year SFHA. Low-priority FIT are often sites which can have flood capacity issues if debris is not managed, but is not typically a flood risk, and were therefore not cross-checked.

Episodic sedimentation will at times temporarily aggrade the bed in a reach where the flood capacity is general sufficient. Hecht (in prep) has shown that post-landslide or post-wildfire sedimentation can often result in aggradation approaching the bankfull depth as taken from regional curves. Such reaches can often be recognized by partial burial of floodplain vegetation, notable of understory plants such as hazelnut, vinca, poison oak, or huckleberry. Such locations will generally be suited to either wood or gravel augmentation, which should be deferred until the aggraded pools or floodplains have been returned to their normal channel geometries, and where episodically induced increased risk of flooding will no longer be perceived. In many cases, return of the channel and floodplain depths to pre-existing norms can take between one (for the upper Carmel -- Hecht, 1981), and 5 or 6 years (many United State Forest Service [USFS] studies, especially by the Chaparral Watersheds Experiment Station in Glendora).

Table 3-2 District Flood Inspection Locations (FIT) and priority

	FIT Priority		
Reach Name	Low	Medium	High
CC11	-	-	1
CC12	-	1	-
CC13	-	1	-
CC14	-	1	-
CC15	-	3	-
GR10	2	-	-
GR11	2	-	-
GR4	1	-	-
GR7	-	-	4
GR8	-	-	1
SC4	1	-	-
UC1	1	-	-
UC6	1	-	-
UPC5	1	-	-
UPC6	2	-	-
UPC8	2	-	-

Access to reaches, presence of access roads

As part of the process used for scoring the MCDA, Program planners evaluated CPAD maps and District fee and easement maps provided by the District to identify reaches that appear to have a) a significant buffer of land that is in fee or easement or is owned by a public entity that has a strong working relationship with the District (e.g. Santa Clara County Parks), and b) apparent mechanized access to the channel banks. In many cases, the District has maintenance roads adjacent to creeks that provide access. In others, Santa Clara County Parks, and municipalities have recreational creek-side trails. For the purposes of scoring this criterion, we assume that creek-side trails, excluding pedestrian bridges or other observed constrictions, can be used for access.

During field-site evaluations, a more detailed reconnaissance-level analysis of access, in support of conceptual plan development conceptual designs we will develop for up to twenty gravel or LWD augmentation sites. The field evaluation will consider traffic issues, staging and access, but will not be comprehensive. It will be the responsibility of the District to arrange access and staging, based on our preliminary recommendations. Stream reaches were binned and scored per **Table B1** and **Table B2.**

3.2.4 Reach Criteria Scoring and Weighting

Scoring of reaches will be on a -1 to +1 scale based on a holistic view of criteria within each category. Weighting of each criterion has been assigned by the Team and District staff. Scores have been weighted to emphasize criteria that are more important:

- For Criteria 1, 3, 5, 6, and 7 (for LWD augmentation prioritization only) the Team and District selected a weighting factor of 2.
- For Criterion 2, the Team and District has been assigned a weight of 1, because protected areas are not likely as important as other factors in modulating gravel deficits.
- For Criterion 4, the Team and District has assigned a weighting factor of 3, because the reaches that tend to accumulate gravel are very poor candidates for gravel augmentation. LWD is likely a very good tool to store, or sculpt habitat features using sediment that would otherwise deposit in areas where it needs to be removed.
- For Criterion 7, the Team and District has assigned a weighting factor of 3 for gravel augmentation prioritization because Criterion 7 captures steelhead

presence, and steelhead habitat potential based on extensive work by the District and others.

- For secondary screening Criteria 9a, the Team and District have assigned a weighting factor of 1. A lower weight was placed on Criteria 9a because the District wants to target streams where flood risk is minimized, but also wants to consider high scoring reaches that are potentially in regulatory floodways.

- For secondary criteria 9b and 9, the Team and District assigned a weighting of 2, because these factors are likely more important screening factors than the absence or presence of a regulatory floodway (Criterion 9a).

3.3 Translating Priority Reaches into Potential Priority Sites

To translate high-scoring priority reaches into priority sites to be considered for field evaluation, and eventually implementation of gravel and/or LWD augmentation projects, the Team will use the following criteria. This selection process produced 47 priority sites (**Appendix C**). Priority sites are named based on the reach and are sequentially numbered in upstream to downstream order (e.g. SC1-1 is the upstream-most priority site within Stevens Creek Reach 1 [SC2]).

3.3.1 Gravel Augmentation Sites

Gravel augmentation will be targeted for the top of each priority reach, or the most feasible location near the top of each reach. Because gravel is mobile, and reaches were mapped based on their status in or out of a regulatory floodway, and whether the reach may be subject to adverse flood risk, we proposed placing material within reaches in such a way where placed gravel can be mobilized downstream through the reach in which it is located. In general, this approach will allow placed gravel opportunity to improve habitat functions and values over the greatest possible distance along high scoring reaches.

3.3.2 Wood Augmentation Sites

Where priority reaches are co-located for gravel and LWD placement, we anticipate using the access established by the proposed gravel project to implement one or more LWD projects downstream of the gravel augmentation project. In addition, the Team may select additional locations downstream, through each priority reach where LWD projects can be implemented.

When multiple reaches received the same score for LWD, reaches with higher scores for Gravel were prioritized.

3.3.3 California Department of Fish and Wildlife Fish Passage Impediment Database

Gravel and LWD augmentation are potentially useful tools for ameliorating fish passage impediments in streams. Physical impediments limit the passage of migrating adult SC-CCCST upstream, the movement of juvenile SC-CCCST and the outmigration of SC-CCCST smolts. Fish passage impediments are common in tributary streams to the San Francisco Bay. The streams included in this Program are no exception. Fish passage impediments include low-flow stream crossings, weirs, rubble, and culverts, which may have been constructed prior to fish passage requirements. Some may have been built after fish passage requirements had become policy, but prior to implementation of current fish passage design policies, which require shorter drops for juvenile salmonid passage. In many locations channel incision exacerbates fish passage impediments and can expose in-channel structures which were formerly not exposed in the streambed. Work has been implemented to remove barriers and impediments, and planning efforts are underway to remove many remaining barriers (e.g., the Singleton Road trail crossing).

We evaluated the CDFW fish passage database and identified passage impediments that are likely to be improved or maintained as a result of gravel or LWD augmentation through each study reach. We isolated passage impediments based on data within the CDFW database, with focus on the notes entered into the database by the surveyor. Impediments selected for inclusion include primarily leaping and velocity impediments, which we anticipate can be best mitigated by building up the bed downstream of the impediment using gravel augmentation, LWD augmentation, or both. Fish passage impediments have been totaled for each reach, and their location is available in the project GIS, and are mapped in **Plates 1-6**.

The inherent temporal variability of many passage impediments and barriers, and the varying amount of time since the barriers and impediments were last surveyed diminish the utility of this metric. The District recognizes this and is in the process of resurveying fish passage barriers as part of their master planning effort. Since these data are not available, the CDFW database is the best available data and field staff will visit CDFW listed passage impediments along high-priority reaches and assess whether gravel and/or LWD augmentation are appropriate for improving fish passage.

3.3.4 Implementation Access and Staging

The Team reviewed sites which meet criteria laid out in **Section 3.3.1**, **Section 3.3.2** and **Section 3.3.3**, and identify such sites that appear to have reasonable and proximal access and staging area. This will be performed at the desktop-reconnaissance level, using the same datasets and follow the same assumptions as described in Section 4.3.

3.3.5 FEMA Flood Insurance Rate Maps

The Team will review sites which meet criteria laid out in sections 3.3.1 through 3.3.4, and identify such sites that appear to be less prone to potential flood risk. The Team will review the FEMA Flood Insurance Rate Maps (FIRMS) to look for sites within prioritized reaches where:

- BFEs are contained within top-of-bank and do not appear to overlap with buildings, or other visible infrastructure.
- Priority will be given to areas where BFEs appear to be confined to the public right-of-way, including District fee and easement, and county and municipal park lands.

3.4 Selection of Priority Field Sites

From the list of 47 priority sites, the Team, working closely with District staff selected 32 potential project locations were selected to be evaluated in the field. In many cases, gravel and LWD augmentation project sites are co-located, or proximally located. 15 gravel augmentation sites and 17 LWD augmentation sites were selected for field evaluation. **Appendix C** presents the 47 priority sites as well as the 32 priority field sites selected from that list.

3.4.1 Field Sampling Protocol

The Team has developed a field sampling protocol and form sheet in order to evaluate conditions in a rigorous and consistent manner. The field protocol will be implemented at up to 30 project sites, from which twenty project concepts will ultimately be developed. **Appendix D** presents the field site sampling protocol and data collection sheets.

3.5 Selection of Conceptual Design Sites

The Team used field-based site evaluations to differentiate twenty conceptual design sites selected from the 32 priority field sites.

Each potential project site was scored by both the geomorphologist and the biologist on habitat improvement potential if a gravel augmentation or LWD augmentation is implemented. Scores range from 1 to 4, with 1 being the highest perceived opportunity for improvement as a result of potential gravel or LWD augmentation. The project potential scores are based on a set of evaluation criteria. For the physical attribute scores, these criteria include:

- Site access and staging, including fee and easement or other ownership at the site;
- Potential flood risks of a project, and if the site is in a regulatory floodway;
- Channel stability and risks associated with stability issues;
- Channel dimensions, including width, depth, and slope;
- Regulatory input; sites previously identified as lacking habitat may be prioritized over sites that are not;
- Potential impacts to historical architectural features;
- District staff input so that top twenty sites meet district objectives, and phase well with other ongoing planning efforts;
- Episodic or steady-state conditions; and
- Overall feasibility and constructability based on initial conceptual approaches.

For ecological-biological scores, the criteria include:

- Existing channel gradation and existing rearing, spawning and adult holding habitats;
- Embeddedness and existing substrate composition;
- General channel morphology, presence or absence of bars, riffles, runs, or pools;
- Floodplain connectivity;
- Cover, including riparian vegetation, undercut banks, or channel roughness elements (e.g. boulders, wood, etc.);
- Fast- and slow-water food-producing habitats;

- Turbidity;
- Sediment supply from upstream and mined locally from channel banks; and
- Stream temperature.

The geomorphic and biologic scores are then multiplied together and sorted. The top scoring sites are advanced to conceptual designs. Final selection of the twenty conceptual design sites are prioritized so that each Program stream had at least one site in final list. The final twenty conceptual design sites are presented in **Table 3-3**, below.

Table 3-3 List of final conceptual design sites. Each site may include one gravel augmentation project and one or more large woody debris augmentation project.

Site Name	Number gravel augmentation projects	Number large wood augmentation projects
GC1-1	1	1
GR1-1	1	1
LGC2-2	1	1
UPC2-2	0	1
LGC1-1	1	1
SC1-1	1	1
UC4-5	1	2
GC3-1	1	1
UC4-3	1	1
CC1-2	1	1
Subtotals	9	11
Total		**20**

4 PROJECT IMPLEMENTATION APPROACH

4.1 Concept Development Tools

The goals of the MCDA reach prioritization process, site selection and refinement present in **Section 3** are a) to develop a set of analytical criteria that are designed to differentiate among reaches, and b) to guide design concept development once twenty sites have been selected. Additional considerations from field and desktop evaluations also guide the site-specific design approach:

- Existing habitat types at and directly adjacent to the site, and potential impacts to those habitats, based on field observations;
- desired habitats;
- watershed geology;
- existing geomorphology, history of incision, watershed history, and sediment continuity;
- hydraulics and mobility estimates;
- placement life expectancy, volume and source of gravel and LWD;
- gravel gradation, historic sources and angularity (or roundness);
- potential LWD stabilization approaches and site-specific anchoring considerations;
- episodic variability and position in the landscape;
- potential negative impacts of augmenting gravels; of augmenting LWD;
- water quality considerations including temperature, and turbidity downstream of reservoirs;
- flooding considerations;
- potential access and constructability; and
- other regulatory concerns and input from key regulatory staff in this region of California.

Conceptual designs are presented in project concept summary sheets. Each set of sheets is generally organized in the following way:

1. Site summary sheet including introduction to existing conditions, a statement of the problem and goals for the site.
2. For gravel augmentation concepts, an evaluation of hydraulic and sediment transport capacities, gradation and life expectancy estimates.
3. Gravel augmentation conceptual layout and plan with discussion of access.
4. LWD augmentation conceptual layout and plant with discussion of access.
5. Summary of goals, proposed success criteria and monitoring methods to evaluate those success criteria.

Note that most concept summary sheets will include a gravel and LWD project, however some deviate from that pattern and sheets will be added or removed accordingly.

The following sections present an overview of gravel and LWD augmentation methods appropriate for Program streams, the methodology for evaluating stability and longevity of design concepts, sediment and wood sourcing, a discussion of proposed success criteria, monitoring and adaptive management. The general discussion presented below guides the site-specific details presented on the project concept summary sheets (**Appendix E**).

4.2 Gravel Augmentation

As with all restoration projects, gravel augmentation projects implemented as part of the Program are, to varying degrees, experimental. Thus, planning long-term gravel augmentation benefits from lessons learned from initial projects. In all cases, we anticipate that as augmented coarse sediment is added, a portion of the augmented sediment will transport through both advection (moving as a pulse) and diffusion (spreading) (Madej and others, 1996). Transported sediment is likely to have habitat benefits downstream of the injection site in most cases. However, in some situations, transported sediment may not benefit habitat. In addition, transported gravels may or cause undue flooding concern downstream, which may need to be evaluated and possibly maintained to meet FEMA flood capacity requirements. As a result, in many situations, a two-phase approach to gravel augmentation is desirable. The first, shorter-term pilot augmentation phase, followed by a long-term phase which benefits from the lessons learned through monitoring and adaptive management of the first phase. In most cases, short term sites should be distributed, to the extent practicable, along a stream course, to encourage more rapid replenishment across longer reaches (e.g. USACE, 2013). Long-term augmentation sites should be considered at feasible sites closest to the limit of anadromy, where an ongoing feed of coarse sediment at the upstream end of the channel sustains bed features in the long term.

In many streams of Santa Clara County significant logistical barriers make the two-phased approach more challenging. Guadalupe River gravel augmentation by USACE took place within the footprint of the larger Guadalupe Flood Control Project and thus, was not subjected to the same logistical barriers faced by the Program presented here. The prioritization scheme presented here results twenty conceptual site plans, distributed among the 8 Program streams. Thus, we have developed 1 or more project concepts for each of the Program streams. In the cases where multiple projects are proposed on a stream they should be designed to be implemented hand-in-hand, evaluated collectively, and work toward a long-term gravel augmentation plan. Should planning efforts that result from the Program suggest more sites may be sought on a particular stream or reach, the priority reaches and field sites can be revisited and design concepts developed, as a separate effort.

Eventual success is more likely because the prioritization and selection criteria presented in **Section 3.2** favor reaches where access at and downstream of project locations is generally favorable. However, to address the inherent uncertainties, monitoring and adaptive management recommendations are required. Monitoring and adaptive management recommendations are discussed later in **Section 4**.

4.2.1 Potential Methods for Augmenting Gravel

In this section we present a number approaches to gravel augmentation adapted from the gravel augmentation literature which may be appropriate for this Program. Most of these approaches have been presented and discussed in significant detail by Bunte (2004), and some of them implemented within the Santa Clara valley (e.g. Chartrand and others, 2012; USACE, 2013). Most importantly, each site should be considered carefully, and an augmentation approach must be custom tailored. Site-by-site examples, along with a presentation of the rationale for selecting specific methods is presented in **Appendix E**.

Direct Gravel Placement Methods

The placement methods below lend themselves to short-term gravel placement, largely because they are not as straightforward, and therefore potentially more expensive when used to supply a reach with gravels year-on-year but will typically encourage quicker habitat enhancement.

The methods described in this section generally require access to channel with heavy equipment and thus, typically impose more temporary impacts to riparian and aquatic areas. In areas where dewatering is required for LWD augmentation implementation, the following gravel augmentation methods may be more cost effective if implemented at the same time as LWD augmentation.

Adding Riffles to Mid-channel Pools

A common problem in streams downstream of dams are long mid-channel pools (long, flat bottomed, channel-wide pools) which have limited habitat value; Santa Clara Valley streams are no exception. These long, featureless pools generally occur where reaches are supply-limited (Excessive flows relative the quantity and caliber of bed sediment.). Adding coarse sediment to form riffles has been shown to add functional habitat (Kondolf and Minear, 2004).

Long mid-channel pools typically form in low-gradient streams, and we anticipate that clean gravels places as part of the Program will be highly transmissive and encourage hyporheic flow, critical to good spawning habitat. Placed gravels have the risk of forming critical riffles due to their highly transmissive nature, particularly in the first years following implementation, however the risk is minimized in low-gradient reaches.

Due to incision, many candidate locations for gravel augmentation may experience higher shear stresses more frequently than under historical conditions. Inclusion of larger, immobile or low-mobility coarse sediment may be appropriate. In addition, the inclusion of LWD augmentation projects are anticipated to improve retention.

Please see the project concept summary sheet for Uvas Creek 4-5 (UC4-5) in **Appendix E** as an example of a site where adding a riffle to a mid-channel pool is proposed.

Riffle Supplementation

Riffle supplementation describes extending and enlarging existing riffles increase available spawning habitat. When present, riffles in the Program streams are commonly smaller and the gravels more embedded. In areas where existing riffle-to-riffle slope is appropriate, this method is a good approach when trying to avoid undue flooding impacts because the effective flow area (the effective cross-section floodwaters experience during high flows) is not reduced. Please see the project concept summary sheet for Los Gatos Creek 2-2 (LGC2-2) in **Appendix E** as an example of a site where riffle supplementation is proposed.

Alluvial Mimicry

We consider both rifle supplementation and adding riffles to mid-channel pools to be alluvial mimicry, consistent with establish geomorphic metrics, however alluvial mimicry also encompasses restoration of a broad range of alluvial features encountered in the Santa Clara Valley. This may include forced bars, creek confluence deltas, or other complex bed arrangements, based on local conditions.

Because the Program seeks to augment spawning and rearing habitat, alluvial mimicry may include augmentation of poorly graded material, including cobbles and boulders in geomorphically appropriate locations.

Consideration must be given to the impacts of placed material on habitat conditions upstream of the planned placement site; placed material may flood features upstream and negate or reduce the positive habitat impacts of gravel augmentation (Elkins and others, 2007).

Alluvial mimicry, riffle supplementation and adding riffles to mid-channels pools are significantly more labor intensive that methods discussed below, and the incremental cost increases of implementation should be carefully considered against habitat improvements (Kondolf and Minear, 2004).

Bank Draping

Draping gravel along the banks for augmented reaches approach has been successfully implemented on Stevens Creek at Blackberry Farm Park. Bank draping does not attempt to explicitly create or mimic alluvial features, but rather seeks to place gravels distributed through a reach in a way such that moderate flows can mobilize and rework the sediments.

Bank draping may be an appropriate way to avoid undue flooding issues at sights where flood risk has been identified as a priority. Additionally, bank draping may also be appropriate for long-term augmentation sites and seen as sort of hybrid between the placement methods discussed above and the placement methods discussed below. **Figure 4-1** presents an example of bank draping used at the Stevens Creek Blackberry Farm Phase II channel restoration project in 2013.

Figure 4-1 Gravel draped on both banks on Stevens Creek at Blackberry Farm Park, Santa Clara County, California.

4.2.2 Indirect Gravel Placement Techniques

The placement methods described in this section are typically used at long-term injection points. Indirect placement can minimize impacts associated with getting in the channel and constructing alluvial features, however, they rely on the river to transport the material and construct desirable habitat features. Stormflow frequency and duration are unpredictable. As such, projects may not realize their habitat goals for months or years. Indirect methods are particularly appropriate for long-term gravel augmentation where ongoing augmentation downstream of reservoirs or other sediment trapping infrastructure is desirable.

Injection Piles

Injection pile placement describes a method of placing gravel in a large pile at the injection site within the channel. Mobilizing flows will redistribute the channel forming gravel bars and other features in response to the channel's incipient morphology. Piles are placed prior to, and potentially between events. Large stockpiles may cause undue flood risk in certain locations within the Program streams. In addition, even washed gravels can create turbidity when placed during inter-storm periods, which the District may seek to avoid. Injection pile locations need to be selected carefully in order to minimize the impacts of the injection pile itself, as well as the access route to the injection pile.

High-flow Injection

High-flow injection is similar to standard injection piles, however high-flow injection seeks to avoid undue aquatic impacts by placing a pile of gravel outside of the low-flow channel, so augmented gravels are only mobilized when high flows occur. This method can help minimize turbidity concerns. Like standard injection piles, High-flow injection pile locations need to be selected carefully in order to minimize the impacts of the injection pile itself, as well as the access route to the injection pile.

High-flow injection is not currently proposed at any of the nine proposed gravel augmentation sites presented in **Appendix E**. Please refer to Bunte (2004) for more detailed discussions of this placement method.

High-flow Direct Injection

High-flow direct injection requires using a belt conveyor or similar means to feed sediment to the channel during storm event. Like high-flow injection piles, direct injection avoids concerns over turbidity. High-flow direct injection has the additional advantage of reducing the impacts to banks, compared to injection piles, as long as the belt conveyor and loaders can be staged outside of the riparian corridor. Additionally, high-flow direct injection can help alleviate flood risk because it does not require placing a large pile in the channel which can block flows.

High-flow direct injection requires manually feeding gravel to the channel during high-flow periods, a significant logistical hurdle, and as such, high-flow direct injection is expected to be the costliest long-term gravel augmentation method.

Planned augmentation should recognize the need for periodic updates to meet evolving land- and water-use changes. Success of a longer-term program is much more likely if known or likely changes are anticipated in the plan. Even within the limited eight-stream Program, significant evolution can be anticipated during the next few years.

High-flow injection is not currently proposed at any of the nine proposed gravel augmentation sites presented in **Appendix E**. Please refer to Bunte (2004) for more detailed discussions of this placement method.

4.2.3 Sediment Gradation

Gravel augmentation designs specify the sediment gradation for use in the above gravel augmentation approaches (e.g. injection pile, riffle supplementation, etc.). When selecting the gravel augmentation gradation, the target design conditions are first considered. For lower gradient riffle-pool reaches, a target spawning gradation is selected following Kondolf and Wolman (1993) and then adjusted using the sediment transport modeling detailed below to meet the target transport objective. Gradations are typically coarsened so that the injection pile sediments are transported incrementally over several years, with an average transport rate of 100 to 300 tons per year. Gradation adjustments account for hydrologic forcing which varies between sites based on channel slope and geometry, and stream power. For steeper step-pool and plane-bed channels, as similar approach is taken, though a higher fraction of augmented material will exceed 128 millimeters in diameter (cobbles and boulders) to support rearing.

For projects that use quarry-sourced gravels, attempts to simplify the gradation should be made in order to save cost. When possible, using mixes of readily available quarry gradations will simplify the sediment acquisition process. For projects that use gravel extracted as part of SMP maintenance, or from reservoir delta deposits, gradations should be as simple as possible to minimize waste yet assure equal distribution (e.g. a well graded mix) through the grainsize gradation.

The quantity and augmentation method may affect the gradation itself. For example, if existing conditions allow for augmentation via a high-flow injection pile, the intermittent incorporation of the sediments at only high flows may avoid the requirement to add larger stabilizing cobbles and boulders. Other existing conditions that are considered should include existing bed gradation, upstream sediment supply, and locally-mined sediment sources from the channel banks, bars, or terraces.

Several other design questions are addressed using a bedload transport model. Some of these questions are:

- How quickly will gravel augmentation sediments be transported downstream?
- How long will gravel injection piles be available for sediment mining?
- Given the channel geometry, at what flows is most sediment being transported?

While the Wilcock and Crowe (2003) bedload transport model is widely used in many engineering and geomorphology applications, it is only applicable for modeling sediment mixtures which are sand-matrix supported, with a significant portion of sand in the mixture. Because the focus of these gravel augmentation projects is on spawning and rearing gradations, and the contemporary sediment sources for the Program streams are not sand-dominated, no sand was used. Instead, we have used a grain-size specific gravel-only transport model from Parker (1990) to quantify the bedload capacity for a variety of grain sizes and stream discharges. This model calculates the grain size-specific bedload capacity of a channel at a range of flows. Bedload capacity is different from a bedload transport rate; capacity is the total bedload that a given flow can transport. Bedload capacity can differ from entrainment and transport of a gravel augmentation pile for two primary reasons. First, sediment already being transported from upstream will decrease the ability of the flow to entrain sediments. Second, local heterogeneity in bed gradation, channel geometry, and velocity field can spatially alter the likelihood of sediment entrainments. As a result, calculated bedload capacity is an upper limit of potential transport. Many of the conceptual designs utilize gravel injection piles and incorporate gravels from one bank and so we have chosen to present bedload capacity as a rate in tons per year per unit of channel width.

Model inputs include gravel augmentation gradation, estimated channel roughness, channel slope, and historical hydrograph. For sites that are not close to a flow gage with a long historical record, the nearest gage is used and scaled based on the change in watershed size. The model calculates the historical effective discharge, or discharge for which most of sediment is transported. This often not the highest flows; lower flows tend to have a lower transport rate but occur more frequently than high flows and can therefore me more “effective” at transporting sediment. Other inputs include gravel gradation used, channel roughness, measured channel bed slope, and channel cross-section.

The model calculated a dimensionless bedload transport, W_i^*, for each grain size bin in the gradation:

$$W_i^* = 0.0218\, G(\phi_i)$$

where $G(\phi)$ is defined as:

$$G(\phi) = \begin{cases} 5474\left(1 - \frac{0.853}{\phi}\right)^{4.5} & for\ \phi > 1.59 \\ exp[14.2\,(\phi - 1) - 9.28(\phi - 1)^2] & for\ 1 \le \phi \le 1.59 \\ \phi^{14.2} & for\ \phi < 1 \end{cases}$$

and ϕ_i is a function of the ratio of a given grain size, D_i , to the geometric mean of the gradation, D_{sg},

$$\phi_i = \omega\, \phi_{sgo} \left(\frac{D_i}{D_{sg}}\right)^{-0.0951}.$$

The variable ϕ_{sgo} denotes the ratio of dimensionless shear stress, τ_{sg}^*, to a reference shear stress, $\tau_{ssrg}^* = 0.0386$. Dimensionless shear stress is calculated by,

$$\tau_{sg}^* = \frac{u_*^2}{RgD_{sg}}$$

where u_* is the shear velocity in m/s, R is the submerged specific gravity of sediment, set to 1.65, and g is the gravitational constant in m/s^2. The variable ω denotes the generalized strain function where

$$\omega = 1 + \frac{\sigma_s}{\sigma_s(\phi_{sgo})}\left[\omega_0(\phi_{sgo}) - 1\right]$$

where σ_s is the arithmetic standard deviation of the grain size, and where ω_0 and σ_s are strain parameters set as a function of ϕ_{sgo} shown in **Figure 4-2**. All grain sizes in this model are represented on the Phi-scale.

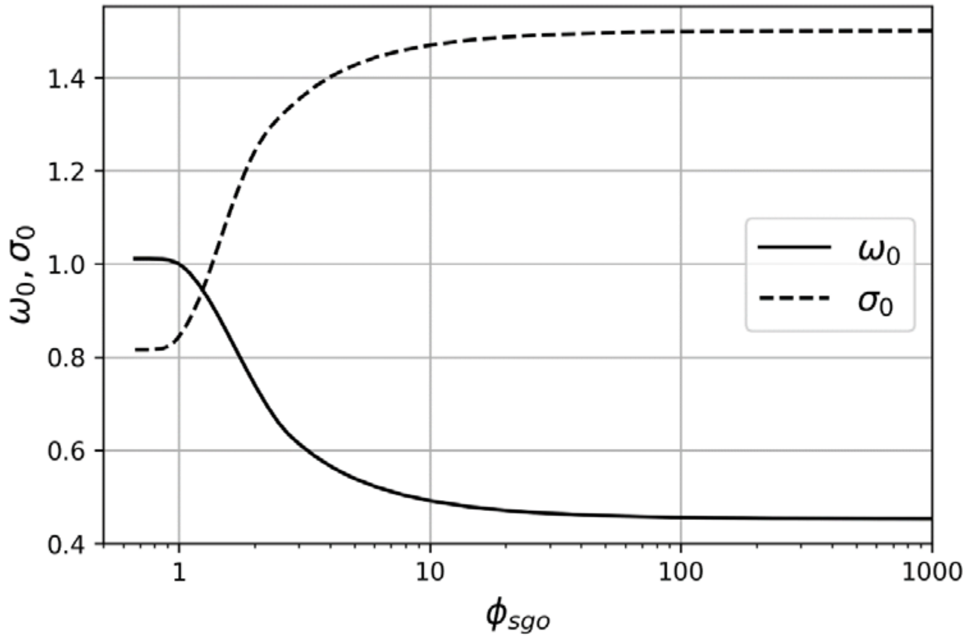


Figure 4-2 Strain functions used to estimate sediment transport capacity.

Model results include a bedload transport capacity at each flow, and the corresponding bedload grain size distribution (GSD).

The model is used to calculate the transport capacity for each timestep in the historical hydrograph. Then, flows are binned and bedload calculated in that bin is totaled across the entire flow history to give a total bedload capacity. The flow bin with the highest total transport is the effective discharge.

Using the cross-section measured during the field surveys, we applied the Manning's Equation to estimate the height of a key channel discharges, including the 100-year flow and the effective discharge:

$$V = \frac{k}{n} R_h^{2/3} S^{1/2}$$

where V is the cross-section averaged velocity, R_h is the hydraulic radius, S is the slope of the hydraulic grade line, which is assumed approximately equal to the channel bed slope, k is a unit conversion factor set to 1.49, and n is the Gauckler-Manning coefficient which is estimated in the field for each site based on channel roughness elements.

Sediments that are sized for spawning and rearing gravel are likely to be mobile at most flood flows. However, annual flows and corresponding bedload transport are highly dependent upon inter-annual climatic cycles (droughts, wet periods, etc.). Because of this uncertainty, we recommend an adaptive approach to project maintenance activities like gravel injection programs. However, to appropriately prioritize completion of gravel augmentation projects, we have included an estimate of gravel augmentation lifetime expectancy of the specified gradation for each conceptual design. Using the model, we have a calculated transport capacity for each historical water year. Given the uncertainties in annual rainfall, we have simulated 5000 realizations of a 10-year hydrograph sampling from historical water years. The realizations sample starting 1990. With these 5000 realizations, we have developed a statistical understanding of the most likely transport capacity, which we have termed the 'Expected' transport capacity and is represented by the mean value of the 5000 realizations. We can then use a window ±1 or 2 standard deviations to understand the 68 percent and 95 percent confidence intervals. In most cases, historical bedload capacity varies by several orders of magnitude and the confidence intervals are quite large. Over time scales of several years however, we may expect transport capacities to average out to something close to the expected value, which may be useful for planning potential gravel augmentation cycles.

The attached conceptual designs for the top twenty sites for which we are preparing conceptual designs, include model results, which consist of six figures or tables.

1. Flow-duration curve

   A flow-duration curve is calculated and plotted for the entire historical flow record. Key discharges are marked with dashed lines.

2. Modeled historical bedload capacity

   Bedload capacity is calculated using the model detailed above for the entire historical flow record. Flows and corresponding bedload capacities are binned and summed across the relevant flow range. The flow bin with the highest cumulative bedload capacity is the effective discharge, which is identified as a key discharge and labeled on **Figure 4-1**. When applicable the next highest discharge is also identified.

3. Channel cross-section

   During the field surveys, representative cross-sections were surveyed in an arbitrary datum. Cross-sections are plotted with key discharges, often including the flow of record, or the 2017 peak flow. This figure may can be used to understand potential flood capacity issues.

4. Bedload GSD

   The model calculates the GSD of bedload at all flows. The GSD of bedload at key discharges identified on previous plots is compared to the suggested injection or supplementation gradation. Often, the bedload GSD at the effective flow rate is finer than the design gradation because finer sediments are transported more easily than coarse sediments. However, we do not expect the pile to be completed depleted of small gravels as the cobbles and boulders will act to armor the injection pile or supplementation, slowing the transport of smaller gravels.

5. Expected cumulative transport capacity

   This figure presents the statistical variation across the 5000 realization of 10-year projected bedload capacity. The expected value is the expected transport capacity across the 5000 realizations sampled from historical bedload capacity (i.e. mean bedload capacity). The 68 percent and 95 percent confidence intervals are represented by 1 or 2 standard deviations of the 5000 realizations. Often, these confidence intervals represent a large variation in potential bedload capacity, representing the large variation that occurs with climatic cycles (droughts, wet years, etc.). The dashed line represents the cumulative injection recommendation, if any. Often the design injection scenario does not occur every year and so the pile will start large but meet the expected bedload capacity after a number of years before injection occurs again.

   It is important to note that, since transport is calculated per unit bed width, we have made assumptions about the effective bed width for each site concept. Changing the conceptual approach, either by changing the geometry of the injection pile, or by switching the approach from injection pile to riffle supplementation, for example, will likely have a significant effect on the sediment yields.

It is also important the background sediment transport will reduce capacity. In some cases, where projects are located just downstream of reservoirs or sediment sinks, the bedload transport capacity estimates approximate actual capacity, however in some cases there is significant existing bedload transport which should be considered. Where available, field data should be used to estimate existing sediment transport in order evaluate capacity. This may be in the form of bedload yield measurements calculated from direct bedload transport measurement or from sediment source analyses.

6. Bedload capacity

   This table gives the modeled bedload capacity for water years 2010 – 2017 and shows a wide variability capacity over climatic cycles. Each year is labeled as dry, average, or wet from a precipitation perspective. Because many of the sites are below major reservoirs, total annual flow and therefore bedload capacity many not be correlated with precipitation. Based on observation made by Balance staff in the field, we infer that the current 2017 values may be somewhat higher than expected, but these values can be used as a conservative estimate of bedload capacity. Flows from water year 2017 are preliminary and can be updated once the data is available.

4.2.4 Gravel Augmentation Sourcing

A comprehensive gravel augmentation program must consider sustainable sourcing of coarse sediment. To balance short term mitigation demands with long-term augmentation goals, two separate short- and long-term goals with respect to sourcing gravel for augmentation may be appropriate.

It is likely that short-term demands will need to be met with gravel purchased from local gravel quarries. Such material is generally available in the quantities desired, is cost effective (see recent discussion in USACE, 2013), and places fewer logistical and regulatory demands on the District.

In the long-term the District should consider harvesting gravels from within creeks under District jurisdiction, and ideally from within the same watershed as planned gravel augmentation projects. There are myriad reasons why local sourcing is preferential to purchasing imported coarse sediment material. The primary reasons are as follows:

- Importing gravels can have detrimental impacts on exporting watersheds (Kondolf, 1998).
- We expect gravel from local quarries will generally be more rounded than those within the Project streams. Rounded gravel more mobile and therefore are likely to be transported at lower flows for a given gradation.
- Sources from historic dredge mine tailing piles in the California Central Valley raise concerns over mercury contamination (Harvey and others, 2005).
- Reduced environmental impacts, and potentially reduced cost, due to transport of purchased gravels.
- District reservoir capacities are diminishing over time (USACE and others, 2013). Harvesting gravels from reservoir deltas can help maintain and increase reservoir capacity.
- The District owns, or is likely to have easement to numerous reservoir harvest access points, reducing coordination, and increasing the likelihood of long-term success.
- Imported river-run gravels will have different angularity and provenance than intra-basin sources gravels, and though there is uncertainty, it is thought that salmonids may not prefer such materials for spawning (Harvey and others, 2005). Bunte (2004) cites increased utilization of “native” gravels compared to imported gravels.

Local sediment sources offer the advantage of District control from source to placement, however managing the process presents significant regulatory and logistical hurdles:

- In the short-term, utilizing local sediment sources may not be feasible due to the planning and permitting required, thus purchase and import of sediments may be required.
- Address concerns regarding elemental and methylated mercury in reservoir sediments and the potential impacts and mitigation measures.
- To meet long-term gravel augmentation goals the District must establish a handling and stockpile facility, or facilities.

- A large fraction of sediment deposited in reservoirs are fined grains sands, silts and clays. Gravel harvesting programs need to address disposal of this sediment, which in many cases will be laden with mercury.
- Depending on the pathogen best management practices (BMPs) adopted, such a facility should have adequate space to sort, wash and dry sediment from individual watersheds separately, thus it may be advantageous to setup multiple handling and stockpile facilities for each of the major watersheds.
- Timing of coarse sediment harvesting may be affected by reservoir levels and the timing of future maintenance activities, thus gravel augmentation projects should be opportunistically implemented as sediment becomes available, or more likely, large stockpiles will be necessary.
- If complex gradations are required, supplementation of locally harvested gravels may be required to achieve desired outcomes.

4.2.5 Local Sediment Sources

Pathogens and Vectors

Known pathogens and vectors within Santa Clara County and neighboring counties include Phytophthera ramorum (plant pathogen that causes Sudden Oak Death), Chytridiomycota (commonly, Chytrid) a fungus that can kill amphibians, and various noxious weeds and flora. Though not currently present in Santa Clara County, Zebra mussels have been located in San Benito County.

District SMP follows BMPs are in place to guide maintenance practices and equipment, and those should be extended to address harvesting and placement of LWD and gravels using guiding documents such as Sweicki and Bernhardt (2013) for Phytophthera ramorum. Most BMPs address equipment, clothing and watercraft contamination (e.g. CDFW, 2016). SMP BMPs listed in their permits regarding equipment cleaning which can be adapted to gravel and LWD augmentation activities. Thus, prior to harvesting LWD and gravel from reservoirs and transporting the material, current BMPs should be adapted, if necessary county-wide and site specific BMPs for gravel and LWD. In general, pathogens of concern are easily moved through watersheds by flowing water, and transported organic and inorganic materials, and thus, BMPs should focus on inter-watershed contamination prevention.

Acceptable Amount of Organic Content

Retention of organic material in stream systems reduces the release of carbon to the atmosphere (Battin and others, 2008). Organic materials are an integral part of streambed ecology. In addition to differences in organic matter quantity and quality, urban streams also differ in organic matter retention. Coarse and fine particles released to measure organic matter transport in Atlanta, Georgia streams traveled much farther before leaving the water column in urban streams than in forested streams (Paul 1999). Combined with the data from benthic organic matter storage, their study suggests urban streams retain less organic matter, a fact that could limit secondary production in urban streams (Paul 1999). Re-introducing organic material that is harvested from reservoirs may provide additional ecosystem functions to gravel augmentation projects.

ASTM international, a standards organization commonly used to guide materials testing and geotechnical standards for construction materials used in restoration, classifies inorganic soils as soils containing less than two percent by weight of organic or other deleterious material (ASTM 2974). Higher percentages of organic content in the placed gravel augmentation can cause deflation or other unanticipated changes to the longevity and stability of built features. In cases where gravel is placed by injection pile, or conveyor, the District may want to consider allowing up to five percent by weight.

The District may want to consider reintroducing side-cast organics that are generated by the gravel sorting and screening process, that may otherwise be disposed of, to support the aquatic food web. Such material could be strategically placed integrated part of gravel and LWD augmentation projects (e.g. jammed and ballasted against the upstream side of a rootwad). Such material would not fall under the LWD classification put forth by SMP and thus we expect adequately small to limit potential risk to major infrastructure.

Sediment Quality and Approaching Mercury Contaminated Sediment Sources

Reservoir deltas have been identified as a potential source of gravel for this type of project. Reservoir delta gravels within the Guadalupe River Watershed (i.e., Calero and Guadalupe Reservoirs) may be impacted by historic mercury mining. Streams with potential historical mercury concerns are identified in **Table 4-1**.

Table 4-1 Summary of potential sediment source area reconnaissance and potential mercury contamination issues

Creek	Reservoir / Tributary arm	Likely Public lands?	Likely property owner, access	Historical Mining-Related Mercury Concerns?	Notes
Coyote	Anderson Lake				
Coyote	North Arm	Yes	SCVWD, Coyote Ridge Property	No [1]	Las Animas Creek, Delta mining appears feasible, access likely via Shigle Valley Road, to ranch roads
Coyote	South Arm	Yes	SCVOSA	No [1]	Access potentially through Oakridge Court to ranch roads
Coyote	Packwood Creek	Yes	SCCP	No	Appears inaccessable, but mostly on Parks land, large deep seated landslide near mouth
Coyote	Coyote Lake				
Coyote	North tributary	Yes	SCCP, possibly SCCOSA	No	Larios Canyon at Coyote Dam, access appears excellent: directly from Dam roadway
Coyote	South Arm	Yes	SCCP	No	Broad deltaic deposits, access likely via Roop Rd, or Gilroy Hot Springs Road
UPC	Cherry Flat Reservoir	Yes	City of San Jose, surrounded by SCVWD	No	Possible access via Alum Rock Falls Road, delta appears challenging to access via trails
Stevens	Stevens Creek Reservoir				
Stevens	North Arm (Swiss Creek)	Yes	SCVWD, possibly access through SCCP	No [1]	Directly adjacent to Stevens Creek Quarry
Stevens	South Arm	Yes	SCVWD, possibly access through SCCP	No [1]	Calfire Station 23
Los Gatos	Lexington Reservoir				
Los Gatos	Soda Spring Canyon (East)	Yes	SCVWD, potentially MPOSD	No	Alma Bridge Road
Los Gatos	Lyndon Canyon (West)	Yes	SCVWD	No	Access may be through private land of Caltrans Highway 17 ROW
Los Gatos	Limekiln Canyon	Yes	SCVWD, potentially MPOSD	No	Access by way of Limekiln Canyon Road, or Alma Bridge Road
Los Gatos	Los Gatos Creek	Yes	SCVWD	No	Cruz Highway, Alma Bridge Road
Los Gatos	Lake Elsman		Private (CPAD, 2016)	No	Access appears challenging, narrow or no trails, surrounding property doesn't appear to be in public easement
GC	Guadalupe Reservoir	Yes	SCVWD SCCP	Yes	Hicks Road, steep banks but access may be feasible
AC	Jacques Gulch	Yes	SCVWD SCCP	Yes	Alamitos Road, access appears feasible
AC	Larrabee Gulch	Yes	SCVWD, SCCP, SCCOSA	Yes	Appears to be inaccessible
Uvas	Uvas Reservoir				
Uvas	Eastman Canyon	N	Private Property (CPAD, 2016)	No [1]	Access via Eastman Canyon Road, looks
Uvas	North Arm	N	Private Property (CPAD, 2016)	No [1]	Access via Uvas Road appears excellent

Notes

1 Although historical mercury mining was not conducted in their watersheds, Anderson Lake, Stevens Creek Reservoir, and Uvas Reservoir are included on the CWA 303(d) list as impaired for mercury due to unknown sources. The listings are based on results of fish tissue monitoring conducted in 2001 and 2007.

UPC: Upper Penitencia Creek, GC: Guadalupe Creek, AC: Alamitos Creek

Because of concerns related to turbidity, the State of California requires that gravels used for augmentation be washed or dry-sorted to remove fines in most cases (Harvey and others, 2005). Because elemental and methylmercury concentrations are thirty to fifty times more concentrated in finer grained, clay- and silt-sized particles (Alpers and others, 2018), in it anticipated that sorting of washing of gravels will reduce mercury concentrations significantly. Handling and disposal of the large quantities of fines that gravel harvesting is likely to generate present a significant challenge.

Historic Mining and Mercury TMDL

Mercury mining was conducted in the New Almaden Mercury Mining District of the Guadalupe River headwaters from about 1850 to 1920 (SCVWD 2015, Williams 2014). Past mining activities resulted in the transport and deposition of mercury into some of the local receiving waters. Methylmercury occurs when elemental mercury is subjected to warm, anoxic environments. This can occur in alluvial environments, but more common in fine-grained environments such as wetlands, lakes and ponds. While elemental mercury is not easily bio-accumulated, its more toxic, bioavailable form, methylmercury is of significant concern to wildlife and humans. The Clean Water Act (CWA) Section 303(d) list identifies mine tailings as the source of mercury contamination in the Guadalupe Reservoir, the Calero Reservoir, Guadalupe Creek, Alamitos Creek, and non-tidal reaches of the Guadalupe River. As a result of the 303(d) listings, the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) developed the Guadalupe River Watershed Mercury Total Maximum Daily Load (TMDL) Project Staff Report in support of a Basin Plan amendment (Staff Report; SFBRWQCB 2008). The Staff Report describes the history of mercury mining in the New Almaden Mining District, models mercury sources within the watershed, and lists mercury allocations for each source designed to meet numeric targets for fish tissue.

The Guadalupe River Watershed Mercury TMDL Implementation Plan identifies parties responsible (including the District) for specific mercury cleanup and abatement actions, fish tissue and water monitoring activities, and implementation of technical studies. Some of these actions include sediment removal from creeks and upland areas.

Sediment and Gravel Management

In addition to the TMDL-related actions, the District is involved in other sediment removal projects in the Guadalupe River Watershed whose primary purpose is not mercury remediation. These projects may occur as part of the Santa Clara Valley Habitat Plan, the District SMP, or other District programs. The District's SMP provides permit coverage for minor mercury remediation associated with these types of sediment removal projects, however these may need to be modified in order to implement a gravel harvesting and reuse plan.

The Santa Clara Valley Habitat Plan (ICF 2012) also recognizes that sediments in the Guadalupe River Watershed may be contaminated with mercury. Section 2.3.4 of the Habitat Plan describes how current regulations require that sediment be tested for contaminants, including mercury, before it is used elsewhere in the watershed or distributed to a landfill. Sediment that tests positive for mercury must be disposed of in a hazardous material facility. The Habitat Plan also describes a potential Gravel Enhancement Program within the Guadalupe River Watershed which involves trapping, sorting, and washing of gravels for transportation to locations beneficial to fish habitat, as discussed above.

Best Management Practice (BMP Number GEN-3) developed for the SMP (SCVWD, 2014) clarifies that soils in the Guadalupe River Watershed that are likely to be disturbed or excavated should be tested for mercury. If mercury concentrations exceed 0.2 mg mercury per kg erodible sediment (dry weight, median), the soils should be removed and disposed of in a Class I landfill following established work practices and hazard control measures. The same mercury concentration threshold may apply to Guadalupe River watershed gravels used in gravel augmentation projects. However, there are remaining unanswered questions, that merit consideration by the District and regulatory agencies which may allow for relaxation of these standards:

- The conversion of elemental mercury to more toxic methylmercury reduced when hyporheic flow is encouraged. Though poorly understood, it is anticipated that gravel augmentation will improve hyporheic flow (Alpers, 2018) and reduce opportunities for methylation of elemental mercury.
- Also, we anticipate gravel augmentation will slow incision, thus reducing the potential for erosion of fine-grained floodplain sediments which are potentially sequestering mercury. It should be noted that in some cased gravel and LWD augmentation may cause bank erosion, and locations and designs approaches should be adapted to minimize disruption of sequestered mercury, downstream of reservoirs.
- Finally, removal and disposal of mercury laden fine-sediment as a result of harvesting gravel has the potential to reduce overall loading.

The Sediment Characterization Plan (SCVWD, 2013), included as **Appendix G** to the SMP, describes sampling methods and procedures designed to meet the objectives of landfill acceptance, sediment reuse sites, water quality protection, and fish and wildlife protection. Gravels in the Guadalupe River Watershed being considered for use in gravel augmentation projects should be sampled using composite sediment sampling methods.

District Sediment Management Program Coarse Sediment Removal

The District SMP must periodically remove sediment from channels in order to maintain conveyance and reduce flood risk. Channel maintenance sediment removal has been identified as a potential source (e.g. USACE and others, 2013) and through discussions with the District.

There are distinct advantages to repurposing removed coarse sediment. Repurposing removed coarse sediment is likely to be more cost effective than purchasing gravel from local quarries. Much of the cost involved in purchasing gravel is transporting the material to the site, thus potential savings could be significant, when purchased gravels must travel from Sunol, Pleasanton, or San Benito quarries.

Locally-sourced sediments should be cleaned, sieved, and sizes selected to match the design gradation. Removal and disposal of fines and contaminants will likely be required.

Reservoir Delta Sediment Harvesting

To promote the longevity and sustainability of gravel augmentation, the District and regulatory agencies should consider District managed reservoirs as a primary source for coarse sediment. **Table 4-1** presents a desktop evaluation of potential reservoir delta harvesting locations, access, and mercury contamination considerations. In this section we present two potential approaches to harvesting gravel from reservoirs, however further coordination and permitting with regulatory agencies, including California Environmental Quality Act (CEQA and Surface Mining and Reclamation Act (SMARA) review, and associated technical studies will likely be necessary to evaluate sediment quality, caliber and location, at which point a preferred alternative can be selected. The first recommended alternative is to install gravel traps along inlet channels to the reservoirs. Alternatively, dredging deeper in the reservoir along the more distal, submerged beds of the reservoir deltas.

Gravel traps may be hardscape, and should be carefully located below the highwater line, to reduce the potential impact to aquatic vegetation and habitat. The SCVHP[14] ICF, 2012) does not cover fisheries related natural resources, however it cross-references the proposed Three Creeks Habitat Conservation Plan. The Three Creeks Habitat Conservation Plan has been replaced by the broader master planning effort currently underway, however the SCVHP document has been approved by agency staff and we recommend building on recommendations contained within the SCVHP.

From SCVHP (2012):

> *Installation of gravel traps in the upstream reaches of Coyote, Anderson, Almaden, and Guadalupe reservoirs (below the high-water line) are proposed. The traps are needed to sort and wash gravel to remove fine sediments to improve spawning habitat for native fish. Washed gravel would then be transported to locations beneficial to fish habitat. Excavation may occur a maximum of one time per year per gravel trap if needed, but is expected to generally occur once every 3 years per gravel trap. The need to conduct excavation depends on the number of storms in a given season, how much gravel comes out of the watershed, and the need for gravel enhancement in downstream locations. Excavation will occur in the summer when the reservoir level has dropped below the location of the gravel trap such that the gravel trap will be dry. If excavated gravel needs to be stockpiled, placement will avoid sensitive natural communities such as wetlands and serpentine grassland. Whenever possible, existing access roads will be used to transport gravel from the excavation sites to processing facilities in the respective downstream watershed.*

Gravel traps offer a number of advantages:

- If properly located, gravel traps are unlikely to impact large areas of wetland and riparian fringe;
- easy to access via, when reservoir levels are low enough;

[14] The Santa Clara Valley Habitat Plan is a planning framework designed to promote the protection and recovery of natural resources while streamlining the permitting process for planned development, infrastructure, and maintenance activities.

- many headwater streams intermittent, and the District would likely be able to remove gravels "in the dry" at most locations; and
- harvesting would take place during the dry season.

If sub-surface mapping investigations suggest suitable material in suitably coarse material is present, dredging suitable sediments from within reservoirs deeper in the water column in the delta deposits may be preferable in reservoirs that do not have significant mercury concerns. Boat access would even further reduce riparian and wetland impacts, however harvesting may need to take place during the wet season, when ambient turbidity is high and turbidity (a potential associated contaminates) caused by harvesting course sediment is less of a concern.

It is our understanding that bypassing of Lake Almaden, as well as Ogier and Metcalf ponds is being considered, however if plans change, or are delayed, gravel traps of delta harvesting should be considered for the long-term planning of those assets.

As with SMP maintenance sediment removal, locally-sourced sediments should be cleaned, sieved, and sizes selected to match the design gradation. Removal and disposal of fines and contaminants will likely be required.

4.3 Large Woody Debris

Below we discuss a number of proposed approaches to large wood augmentation which may be appropriate for this Program. These approaches are discussed in the recent U.S. Bureau of Reclamation (USBR) and USACE National Large Wood Manual (USBR-USACE, 2016). Another excellent reference is **Appendix G** of the Washington State Aquatic Habitat Guidelines Program – Stream Habitat Restoration Guidelines 2012 (Cramer, 2012). Some have been implemented in restoration projects within the Santa Clara Valley (e.g. Chartrand, 2011, Chartrand and others, 2012, Donaldson and others, 2015). Habitat goals and success criteria of site should be considered carefully, and a LWD augmentation approach must be custom tailored.

4.3.1 Source and Species

LWD and have a finite life span. Although the LWD structures are strong and resilient initially, they decompose over time. Wood that is consistently submerged is not prone to decay by common decay fungi, though bacterial and soft-rot fungi can attack submerged wood and cause slow decay. The most common scenario for functional LWD structures is It is expected that they will slowly break apart over approximately 5-25 years, though, in some cases LWD can last much longer (USBR-USACE, 2016). The longevity of LWD is largely controlled by the tree species used, and inundation patterns and timing. As a general rule, wood with more nitrogen per unit of carbon (e.g. cottonwoods, willows and alders) will decay faster than those with lower nitrogen-carbon ratios (USBR-USACE, 2016).

Redwood and eucalyptus are generally considered to be the most widely available and durable options. Eucalyptus has the advantage of being a fast-growing non-native, and thus likely to more widely available from local agencies and arborists. Wood should be well cured, especially non-natives, to prevent re-rooting after placement. **Appendix F** summarizes relative wood durability from two sources (Highley, 1995 and USDA, 2010), which can be used to estimate the durability of many wood native and non-native wood types.

We understand the District currently stockpiles LWD. This Program be continued and expanded as needed to support LWD management as part of this Program, and the anticipated need for additional LWD in the future. In addition, we the District should consider options for collecting and stockpiling LWD in suitable condition and of suitable species which is trapped at reservoir spillways. In addition, partnerships with local agencies such as Santa Clara County Parks, Santa Clara Valley Open Space Authority, and the Midpeninsula Regional Open Space District, as well as local arborists who can be an excellent source of LWD. Encouraging those partners to remove trees with rootwads intact will increase the habitat value of placed LWD.

As with gravel sourcing, pathogens may be a concern, and we anticipate in many cases treatment will not be practical or feasible for locally sourced LWD, thus LWD may need to be stockpiled in such a way that is sensitive to BMP requirements, once they have been discussed with the appropriate regulatory agencies and established for the Program.

4.3.2 Design Considerations and Stabilizing Methods

Design Discharge

A 100-year recurrence flow is often used in urban stream settings as the flow to evaluate the forces LWD can be subjected to and design appropriate stabilizing methods (USBBR-USACE, 2016, Donaldson and others, 2015). In addition to bracketing the forces imposed on a LWD structure, evaluating the effects of the proposed LWD structure for the 100-year recurrence flow is mandated for many reaches within the Santa Clara County. Balance has developed a log buoyancy modeling tool following D'Aoust and Millar (2000), which can be implemented to evaluate the stabilizing needs for the design once logs have been sources and selected. In addition, a recently developed log stability design tool developed by the USFS and presented in Rafferty (2017) shows great promise. Both tools accommodate different wood densities, rootwad sizes, configurations and exposures, and incorporate a user-defined factor of safety. Drag forces can assume a velocity equivalent to the 100-year flow, or from more frequent recurrence flows, at the discretion of the Team and stakeholders. These tools can be used to evaluate the required cable and duckbill sizes for installations or can be used to evaluate ballast requirements. Rafferty (2017) however, appears to have a growing user-base and body of documentation, and support of federal funding, and thus is likely to reduce the liability exposer for the District, thus we recommend evaluating LWD stability using their tool.

In cases where LWD is perceived to cause and undue rise in the flood water surface elevation, additional grading within the project boundary may be required. In certain areas within the county, the District may need to issue a Letter of Map Revision (LOMR) to FEMA.

In addition, evaluating the effective sediment discharge is an important design consideration. Placing LWD in such a way as to maximize the effect on sediment transport will generally impart the most bed complexity (e.g. placing a log too high above the channel may not achieve the desired bed effects).

To reduce the likelihood of LWD transporting downstream, and associated flood impacts, the District requires that LWD be placed and secured. As infrastructure ages, and bridges and culverts are replaced, the District should consider working with municipalities and agencies to design creek crossings that can pass LWD without obstructions, thereby minimizing the need for securing LWD (Lassettre and Kondolf, 2012). The current hydraulic design manual (SCVWD, 2009) requirements largely address this with new design, but additional opportunities to modify and improve bridge design to accommodate wood passage may reduce maintenance costs, and loss of habitat due to maintenance. In the interim, we present below a suite of techniques which can be used to stabilize LWD structures.

Cabling

Cabling logs typically involves installing LWD and attaching it to duckbill anchors by way of a cable. It can be used as the only means of anchoring LWD or in conjunction with other stabilizing techniques. It should be noted that the primary forces on the logs are buoyant. When duckbills are used, we recommend anchoring the duckbills at a 45-60-degree angle (from horizontal) in the upstream direction for the transverse log, and in the bank direction for the bank parallel logs. Duckbills do not penetrate cobbles well and extra consideration should be taken to drive the duckbills to an adequate depth. Extra duckbills may be required in the case a buried boulder or cobble is struck during the driving process. **Figure 4-3** illustrates various examples of stabilization approaches, including cabling (Panels 1 and 2).

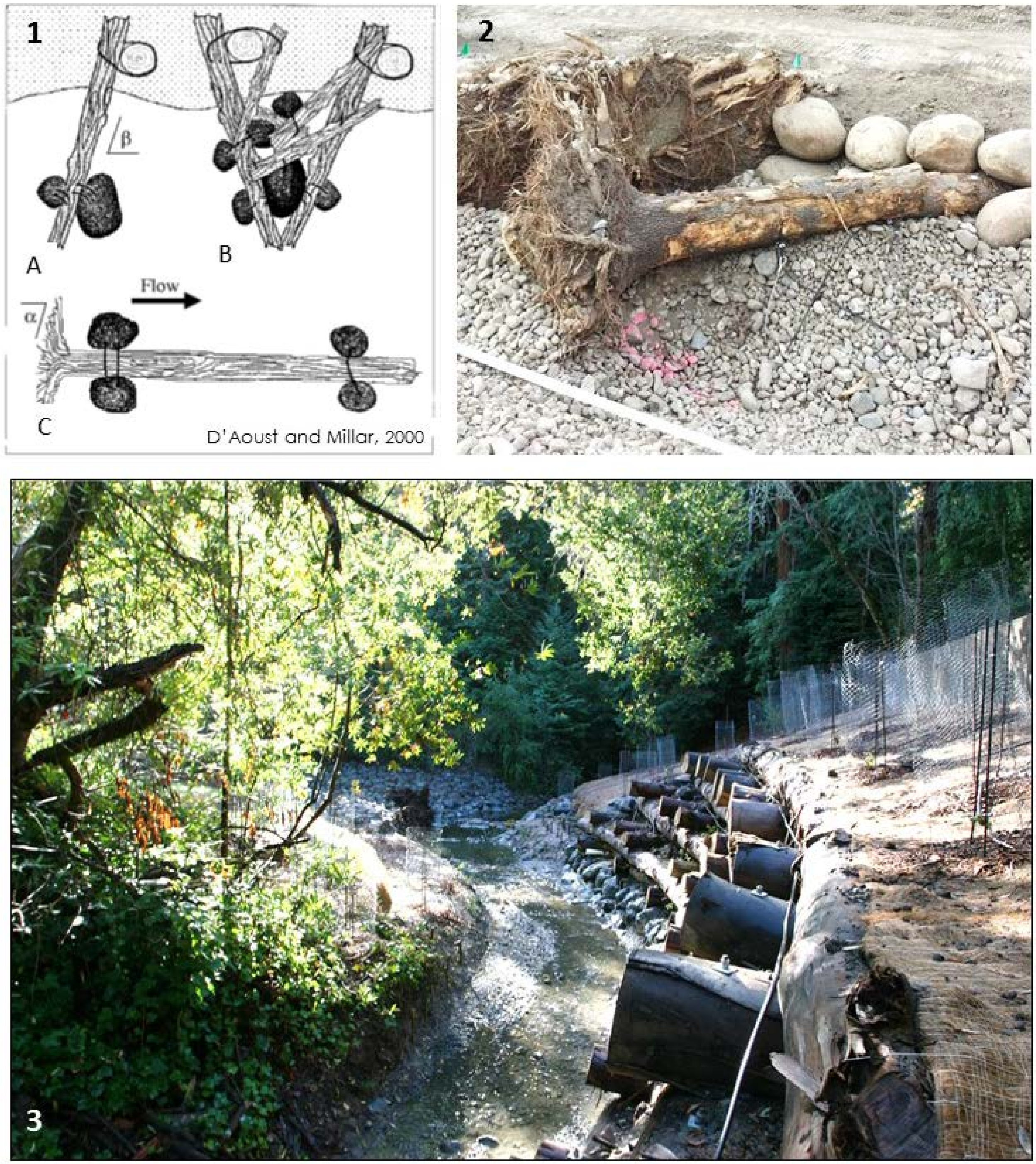


Figure 4-3 **Examples of stabilizing methods for large woody debris.** Panel 1 illustrates methods for ballasting logs, and engineered log jams with large boulders. In addition, Panel 1 illustrates pinning large woody debris to living trees on streambanks. Panel 2 illustrates a rootwad placement which utilizes ballast/burial in tandem with cabling. Panel 3 illustrates a bio-engineered cribwall.

Ballasting

Ballasting entails using large rock to either pin LWD in place or fastening large rocks to logs using cables or rod fasteners (**Figure 4-3**, Panels 1 and 2). Ballasting offers advantages over cabling in many applications, primarily that a well-designed ballast application will accommodate settling, scour better than cables. When scour occurs around a cabled log the placement is more likely to be compromised. The cabled log can swing freely, causing the log to work free of the cabling or to destabilize other bed features. Ballasted logs tend to settle into position, by tipping, rolling or translation when scour occurs, and are less likely to end up oscillating in the flow and working themselves free.

Drive-pointing/Burial

In some circumstances, logs can be "sharpened" and driven into the banks or bed of a stream. Alternatively, logs can be buried in the banks to provide stability (**Figure 4-3**, Panel 2). Both approaches are similar to ballasting, though in this circumstance, the weight of the local bed and bank material are used to stabilize installed logs. These methods are more appropriate in applications where the channel is not expected to migrate significantly. Most Program streams are not expected to migrate significantly, although there are some reaches where migration may occur.

Pinning

Pinning logs involves placing logs strategically against, between or upstream of existing riparian features such as trees, bedrock exposures, or boulders (**Figure 4-3**, Panel 1a). When pinning is utilized to stabilize LWD, the root strength, and overall health of the living trees, soil properties should be considered, and stability of other pinning features must be considered. Balance has developed a stability calculator to estimate the stability of living trees used for pinning LWD (Ruttenberg and Ballman, 2013) which can be used to aid log selection, or after logs are selected to evaluate supplemental additional stabilization requirements.

Engineered Logjams

Engineered logjams generally describe a large multi-log structure typically use one or more of the stabilizing techniques described above to keep the logjam in a fixed location (**Figure 4-3**, Panel 1b). Engineered logjams are designed to restore complex stream function, including creating pools, eroding banks, and encouraging recruitment, depending on the approach taken.

Bio-engineered Log-crib Walls

Bio-engineered log-crib walls are generally used for bank stabilization and describes a rock cored banks of "wall" of interwoven stretcher and stringer logs (**Figure 4-3**, Panel 3). Log-crib wall cribbing is typically bolted together, and ballasting of the rocks into the rock-core reduces the likelihood of failure. Log-crib walls can include root wads to enhance bed and bank heterogeneity, while protecting bank-side infrastructure or property, a potentially important factor in the highly urbanized areas of the Program streams. Log-crib walls are typically planted with riparian species which, over time, replace the strength of the crib wall as the cribbing decomposes.

4.4 Monitoring and Adaptive Management Recommendations

A successful monitoring program originates from a project with well-defined goals and objectives, design rationale, and success criteria. Monitoring and adaptive management should be motivated by well-defined success criteria. Thus, skilled geomorphologists, biologists and planners should be engaged to evaluate sites and develop final designs based on the preliminary work completed as part of this study. For gravel augmentation in particular, monitoring should be structured in a way that allows the District and regulatory agencies to collaboratively learn from implemented projects and refine long-term programs that may come out of this work.

This section describes the recommended approach to developing the monitoring and adaptive management plans for gravel and LWD augmentation projects. Site-by-site preliminary success criteria recommendations will be made on Project Concept Sheets, however final success criteria should come out of the detailed design process, which is anticipated for each site as the District selects projects to complete.

4.4.1 Selecting Appropriate Success Criteria

The first step in defining a monitoring program is to produce a basis of design report which clearly lays out the rationale for the project. At a minimum, design bases reports, should include:

- Clearly defined, site-specific goals and objectives.
- Clearly stated key questions, hypotheses and project scale.
- Existing site context, local and watershed perspectives. Typically, this includes an accurate base map or series of detailed cross sections and long profile.

- Evaluation of local hydrologic, biologic, and geomorphic conditions based on a detailed site evaluation. These evaluations will likely be the baseline conditions against which future monitoring is compared. For example, episodic inputs, as discussed in previous sections need to be assessed, and the relative value to control monitoring sites must be weighed.

- Hydraulic modeling to a) evaluate flood risk in areas where flooding is a concern, and b) evaluate sediment transport and other hydraulic opportunities and constraints.

- Design drawings.

- Success criteria and monitoring plan designed to specifically evaluate those success criteria.

Biological, social (e.g. flooding impacts) success criteria motivate many habitat restoration projects, however physical processes provide the framework for evaluating other issues (e.g. Kondolf and Micheli, 1995). Geomorphic success criteria and observations of physical structure pre- and post-project will enable the District to evaluate the projects as they evolve and make cost-effective adaptive management decisions. We do not recommend fish occupancy or macroinvertebrate metrics be used to develop success criteria. Biologic diversity, richness and abundance are dependent on myriad factors, including catchment-scale factors such as flow regime, stream temperature and water quality; factors out of the control of the Team and the District (Rubin and others, 2017). In their review of restoration projects in Maryland and Colorado, Laub and others (2012) similarly concluded that macroinvertebrate diversity did not correlate with improved channel complexity. Fish usage is also dependent on myriad catchment factors and can change in response to seasonal and interannual variability (Power and others, 1996), thus is a poor metric to measure site specific success. We anticipate that the District may be interested in evaluating occupancy and usage as part of larger Master Planning efforts that integrate other important enhancement actions, however, site specific monitoring should focus on straightforward, easily quantifiable geomorphic parameters (c.f., Dunne and Leopold, 1978; Hecht and others, 2013).

4.4.2 Existing District Guidelines from the Sediment Management Program

In general, project goals and success criteria, and thus monitoring programs have focused on short reaches near the injection site (Harvey and others, 2005). Gravel augmentation is anticipated to have beneficial habitat effects downstream of project sites. However, uncertainty surrounding the sediment transport potential and the proximity of property and infrastructure to creek channels downstream of potential sites presents a significant challenge. The District annually inspects channels within Program streams as part of the SMP. Ongoing District SMP monitoring will help overcome this significant challenge. SMP annual channel inspections are described in the follow excerpt from the SMP manual (SCVWD, 2014):

> *SCVWD staff annually inspect channels to identify bank erosion, levee erosion, levee damage from animals, in-channel blockages (debris, large woody debris [LWD], downed trees), sediment deposition, excessive bed scour, and in-channel vegetation growth that may impede flow conveyance. Staff conducting the inspections use SMP Maintenance Guidelines (MGs), where available, as the basis for identifying deficiencies.*
>
> *MGs do not exist for all channels, and for those channels where there are no MGs, staff rely on data from the as-built plans and associated flow data including the cross sections. In addition, data from existing SCVWD hydraulic models and the corresponding information from the Maps of Flood Control Facilities and Limits of 1 percent Flooding prepared by the SCVWD in 1993 will be used … Inspection staff conduct a visual assessment of the channels. Potential deficiencies are documented on inspection forms and photos are taken of the sites. Information gathered during the inspections is forwarded to technical staff for quantitative analysis and assessment, which may include the collection of survey data and hydraulic modeling. A multidisciplinary team consisting of engineers, biologists, inspection staff, and construction staff meet to review each site, prioritize the site for maintenance, and determine the appropriate course of actions to remedy the deficiency.*

Maintenance Guidelines are described in detail in Section 3 of the SMP (SCVWD, 2014). It should be noted that gravel or LWD augmentation should may cause unanticipated deposition in undesirable locations. Such conditions, if discovered should be maintained for flood capacity. Such additional maintenance efforts may require further in-stream mitigation, and adaptive management, in coordination with the resource agencies to minimize mitigation and ongoing impacts may be necessary. It may be warranted to add a geomorphologist or a stream scientist with geologic registration to the multidisciplinary team.

It should be noted that SMP maintenance activity impacts to spawning gravels are currently evaluated in terms of square feet of disturbed spawning gravels that are at least 18 inches deep (to support redd construction). When the next SMP is issued in 2024, we recommend considering:

- Adding a volumetric measure of streambed impacts to facilitate coarse material augmentation to a) more appropriately account for streambed impacts outside of spawning gravels where the 18-inch depth criteria may be less appropriate and, b) facilitate volume-based augmentation success criteria.
- Applying lessons learned from early projects implemented as a result of this Program.

4.5 Program Monitoring and Adaptive Management Recommendations

Monitoring and adaptive management are critically important for habitat restoration actions because the inherent complexity of stream habitat restoration means that all influencing factors cannot be evaluated prior to implementation (e.g. Wheaton and others, 2004). Thus, a hypothesis-driven project purpose should motivate a monitoring plan with clearly defined success criteria and triggers for adaptive management is a critical part of the planning and design process. Roni and others (2013) present a well-articulated framework for monitoring and adaptive management. The most common approach to evaluating restoration is the before-after design (Green, 1979) which involved monitoring a pre-project baseline condition and the post-project condition. There is the risk of interpreting natural trends and temporal variability as treatment effects. To reduce the risk of such misinterpretation, in some cases, before-after control-impact (BACI) monitoring design may be implemented. This method involves monitoring before and after implementation both at the restoration project site, but also at a suitable control site. With BACI, the standard null hypothesis is generally assumed to be that the trajectory of the difference between the site and the control would be flat in the absence of a restoration action. However, creek ecosystems and specific sites change dramatically due to natural forcing (i.e. the recent extended drought and the very wet water 2017). Thus, where a control site or sites is deemed appropriate, we recommend a trend-based evaluation, where year-on-year information is compiled and evaluated for trends in the changes between the project sites and control sites by knowledgeable experts. In many cases, retaining a professional with long-standing ties to the watershed and site to perform, or contribute to monitoring the site will benefit the project and strengthen the lessons learned.

If deemed appropriate, control sites may be selected from reaches proximally upstream of project sites, or in the case of project proposed just downstream of reservoirs, other nearby creeks may make more suitable controls. If many projects are implemented simultaneously, it is likely that a control site, or group of control sites may be adequate to evaluate a number of projects within at least portions of the chosen watersheds.

Appendix G summarizes potential success criteria, monitoring methods and adaptive management approaches which can be implemented once detailed designs have been prepared. After the project or gravel augmentation program is undertaken the following monitoring approaches should be considered, and the most appropriate methods selected. Below we present a general list of monitoring methods from which site-specific monitoring methods can be selected once the detailed design is in development:

- A post-project "as-built" monitoring survey to serve as the baseline condition against which future conditions are evaluated.
- Evaluation of recent conditions, including the intervening hydrologic conditions since the project was completed, or the last round of annual monitoring. This should include a brief evaluation of potential episodic events (e.g. landslides, new beaver activity, or drought) which establish a narrative for contextualizing the findings. It should be noted that pools regularly fill and scour as a result of natural variation in frequency and magnitude of flow events (e.g. Hassan, 1990), and thus year-to-year and storm-to-storm conditions should be carefully examined to help guide monitoring results.
- Evaluation of expected transport distances over the proposed monitoring period, and subsequently definition the monitoring study area. Tracer studies suggest that transport is stochastic in nature and difficult to predict, thus, an initial investigation phase during monitoring using tracers, could more accurately establish a reasonable area of expected benefits/impacts, over the monitoring period.
- Qualitative or quantitative monitoring of physical placement and stability to evaluate if placed wood is secure, or whether placed gravel is being transported as predicted under flows experienced.
- Cross-section and long-profile, or topographic breakline surveys at regular intervals or following wet-seasons that meet certain hydrologic criteria.

In many cases, the above approaches should be considered adequate, however in some cases, the following methods could be considered to supplement the above techniques in circumstances where more complex objectives are articulated, and watershed inputs which could conflate monitoring results are well understood or easily constrained:

- Dry-season facies mapping and bed texture mapping, either by hand or by unmanned aerial vehicle (a.k.a. drone), where feasible, or both. Bed texture mapping should focus on desired habitat types and should follow methods laid out in Bunte and Abt, 2001).
- Embeddedness evaluations and refuge inventory (e.g. Donaldson, 2011, Finstad and others, 2007).
- Stream flow habitat velocity measurements during appropriate flows and times of year. This may include local continuous flow gaging and should be explicitly tailored to the project. For example, if the intent of a project is to improve floodplain connectivity for off-channel habitat, hydrologic measurements and observations should target timing and duration of floodplain flooding.
- Quantification of organic matter retention (e.g. Ock and others, 2015).
- Repeat collection of full be topography and Habitat Suitability Index (HSI) analysis (e.g. Wheaton, 2004 and Chartrand and others, 2012).
- Gravel tracer studies involving passive RFID tracers, accelerometer RFID tracers, marker lithology clasts, and acoustic monitoring, or painted clasts. Marker lithology clasts can be used to quantify both pre- and post-project distance of travel.

In certain circumstances, monitoring should evaluate negative impacts of gravel or LWD placement. This may include:

- Qualitative or quantitative evaluation of bank erosion or impacts to infrastructure.
- CDFW Critical Riffle Analyses (CRA) to evaluate impacts to fish passage.
- Monitoring directly upstream of site where enhancements may reduce the value of upstream habitat (Wheaton and others, 2004).

If monitoring suggests that the project is not meeting success criteria, the District should consider supplemental surveys, photographs or observations. In some circumstances the District may want to consider additional hydraulic modeling.

5 CONCLUSIONS, RECOMMENDATIONS AND NEXT STEPS

The District's objective is to develop a county-wide gravel and LWD augmentation Program to increase spawning and rearing opportunities in the major steelhead streams in the County. In support of this objective, we have developed gravel augmentation site prioritization criteria, large woody debris placement site prioritization criteria, and identification of priority sites for future implementation based on Program variables for both gravel and LWD augmentation.

To meet the programmatic objectives our approach is to integrate existing data and findings on physical process, fisheries and aquatic habitat available for Program streams and develop criteria which can be used to prioritize placement of gravel and LWD. This is challenging, as data are available from many sources, and in general, most previous work was guided by different goals and therefore compiles and presents information in different ways. This report and the programmatic tools developed herein are intended to meet the first goal, by integrating the existing data to the extent practicable, to examine where augmentation of gravel and LWD will likely be most effective. Considerations used to guide site prioritization and feasibility include hydraulic assessments and evaluation of sediment transport, channel stability evaluation including channel history and projected watershed and channel conditions, channel habitat type and desired channel habitat relative to SC-CCCST, channel dimension and slope, potential to induce flooding, stream site fee and easement identification and stream access for implementation and maintenance, potential gravel and wood source(s), LWD source(s), and volume of placement materials (effective volume of appropriately sized material) i.e., surface square feet and depth.

To meet the above objectives, we developed a multi-criteria decisional analysis (MCDA) matrix, a commonly used programmatic tool used in ecological restoration. The MCDA was based on relevant criteria used to prioritize reaches for gravel and LWD augmentation. The MCDA is specifically structured to stratify stream reaches by feasibility of the gravel and LWD augmentation. From selected priority reaches, 47 high-scoring priority sites were selected for further evaluation and prioritization by the Team and District stakeholders. Of the 47 priority sites 32 were selected for field evaluations. The Team developed a site assessment SOP which was used to evaluate the 32 sites. The SOP outlines evaluation steps as well as ecologic and geomorphic metrics to collect and evaluate and is intended to be used for future evaluations within Santa Clara County.

Based on the data collected during the prioritization process outlined in Section 3 and the design considerations presented in Section 4 the Team has assembled project concept summary sheets for twenty priority gravel and wood augmentation projects.

The District has selected to implement 2 projects on Los Gatos Creek at project site LGC2-2. The project concept summary sheets are included in **Appendix E**. The however the design basis memorandum and 65% design, and specifications commensurate with planned the design-build approach will be prepared separately.

Gravel augmentation implemented as part of this program can and should evolve over the years of the program, based on an initial 5- to 10-year pilot period. Results of observing and monitoring the site can be and should be applied quickly. We should also recognize that the streams of Santa Clara County are generally smaller, have different dimensions, and are more subject to watershed disturbance by wildfires or other episodic events than are common in other portions of the state, most notably the Central Valley streams which tend to be less incised and have snowmelt hydrographs with gentler rises to and recessions from peak storms. Monitoring of the Santa Clara streams should be promptly evaluated, such that lessons learned applied to later phases of each project.

Success criteria and monitoring methods used to evaluate projects based on those success criteria should focus on simple, straightforward metrics. Watershed-scale processes affect site-specific conditions. To minimize the risk of confusing watershed-scale processes with site improvements, we recommend straightforward geomorphic indicators such as topographic and bed texture re-surveys be foundational elements of site-specific monitoring plans.

The Programmatic approach developed here is intended to be applied to the remaining Santa Clara Valley steelhead streams.

5.1 Future Planning

Prior to implementing gravel augmentation to maximize the benefits it is strongly recommended to coordinate with planned District projects in the area. For example, dam seismic retrofit activities on Anderson Dam and Guadalupe Dam may cause significant changes just downstream of those reservoirs, and present ideal conditions for staging and implementing gravel or LWD augmentation projects, but those opportunities are not likely feasible for some time. It should be noted that completion of the following projects may alter the prioritization scoring presented here, thus priority scoring may need to be revisited, and schedule of the potential augmentation projects may need to be coordinated with the schedule of the seismic retrofit projects. The following list summarizes planned District projects that may have impacts on future gravel augmentation project require coordination and evaluation for impacts to gravel and LWD augmentation:

1. Stevens Creek:
    a. Execute re-operation rules for Stevens Creek Reservoir.
2. Los Gatos Creek:
    a. Execute re-operation rules for Lexington Reservoir and associated infrastructure.
3. Guadalupe River, Guadalupe Creek and Alamitos Creek:
    a. Complete seismic retrofits and re-operation rules for Guadalupe Reservoir, Calero Reservoir and Almaden Reservoir.
4. Coyote Creek:

    Seismic retrofit of Anderson and Coyote reservoirs.

This list will need to be updated periodically as new projects get added and existing projects are completed.

5.2 Next Steps

Based on the work conducted and presented herein, we present a list of recommended next steps:

- Site-specific project goal refinement during final design process and concomitant development of success criteria. The result of the Program should be integrated with other ongoing District planning efforts and additional projects should be selected for detailed design and implementation. To satisfy District obligations under Safe Clean Water Priority D4 KPI5, which requires implementing one project in each of the 5 major watersheds (Stevens Creek, Guadalupe River, Coyote Creek, Uvas Creek for a total of 5, which may impact aquatic and riparian habitats. We commend this planning approach, and recommend it continues, especially with regard to gravel augmentation injection pile project, which can be implemented in a cost-effective manner, but may not immediately yield habitat benefits because injection piles are dependent on stormflows to create habitat features. In certain circumstances, alluvial mimicry and riffle supplementation methods may be preferred to expedite habitat enhancement.

- Long-term sustainable gravel augmentation should be pursued through gravel harvesting in District reservoirs. The District should engage the regulatory agencies and stakeholders to develop streamlined protocols and methods to encourage harvesting and reuse of sediment with legacy contaminants within the same watershed to minimize potential risk while maximizing benefits of restoring gravel and LWD supplies to offset reservoir trapping impacts.

- The list of priority reaches, field sites, and conceptual designs should be considered living documents. Opportunities and constraints shift and change. For example, the District may want to pursue more sites on a particular Program stream, at which point District staff should consider returning to the priority reach list and site prioritization to select more short-term projects to help rapidly recover sediment.

- When selecting concepts developed as part of the Program for implementation, consideration should be given to the District division and program that is sponsoring the project implementation, and the goals of that division or program. For example, LGC1-1 is an excellent location for gravel augmentation but, because of the beaver dam downstream, and resultant quiescence during low to moderate flows, we would not necessarily expect gravel to transport at frequent intervals until the beaver dam is destroyed or modified by a significant event. Similarly, at UC4-5, gravel and wood augmentation are recommended for implementation in conjunction with modification of the Miller Avenue stream low-flow crossing, which is significantly impacting the reach.

- The remaining SC-CCCST streams should be enrolled in the Program. To realize the full potential of the stratified prioritization process developed here, we recommend the remaining streams be evaluated simultaneously.

Current FEMA flood regulations make gravel and LWD augmentation more challenging and expensive. Our prioritization scheme incorporates a weighting factor which decreases the likelihood of gravel and LWD augmentation within regulatory floodway. There are ways to manage FEMA base flood elevations in and out of regulatory floodways, and it is our understanding that the District is committed to augmenting gravel, where appropriate, in regulatory floodways. However, gravel and LWD augmentation is generally less risky and success is more likely in areas where existing flood risks are low. Long-term, coordinated planning solutions are recommended to increase buffers, reduce flood risk and thereby increase opportunities for gravel and LWD augmentation.

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PLATES

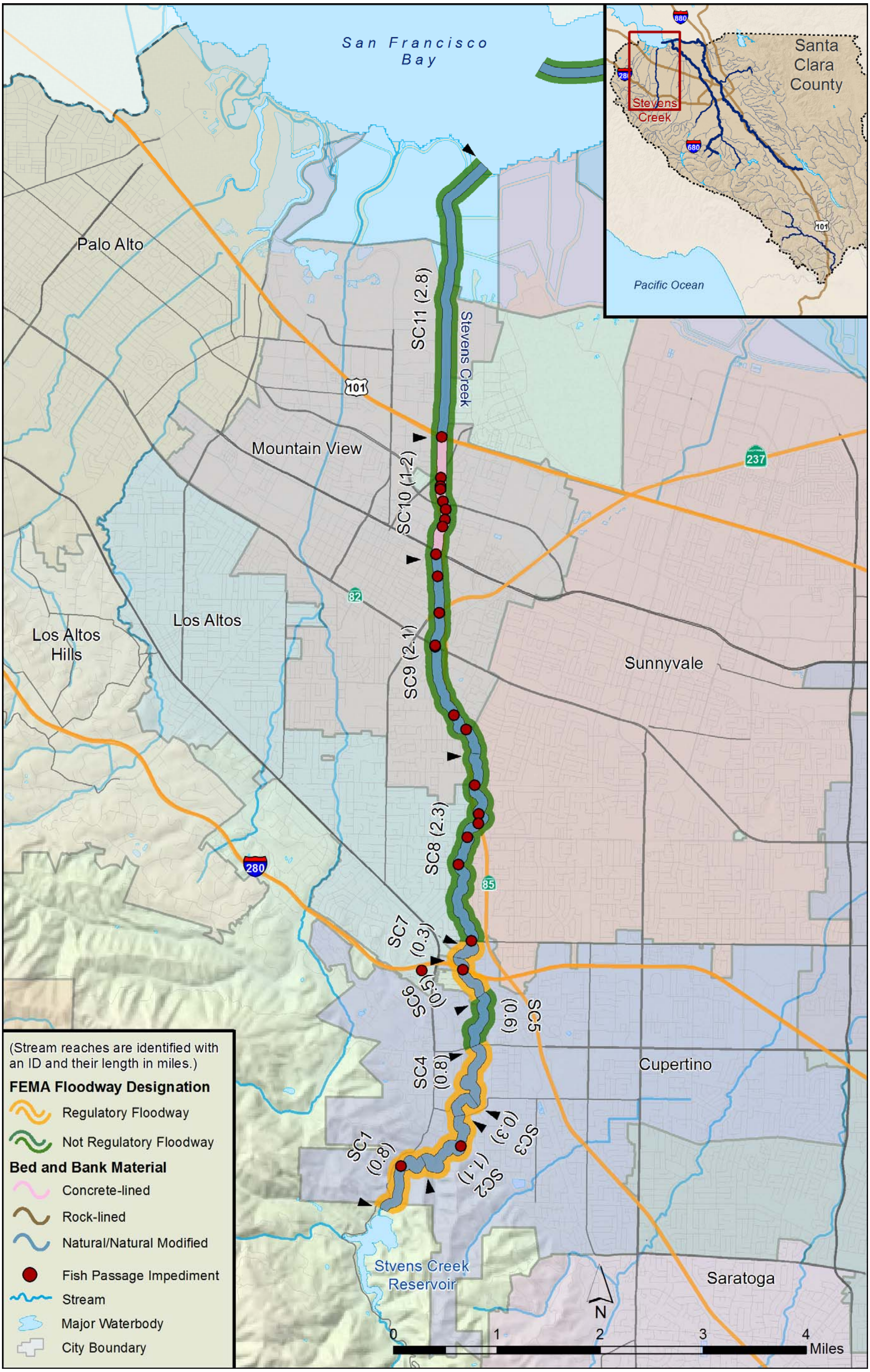

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Plate 1. Stevens Creek, Santa Clara County, California

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

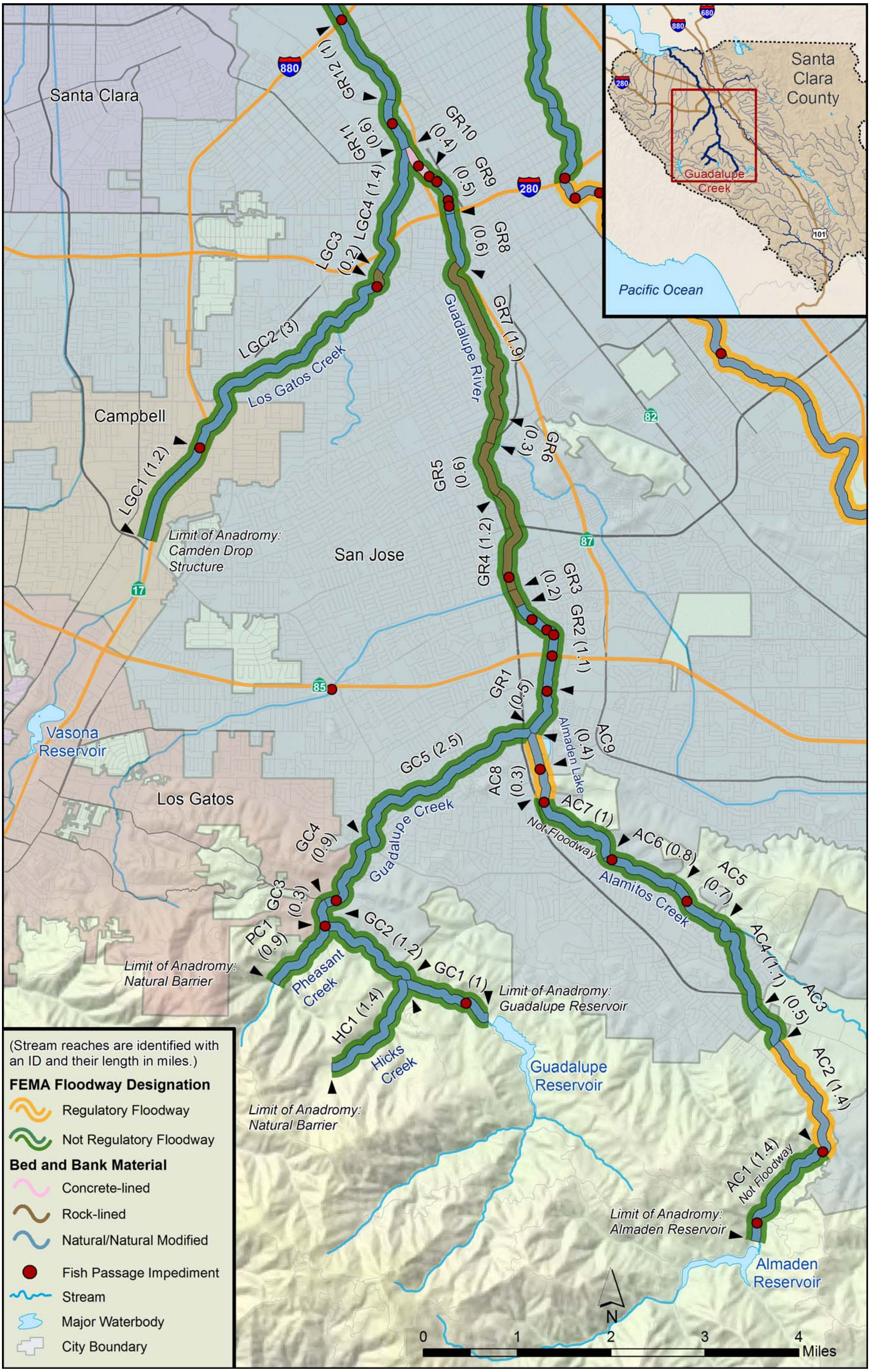

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Plate 2. Anadromous reaches of Guadalupe River watershed, including Los Gatos Creek, Guadalupe Creek and Alamitos Creek, Santa Clara County, California

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

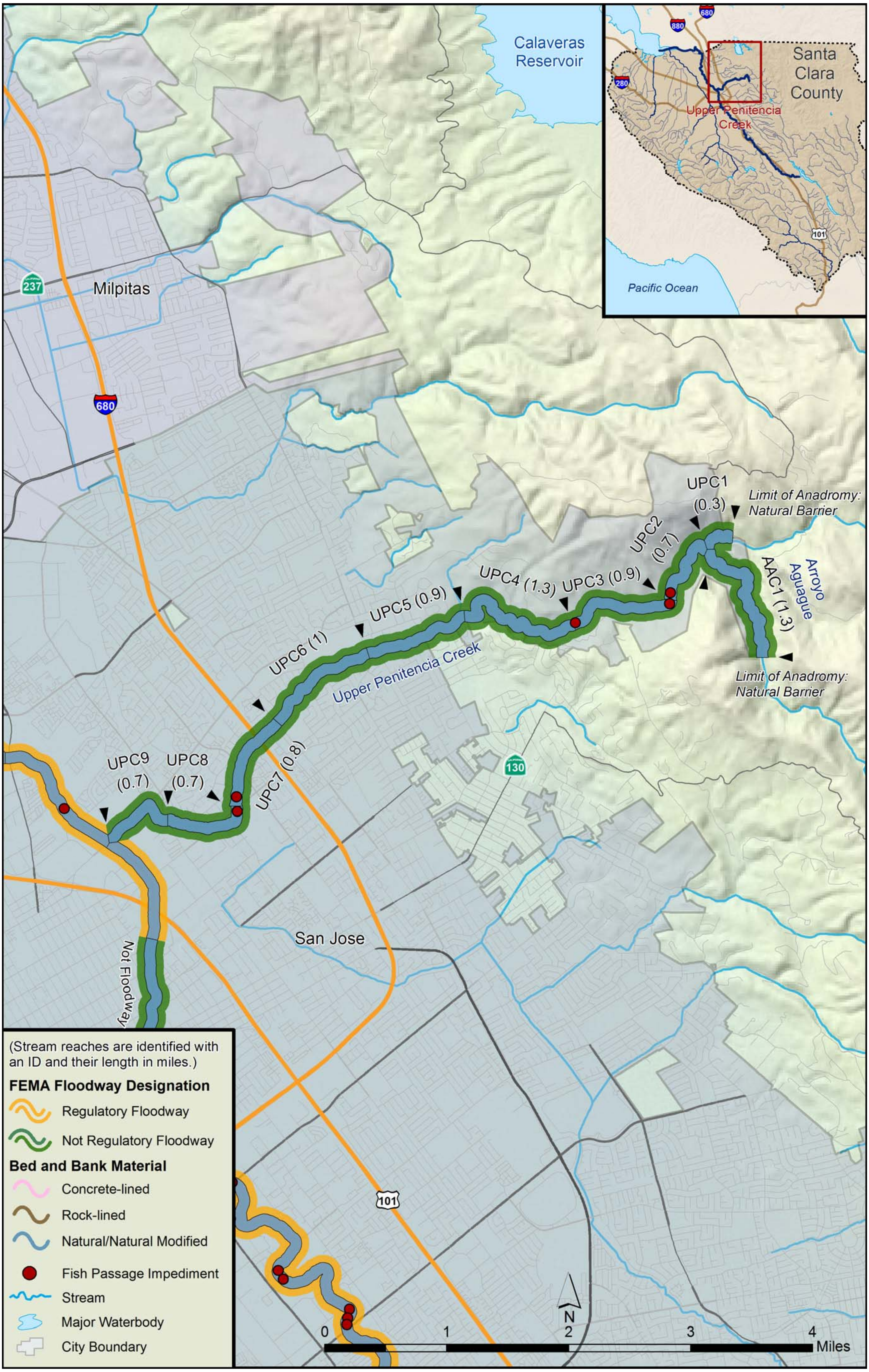

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Plate 3. Anadromous reaches of Upper Penitencia Creek, Santa Clara County, California

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

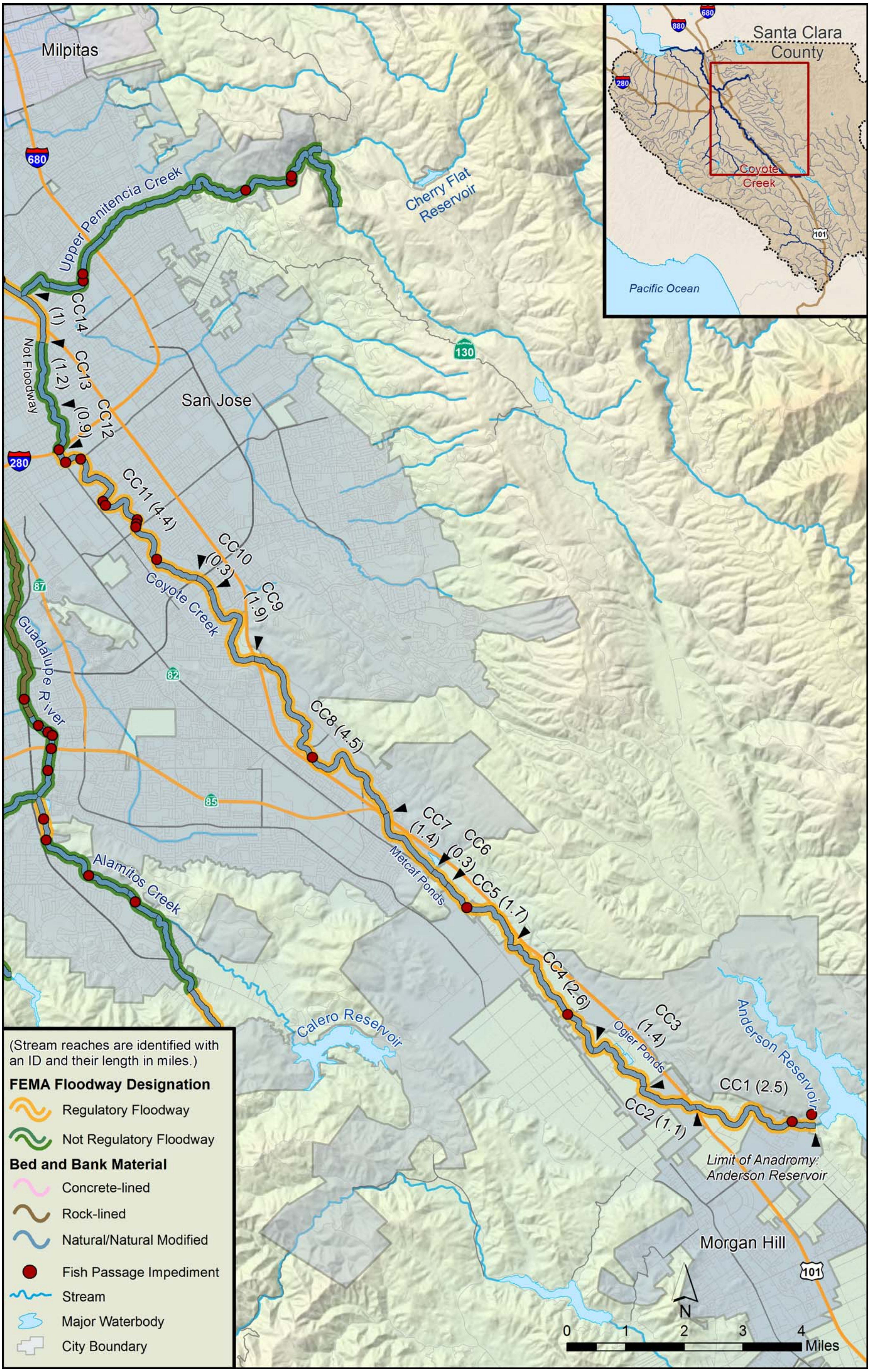

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Plate 4. Anadromous reaches of Upper Coyote Creek, Santa Clara County, California

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

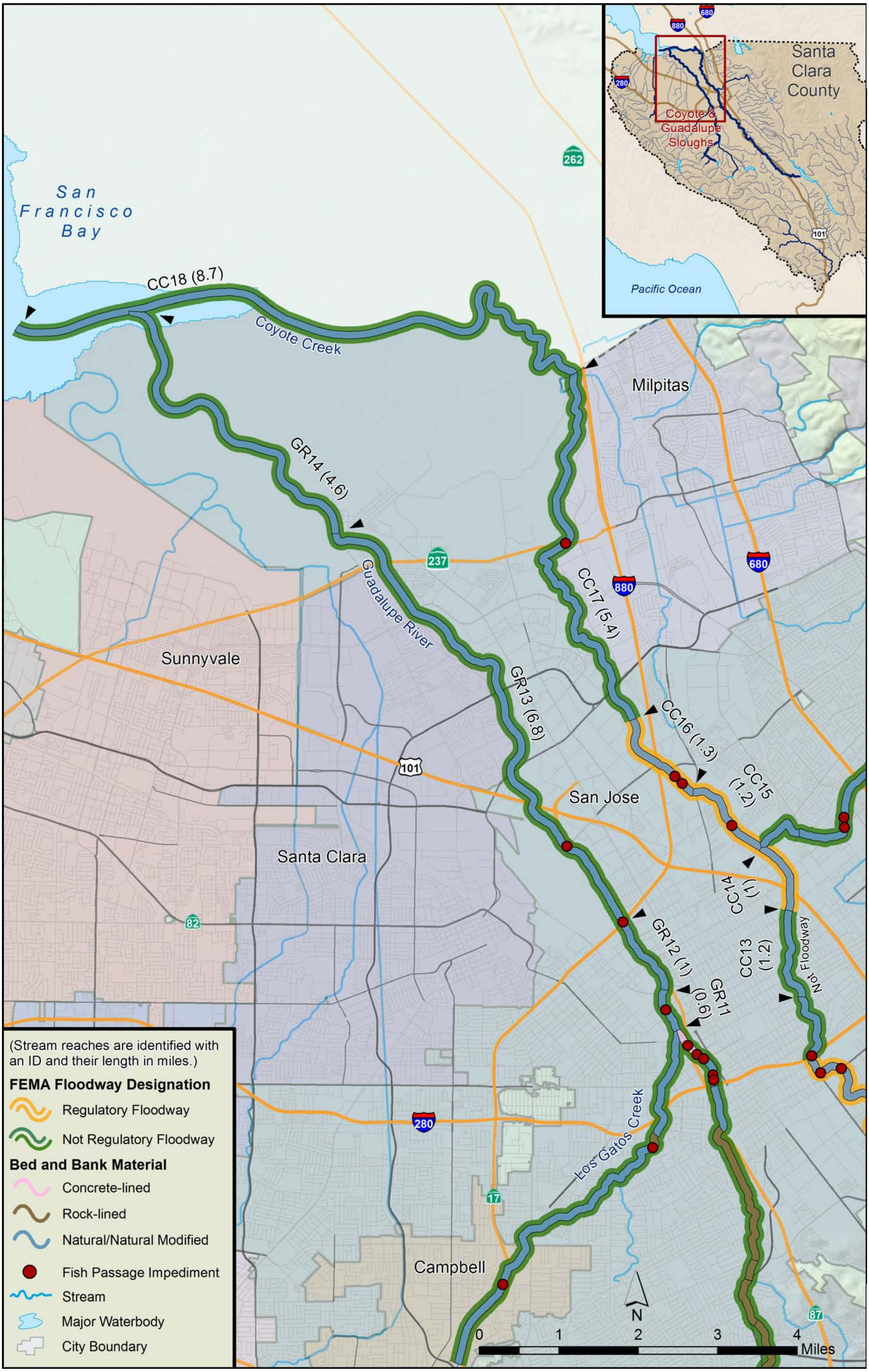

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Plate 5. Anadromous reaches of Lower Coyote Creek and lower Guadalupe River, Santa

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

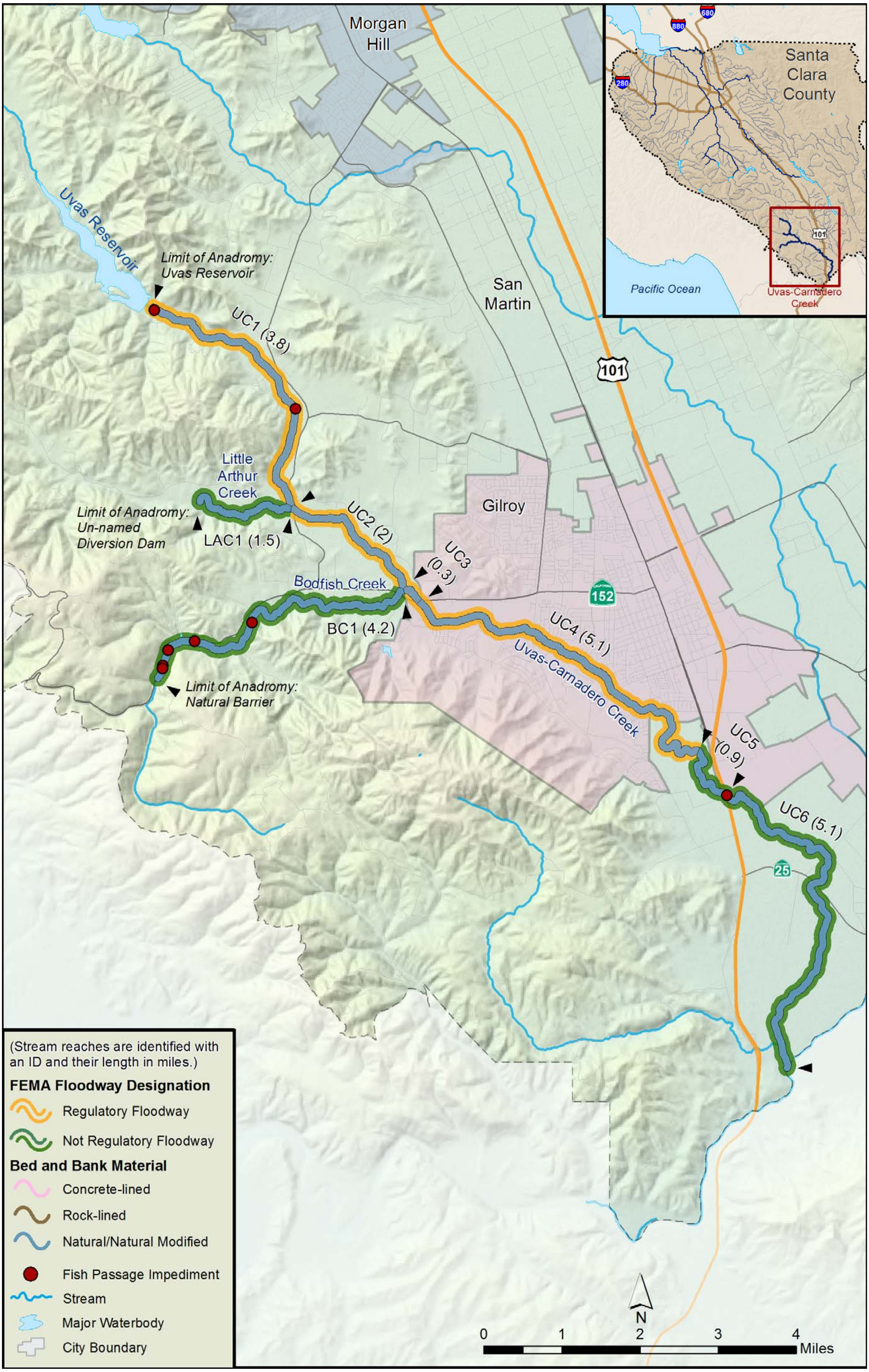

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Plate 6. Uvas Creek and tributaries, Little Arthur Creek and Bodfish Creek, Santa Clara County, California

Prepared by EOA GIS, Data Sources: FEMA, SCVWD, ARCGIS online.

APPENDICES

APPENDIX A

Santa Clara Valley Water District Stream Dry-back Summary Tables

Table A-1: Stream bed dryback data for select years, Stevens Creek, Santa Clara County California

Stevens Creek - Drybacк Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	37700	13:07	DS of Fremont	SC8 station at Fremont Ave
9/30/2003	37700	12:40	DS of Fremont	SC8 station at Fremont Ave

Stevens Creek - Dryback Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	37700	est.	DS of Fremont	SC8 station at Fremont Ave
9/30/2005	37700	11:53	DS of Fremont	SC8 station at Fremont Ave

Stevens Creek - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	12:40	To bay	SC11
9/30/2006	0	est.	To bay	SC11

Stevens Creek - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	24000	13:00	HWY 237	SC9
9/30/2010	27500	11:55	1600 ft US of El Camino	SC9

Stevens Creek - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	6:00	To Bay	SC11
9/30/2011	34250	10:11	2250 ft DS of Fremont Ave	SC8

Stevens Creek - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	34250	est.	2250 ft DS of Fremont Ave	SC8
9/30/2012	34250	12:45	2250 ft DS of Fremont Ave	SC8

Stevens Creek - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	31000	12:10	1300 ft DS of Permanete Diversion	SC7
9/30/2013	37300	11:00	400 US of Hwy 85	SC6

Stevens Creek - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
5/31/2014	57600	11:09	150' US of McClellan Road	Unable to verify with gauge data
9/30/2014	57600	10:45	150' US of McClellan Road	Unable to verify with gauge data

Stevens Creek - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	40150	12:36	850' DS of Holt Ave/ The Dalles	SC8
9/30/2015	34250	14:42	Remington Court	SC8

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location
Stevens Creek dries at Reach SC8 in normal years.
Source: SCVWD

Table A-2: Stream bed dryback data for select years, Los Gatos Creek, Santa Clara County California

Los Gatos Creek - Dryback Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	0	7:33	Guadalupe River	
9/30/2003	0	13:41	Guadalupe River	

Los Gatos Creek - Dryback Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	0	7:00	Guadalupe River	
9/30/2005	0	7:00	Guadalupe River	

Los Gatos Creek - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	-	Guadalupe River	
9/30/2006	0	10:40	Guadalupe River	

Los Gatos Creek - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	6:00	Guadalupe River	
9/30/2010	0	13:20	Guadalupe River	

Los Gatos Creek - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	6:00	Guadalupe River	
9/30/2011	0	6:00	Guadalupe River	

Los Gatos Creek - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	0	13:00	Guadalupe River	
9/30/2012	0	11:10	Guadalupe River	

Los Gatos Creek - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	0	12:30	Guadalupe River	
9/30/2013	0	13:00	Guadalupe River	Gap in gauge Data

Los Gatos Creek - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2014	0	9:11	Guadalupe River	
10/1/2014	16750	1420	Leigh Ave	Gap in gauge Data

Los Gatos Creek - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	16750	13:05	Leigh Ave	
9/30/2015	16750	est.	Leigh Ave	Gap in gauge Data

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
For dates with the comment "Gap in gauge data" water master recorded contiguous flow to Guad River but I was unable to verify this with stream gauge data because of a gap in the records.
Reaches 2, 3, 4 dry during major drought.
Source: SCVWD

Table A-3: Stream bed dryback data for select years, Guadalupe Creek, Santa Clara County California

Guadalupe Creek - Dryback Data 2003

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	10:14	Guadalupe River	
9/30/2010	0	-	Guadalupe River	

Guadalupe Creek - Dryback Data 2005

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	8:22	Guadalupe River	Est Flow to Guad River (4 cfs)

Guadalupe Creek - Dryback Data 2006

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	8:44	Guadalupe River	Est Flow to Guad River (2 cfs)
9/30/2010	0	-	Guadalupe River	Est. Flow to Guad River (1 cfs)

Guadalupe Creek - Dryback Data 2010

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	7:44	Guadalupe River	Est Flow to Guad River (1 cfs)
9/30/2010	108730	9:44	Guadalupe River	Est Flow to Guad River (10 cfs)

Guadalupe Creek - Dryback Data 2011

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	-	Guadalupe River	Est Flow to Guad River (5 cfs)
9/30/2010	0	-	Guadalupe River	Est Flow to Guad River (2 cfs)

Guadalupe Creek - Dryback Data 2012

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	108370	8:58	Guadalupe River	Est Flow to Guad River (2.5 cfs)
9/30/2010	108370	est	Guadalupe River	Est Flow to Guad River (1.5 cfs)

Guadalupe Creek - Dryback Data 2013

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	108370	9:53	Guadalupe River	Est Flow to Guad River (1.5 cfs)
9/30/2010	108370	8:33	Guadalupe River	Est Flow to Guad River (1.5 cfs)

Guadalupe Creek - Dryback Data 2014

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	117750	6:50	DS of Camden Ave	No flow to Guadalupe River
6/30/2010	117750	6:29	DS of Camden Ave	No flow to Guadalupe River

Guadalupe Creek - Dryback Data 2015

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	117750	est.	DS of Camden Ave	No flow to Guadalupe River
9/30/2010	117750	6:00	DS of Camden Ave	No flow to Guadalupe River

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
Reaches GC5 dry during major drought.
Source: SCVWD

Table A-4: Stream bed dryback data for select years, Gudalupe River, Santa Clara County California

Guadalupe River - Dryback Data 2003				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	est.	Bay	
9/30/2010	0	1350	Bay	

Guadalupe River - Dryback Data 2005				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	est.	Bay	Est. flow to bay (11 cfs)
9/30/2010	0	est.	Bay	Est. flow to bay (4 cfs)

Guadalupe River - Dryback Data 2006				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	-	Bay	Est. flow to bay (11 cfs)
9/30/2010	0	est.	Bay	Est. flow to bay (3 cfs)

Guadalupe River - Dryback Data 2010				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	est.	Bay	Est. Flow to Bay (15 cfs)
9/30/2010	0	est.	Bay	Est. Flow to Bay (11 cfs)

Guadalupe River - Dryback Data 2011				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	6:00	Bay	Est. flow to bay (5 cfs)
9/30/2010	0	6:00	Bay	Est. flow to bay (2 cfs)

Guadalupe River - Dryback Data 2012				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	6:00	Bay	
9/30/2010	0	est	Bay	Est. flow to bay (5 cfs)

Guadalupe River - Dryback Data 2013				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	0	est.	Bay	
9/30/2010	0	est.	Bay	

Guadalupe River - Dryback Data 2014				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	105100	7:19	US of Blossom Hill	No flow to Bay
6/30/2010	106566	8:05	DS of Coleman Rd	No flow to Bay

Guadalupe River - Dryback Data 2015				
Date	**Flow Ends at: (Ck. Sta. Ft.)**	**Time of Day:**	**Cross Street**	**Reach/ Comments**
6/1/2010	105650	est.	US of Blossom Hill Rd	No flow to bay
9/30/2010	107431	6:00	DS of Almaden Expressway	No flow to bay

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
Reaches GC5 dry during major drought.
Consistent flow to bay under normal conditions. All Reaches dry during major drought.
Source: SCVWD

Table A-5: Stream bed dryback data for select years, Alamitos Creek, Santa Clara County California

Alamitos Creek - Dryback Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	0	956	Guadalupe River	
9/30/2003	0	-	Guadalupe River	

Alamitos Creek - Dryback Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	0	est.	Guadalupe River	
9/30/2005	0	est.	Guadalupe River	

Alamitos Creek - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	-	Guadalupe River	
9/30/2006	2000	600	Almaden Lake	

Alamitos Creek - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	est.	Guadalupe River	
9/30/2010	0	est.	Guadalupe River	

Alamitos Creek - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
5/31/2011	0	-	Guadalupe River	
9/30/2011	0	est.	Guadalupe River	

Alamitos Creek - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	0	est.	Guadalupe River	
9/30/2012	0	est.	Guadalupe River	

Alamitos Creek - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	0	est.	Guadalupe River	
9/30/2013	0	est.	Guadalupe River	

Alamitos Creek - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2014	31250	6:37	Mazzone Drive	
6/30/2014	31250	8:35	Mazzone Drive	

Alamitos Creek - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	22400	13:44	Almaden Expressway	
9/30/2015	22200	10:34	DS of Almaden Expressway	

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
Reaches GC5 dry during major drought.
AC4-9 dry during major drought
Source: SCVWD

Table A-6: Stream bed dryback data for select years, Coyote Creek above Laguna Seca, Santa Clara County California

Coyote Creek above Laguna Seca - Dryback Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	171300	-	300' DS Metcalf Rd	coyote perc. ponds
9/30/2003	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Drybrack Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	171300	-	300' DS Metcalf Rd	coyote perc. ponds
9/30/2005	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	171300	-	300' DS Metcalf Rd	coyote perc. ponds
9/30/2006	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	est.	Bay	
9/30/2010	0	est.	Bay	

Coyote Creek above Laguna Seca - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	est.	Bay	
9/30/2011	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	171300	-	300' DS Metcalf Rd	coyote perc. ponds
9/30/2012	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	171300	-	300' DS Metcalf Rd	coyote perc. ponds
9/30/2013	171300	-	300' DS Metcalf Rd	coyote perc. ponds

Coyote Creek above Laguna Seca - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2014	192912	11:19	200' DS of Coyote Creek golf access	
9/30/2014	199060	12:53	60' US of Barnhart Ave	Between Ogier ponds 2 and 3

Coyote Creek above Laguna Seca - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	199060	12:36	60' US of Barnhart Ave	Between Ogier ponds 2 and 3
9/30/2015	199060	7:50	60' US of Barnhart Ave	Between Ogier ponds 2 and 3

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
Reaches CC4-18 dry during major drought
Source: SCVWD

Table A-7: Stream bed dryback data for select years, Coyote Creek below Laguna Seca, Santa Clara County California

Coyote Creek below Laguna Seca - Dryback Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	136200	8:08	d/s hellyer	no info. How far DS of Hellyer
9/30/2003	136200	8:08	d/s hellyer	no info. How far DS of Hellyer

Coyote Creek below Laguna Seca - Dryback Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	0	est.	Bay	
9/30/2005	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	est.	Bay	
9/30/2006	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	est.	Bay	
9/30/2010	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	est.	Bay	
9/30/2011	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	0	est.	Bay	
9/30/2012	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	0	est.	Bay	
9/30/2013	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2014	0	est.	Bay	
9/30/2014	0	est.	Bay	

Coyote Creek below Laguna Seca - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	0	est.	Bay	
9/30/2015	0	est.	Bay	

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
Reaches CC4-18 dry during major drought
Source: SCVWD

Table A-8: Stream bed dryback data for select years, Upper Penitencia Creek, Santa Clara County California

Upper Penitencia Creek - Dryback Data 2003				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	0	8:24	Coyote Creek	
9/30/2003	0	15:10	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2005				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	0	15:38	Coyote Creek	
9/30/2005	0	10:45	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2006				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	14:40	Coyote Creek	
9/30/2006	0	6:36	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2010				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	11:00	Coyote Creek	
9/30/2010	0	10:45	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2011				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	12:17	Coyote Creek	
9/30/2011	0	9:10	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2012				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	0	est.	Coyote Creek	
9/30/2012	0	8:55	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2013				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	0	10:14	Coyote Creek	Unable to verify with gauge data
9/30/2013	0	11:43	Coyote Creek	

Upper Penitencia Creek - Dryback Data 2014				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
5/31/2014	21000	est.	Penitencia Creek Rd and Tallent Ave	Unable to verify with gauge data
10/1/2014	22300	est.	300' US of Dorel Drive	Unable to verify with gauge data

Upper Penitencia Creek - Dryback Data 2015				
Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	21000	est.	Penitencia Creek Rd and Tallent Ave	Unable to verify with gauge data
9/30/2015	23500	est.	1500' US of Dorel Drive	Unable to verify with gauge data

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
UPC5-9 dry during major drought
Source: SCVWD

Table A-9: Stream bed dryback data for select years, Uvas-Carnadero Creek, Santa Clara County California

Uvas-Carnadero Creek - Dryback Data 2003

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2003	27000	15:13	DS 101	UC5 -unable to verify with gauge
9/30/2003	100	9:06	100' US of Pajaro River	UC5 - unable to verify with gauge

Uvas-Carnadero Creek - Dryback Data 2005

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2005	0	est.	Pajaro River	n/a
9/30/2005	39200	10:58	US Luchessa Ave	UC4

Uvas-Carnadero Creek - Dryback Data 2006

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2006	0	est.	Pajaro River	n/a
9/30/2006	0	12:05	Pajaro River	n/a

Uvas-Carnadero Creek - Dryback Data 2010

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2010	0	est.	Pajaro River	n/a
9/30/2010	32450	5:53	5450' US of 101	UC5 - adjacent to Farman Lane

Uvas-Carnadero Creek - Dryback Data 2011

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2011	0	est.	Pajaro River	n/a
9/30/2011	32450	11:15	5450' US of 101	UC5 - adjacent to Farman Lane

Uvas-Carnadero Creek - Dryback Data 2012

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2012	0	est.	Pajaro River	n/a
9/30/2012	37800	12:59	1000' DS of Luchessa Ave	UC4

Uvas-Carnadero Creek - Dryback Data 2013

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2013	43250	8:17	700' DS of Miller Ave	UC4
9/30/2013	45900	10:43	2050' US of Miller Ave	UC4

Uvas-Carnadero Creek - Dryback Data 2014

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2014	53275'	12:19	Hecker Pass (HWY 152)	UC4
9/30/2014	58725'	8:46	500' DS of Hecker Pass (HWY 152)	UC4

Uvas-Carnadero Creek - Dryback Data 2015

Date	Flow Ends at: (Ck. Sta. Ft.)	Time of Day:	Cross Street	Reach/ Comments
6/1/2015	45900'	11:00	3550' DS of Santa Teresa Blvd	UC4
9/30/2015	53275'	8:48	3825' US of Teresa Blvd	UC4

Notes:
Dryback is defined as the limit of wetted channel. Channel is assumed to be generally wetted upstream of location.
UC5 and 6 appear to dry somewhat regularly.
Source: SCVWD

APPENDIX B

Multi-criteria Decisional Analysis Scoring Criteria Matrix

Table B1: Rating criteria for scoring Multi-Criteria Decision Analysis to establishing priority reaches for gravel augmentation

	SCORE:	-1	0	1
	General score description	Initial data suggest the gravel augmentation unlikely	Neutral, does not apply, or data absent.	Evaluation criterion favors gravel augmentation
	Primary reach selection criteria			
1	Is there a major range-front reservoir which is disconnecting sediment sources from the channel?	No major range-front reservoir, ample potential supply of sediment	Range-front reservoir, some tributaries un-dammed and supplying sediment	Major tributaries are dammed or have major impoundments
2	Area upstream of reach that is protected (CPAD, 2016). For streams with major water supply reservoirs, area of protect open space is estimated for area downstream of reservoir.	More than 66 percent protected open space	34 to 65 percent protected open space	33 percent or less protected open space
3	Does reach tend to accumulate sediment according the SCVWD Stream Maintenance Program records?	Reach tends to accumulate sediment frequently and at high volumes.	Reach tends to accumulate sediment, but not frequently or in high volumes. Reaches directly downstream tends to accumulate sediment frequently.	No record of sediment removal at reach, and no record of sediment accumulation in the downstream adjacent reach.
4	Based on GHD asset assessment, are the bed and banks along the reach highly manipulated, and therefore gravel augmentation is less likely to improve geomorphic funcion through the reach?	Reach is dominated by concrete-lined bed and/or banks, or a combination of concrete- and rock-lined bed and/or banks, based on GHD channel types.	Reach is dominated b rock-lined bed and/or banks, based on GHD channel types	Reach is classified as natural and/or natural modified based on GHD channel types
5	Is reach proximal to upstream gravel-trapping percolation basins, and therefore augmentation habitat benefits are maximized?	More than three reaches downstream of major sediment sink, or no major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.	One or two reaches downstream of major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.	Reach is directly downstream of major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.
6	Is reach proximal to downstream gravel-trapping percolation basins, and therefore augmentation habitat benefits are minimized?	Reach is directly upstream of major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.	One or two reaches upstream of major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.	More than three reach lengths upstream of major sediment sink, including sediment sinks that are likely to be removed within the next 10 years.
7	Is gravel augmentation likely to improve fish habitat functions and values based on Appendix E to the Report of Independent Science Advisors for Santa Clara Valley Habitat Conservation Plan/Natural Communities Conservation Plan?	75% or more of reach does not fall within Cold-Steelhead and Warm-Potential Trout Mixed Native-Salmon and Mixed Native designations based on District mapping.	At least 25% of reach falls within Mixed Native-Salmon and Mixed Native designations based on District fisheries mapping.	At least 25% of reach falls within Cold-Steelhead and Warm-Potential Trout designations based on District fisheries mapping.
9	**Opportunity to minimize flood risk**			
9a	Is the reach in a regulatory floodway?	The reach is in a regulatory floodway.	The reach is not in a regulatory floodway, but the reach directly downstream is in a regulatory floodway.	The reach is not in a regulatory floodway, and the reach directly downstream is not a regulatory floodway.
9b	Does FEMA mapping show that 100-year flows are likely to break out of the stream channel within the reach?	FEMA maps indicate break out from channel along 100% of the reach length; AND into areas that are approximately 50% urbanized or greater.	Either: FEMA maps indicate break out from channel, but only into areas that are less than 50% urbanized; OR flow is contained in-channel for some significant and continuous portion of the reach.	FEMA maps do not show Special Flood Hazard Zone floodplain adjacent to channel reach (i.e. flows are contained in-channel throughout the reach), including unmapped reaches .
10	**Are access and staging likely feasible and have minimal impacts?**			
	Based on District Fee and Easement Maps, and the California Protected Areas Database, does appear likely that access and staging along the reach can be done efficiently and with minimal impacts?	Access and staging are expected to be very challenging or impossible. Impacts are anticipated to be high.	Access and staging possible, but appear be moderately constrained, or perhaps more costly. Moderate impacts are expected.	Access and staging appear simple and straightforward, and are expected to have minimal impacts.

Notes:

We acknowledge inherent intra-reach variability and further analyses, or input from the District or other agency staff may render different results.

Table B2: Rating criteria for scoring Multi-Criteria Decision Analysis to establishing priority reaches for large woody debris augmentation

	SCORE:	-1	0	1
	General score description	Initial data suggest the LWD augmentation unlikely	Neutral, does not apply, or data absent.	Evaluation criterion favors LWD augmentation
	Primary reach selection criteria			
1	Is there a major range-front reservoir which reduces episodic hydrologic events and therefore reduces LWD recruitment?	No major range-front reservoir, ample potential supply of sediment	Range-front reservoir, some tributaries un-dammed and supplying sediment	Major tributaries are dammed or have major impoundments
3	Does reach or reaches directly downstream tend to accumulate sediment according the SCVWD Stream Maintenance Program records? Can that sediment be retained using LWD (i.e. no major impoundments or sediment sinks between reach and closest dowsntream zone of accumulation)?	Reach directly downstream (1-3 reaches) has no record of recent sediment removal.	Reach directly downstream (1-3 reaches) tends to accumulate sediment, but not frequently or in high volumes.	Reach directly downstream (1-3 reaches) tends to accumulate sediment frequently and in higher quantities.
4	Based on GHD asset assessment, are the bed and banks along the reach highly manipulated, and therefore LWD augmentation is less likely to improve geomorphic funcion through the reach?	Reach is dominated by concrete-lined bed and/or banks, or a combination of concrete- and rock-lined bed and/or banks, based on GHD channel types.	Reach is dominated b rock-lined bed and/or banks, based on GHD channel types	Reach is classified as natural and/or natural modified based on GHD channel types
7	Is LWD augmentation likely to improve fish habitat functions and values based on Appendix E to the Report of Independent Science Advisors for Santa Clara Valley Habitat Conservation Plan/Natural Communities Conservation Plan?	75% or more of reach does not fall within Cold-Steelhead and Warm-Potential Trout Mixed Native-Salmon and Mixed Native designations based on District mapping.	At least 25% of reach falls within Mixed Native-Salmon and Mixed Native designations based on District fisheries mapping.	At least 25% of reach falls within Cold-Steelhead and Warm-Potential Trout designations based on District fisheries mapping.
8	Is gravel likely to be augmented at this location?	Gravel augmentation is likely based on this study.	Gravel augmentation is moderately likely	Gravel augmentation is unlikely
9	**Opportunity to minimize flood risk**			
9a	Is the reach in a regulatory floodway?	The reach is in a regulatory floodway.	The reach is not in a regulatory floodway, but the reach directly downstream is in a regulatory floodway.	The reach is not in a regulatory floodway, and the reach directly downstream is not a regulatory floodway.
9b	Does FEMA mapping show that 100-year flows are likely to break out of the stream channel within the reach?	FEMA maps indicate break out from channel along 100% of the reach length; AND into areas that are approximately 50% urbanized or greater.	Either: FEMA maps indicate break out from channel, but only into areas that are less than 50% urbanized; OR flow is contained in-channel for some significant and continuous portion of the reach.	FEMA maps do not show Special Flood Hazard Zone floodplain adjacent to channel reach (i.e. flows are contained in-channel throughout the reach), including unmapped reaches .
10	**Are access and staging likely feasible and have minimal impacts?**			
	Based on District Fee and Easement Maps, and the California Protected Areas Database, does appear likely that access and staging along the reach can be done efficiently and with minimal impacts?	Access and staging are expected to be very challenging or impossible. Impacts are anticipated to be high.	Access and staging possible, but appear be moderately constrained, or perhaps more costly. Moderate impacts are expected.	Access and staging appear simple and straightforward, and are expected to have minimal impacts.

Notes:

We acknowledge inherent intra-reach variability and further analyses, or input from the District or other agency staff may render different results.

APPENDIX C

Summary of Selected 47 Priority Sites

Table C: Summary of selected 47 priority sites

Site	MCDA Reach score (Gravel/Wood)[1]	Selected for gravel, wood, both?	Recommend gravel, wood, both?	40 Priority sites (number of potential projects at site)	Sites planned for field visit (number of potential projects at site)	Refinement rationale from 47 to 32 potential sites	Fisheries functions and values habitat type	Fish Passage Barrier?	Access notes incl. property ownership and staging ideas	FEMA maps: 100-year flows contained within banks? Contained within fee, easement, or public spaces?	Regulatory Floodway?	Avoids FIT site	Implementation notes: Intended functional lift. Preliminary design ideas or concepts, if possible (subject to change)	SCVWD Top Three Rank Sites	Reconnaissance notes	SCVWD feedback
Alamitos Creek																
AC1-1	19/10	Gravel and wood	Gravel	2	2	Included	CWS	N	Easement, likely access from dam.	Contained	N	Y	Inject gravels at the top of reach to naturally form bed features downstream	Yes	Short reach between spillway and private property. Sourcing intrabasin gravels will be more challenging due to potential mercury issues	Good Access and staging,
Guadalupe Creek																
GC1-1	20/11	Gravel and wood	Gravel and wood	2	2	Included	CWS	N	Fee	Contained	N	Y	Inject gravel directly below gage	Yes		Good Access and staging, point is right on gauge, assuming gravel injection below weir.
GC3-1	12/13	Wood	Wood	2	2	Included	CWS	N	Access via landfill? Otherwise, access appears difficult.	Contained	N	Y	Developed after field recon	Yes		Could be good access and staging, check with landfill. Access point with staging available 0.5 miles downstream at gage 5043.
Guadalupe River																
GR1-1	13/1	Gravel	Both	2	2	Included	MNS	N	Access straightforward. Fee.	Contained	N	Y	Inject gravel downstream of Alamitos drop structure. Wood can be installed here as well.	Yes		Access available. Good entry point for injection to system downstream of drop.
GR9-1	9/8	Wood	Wood	1		Access challenging, not recommended by District fisheries biologist	MNS	Y	Access via p-lot on right bank	Contained	N	Y	Improve passage impediment (accumulated sediments)	No		Upper end of reach has gravels, downstream reach substrate silt/clay with boulders.
GR9-2	9/8	Wood	Wood	1		Access appears challenging. Consider as back-up location	MNS	Y	Access appears difficult	Contained	N	Y	Improve passage impediment	Yes		Existing substrate silt/clay with boulders. Habitat would be improved with gravel enhancement.
Los Gatos Creek																
LGC1-1	17/9	Gravel and wood	Gravel and wood	4	4	Included	WWT	N	Stage and access at Camden Drop Structure, access at ramp on right bank	Contained	N	Y	Inject gravel via a pile, wood near ramp	No	Suggest including this site	May have limited mobility downstream due to drop structure.
LGC2-2	16/11	Gravel and wood	Gravel and wood	2	2	Included	WWT	N	Access via right bank trail. Stage on grass covered terrace, or trail corridor.	Contained	N	Y	Gravel and wood	No	Suggest including this site	Had existing gravel bar used by Chinook in past; may be worth a site visit.
LGC2-3	16/11	Gravel and wood	Gravel and wood	2		Field evaluation suggests this site is in reasonably good condition (gravel bars and riffles already present), relative to LGC2-2, and should be considered a backup to LGC2-2.	WWT	N	Access via right bank trail, parking lot easement on right bank. Stage right bank terrace, or trail corridor.	Contained	N	Y	Gravel and wood	Yes	Better condition than LGC2-2	Potential access.
Stevens Creek																
SC1-1	15/5	Gravel	Gravel and wood	2	2	Included	CWS	N	SCCP. Access and staging appear good	Contained	Y	Y	Gravel and wood	Yes		Good access and staging
SC1-3	15/5	Gravel	Gravel and wood	2		Consider this site a back-up to SC1-1. Priority should be placed at upstream-most reach	CWS	N	SCCP. Access and staging appear good	Contained	Y	Y	Gravel and wood	Yes		Relatively good access depending on how close the equipment needs to get.
SC3-1	14/5	Gravel	Gravel and wood	2	2	Included	CWS	N	City of Cupertino. Access and staging appear excellent	Broad floodway, contained in public area (McClellan Ranch)	Y	Y	Evaluate in the field	Yes		Good access and staging, above restoration area so great potential.
Coyote Creek																
CC1-1	14/5	Gravel	Gravel, possibly wood	2		Field evaluation suggests this site less suitable than CC1-2, but should be considered a backup to CC1-2	CWS	Y	Access through SCCP or fee.	Not contained.	Y	Y	Upstream most point to place gravel. If passage impediment is in place, consider wood.	Yes		Good access and staging
CC1-2	14/5	Gravel	Gravel and wood	2	2	Included	CWS	N	Access trough SCCP, close to Parks service yard. County juvenile facility.	Not contained.	Y	Y	Gravel, wood likely to hold gravels in place.	Yes		Good access and staging,

Site	MCDA Reach score (Gravel/Wood)[1]	Selected for gravel, wood, both?	Recommend gravel, wood, both?	40 Priority sites (number of potential projects at site)	Sites planned for field visit (number of potential projects at site)	Refinement rationale from 47 to 32 potential sites	Fisheries functions and values habitat type	Fish Passage Barrier?	Access notes incl. property ownership and staging ideas	FEMA maps: 100-year flows contained within banks? Contained within fee, easement, or public spaces?	Regulatory Floodway?	Avoids FIT site	Implementation notes: Intended functional lift. Preliminary design ideas or concepts, if possible (subject to change)	SCVWD Top Three Rank Sites	Reconnaissance notes	SCVWD feedback
CC4-1	14/5	Gravel	Gravel and wood	2	2	Included	WWT	N	Access through SCCP from Monterey Road.	Not Contained	Y	Y	Gravel, wood likely to hold gravels in place.	No	Flooding a major concern, already mining channel gravels	Not sure on access here, good to end of last pond, but down to creek may be difficult.
CC4-3	14/5	Gravel	Gravel and wood	2		Field evaluation suggests recent storms have mobilized significant gravels, and gravel augmentation may be more effective in future years.	WWT	N	Access through SCCP from Monterey Road.	Broad floodway, contained in public area	Y	Y	Gravel, wood likely to hold gravels in place.	Yes		Good access and staging
CC9b-1	13/7	Gravel and wood	Gravel and wood	2		Passage reach, rearing not expected, therefore considered a backup.	MN	N	Access from Coyote Creek Trail, and terraces, left bank. Stage off of Yerba Buena.	Contained	Y	Y	Long pool upstream of Upper Silver Creek. Consider riffle supplementation.	No	~2500 foot pool. Benefit of predator fish reduction? Consider as a back up?	Migration corridor only, FAHCE does not expect fish to rear here. Dryback in drought years
Upper Penitencia Creek																
UPC2-2	10/7	Gravel and wood	Wood (relatively low gravel score, county-wide)	1	1	Included	CWS	Y	Alum Rock Park -City of San Jose. Access and staging is excellent.	Not mapped	N	Y	Possibly two grade control structures near each other, consider placing wood to ameliorate passage impediment. May have concrete-rock wall on one or both banks	Yes		Worth evaluating due to potential to ameliorate passage impediment.
UPC4-2	10/9	Gravel and wood	Wood (relatively low gravel score, county-wide)	1	1	Included	CWS	Y	Alum Rock Park -City of San Jose. Large parking lot.	Not mapped	N	Y	Believed to be old swim dam. Recommend considering LWD to ameliorate the passage impediment, likely in combination with modifying the concrete structure.	Yes		Worth evaluating due to potential to ameliorate passage impediment.
UPC4-3	10/9	Gravel and wood	Wood (relatively low gravel score, county-wide)	1		Not a passage impediment, therefore two other UPC locations have been prioritized. This site should be considered a backup.	WWT	N	Alum Rock Park -City of San Jose. Stage at maintenance yard nearby?	Not mapped	N	Y	LWD. Channel is somewhat confined between road and hillslope. Consider ways to prevent hillslope failure, which appears to be an acute problem in the vicinity.	Yes		UPC4-3 and UPC4-4 are similar and in close proximity, so they could both be evaluated. But if only one is chosen, then I think UPC4-3 would be more practical since it is not at a bend in the creek (like UPC4.4 is) and access could be via the adjacent trail.
Uvas Creek and Little Arthur Creek																
UC1-1	14/5	Gravel and wood	Gravel and wood	2	2	Included	CWS	N	Access through easement on right bank	Not Contained	Y	Y	Ideal place to inject gravel, if flooding concerns can be addressed.	Yes		Spawning sized gravels needed. Would have to be downstream of gaging station. Gravels would have high transport potential if Uvas Reservoir spills.
UC4-1	12/5	Gravel and wood	Gravel and wood	2		Difficult access. Should be considered a backup.	CWS	N	Poor Access, need SCVWD to arrange access if possible, or substitute an additional site	Broad floodplain, does not appear to flood structures	Y	Y	Fast water feeding habitat is sought. Other habitat benefits to be evaluated in the field	Yes	Need SCVWD to arrange access	Would be easier to access creek here than at UC4-2. Long deep pools about 1,000 ft downstream of Hwy 152.
UC4-3	12/5	Gravel and wood	Gravel and wood	2	2	Included	WWT	N	Access excellent. Easement.	Broad floodplain, may impact Solorsano Middle School	Y	Y	Fast water feeding habitat is sought. Other habitat benefits to be evaluated in the field	Yes		If we placed gravel here, downstream reaches may benefit once gravels are transported.
UC4-5	12/5	Gravel and wood	Gravel and wood	4	4	Included	WWT	N	Access excellent. Easement.	Broad floodplain, may impact Solorsano Middle School	Y	Y	Fast water feeding habitat is sought. Other habitat benefits to be evaluated in the field	Yes	Great opportunities between here and Miller	Long pools between here and Miller Ave, with some good riffles present.
			TOTAL NUMBER OF PLANNED PROJECTS	47	32											

Notes

[1] For reference, average MCDA gravel reach score is 8.95 and average LWD reach score is 4.73

SCCP: Santa Clara County Parks. CoSJ: City of San Jose

APPENDIX D

Field Sampling Protocol and Example Sampling Sheets

STANDARD OPERATING PROCEDURES AND DATA COLLECTION FORMS FOR CHANNEL INVENTORY AND STREAM HABITAT SURVEYS CONDUCTED AT GRAVEL OR LARGE WOODY DEBRIS AUGMENTATION PROJECT SITES

Report prepared for:
Judy Nam
Santa Clara Valley Water District

Prepared by:
Eric Donaldson, P.G.
Barry Hecht, C.E.G., CHg
Kealie Pretzlav, PhD

With assistance from:
Bonnie de Berry, EOA, Inc.
Paul Randall, EOA, Inc.
Tom Keegan, Helix Environmental Planning, Inc.

Balance Hydrologics, Inc.

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1.1 Introduction

The following Standard Operating Procedure (SOP) describes procedures to assess existing stream channel and habitat conditions at potential gravel and/or wood project sites. These procedures involve both desk top analysis of available information and the collection of field data and observations made at selected stream reach locations. These data can then be used to refine the list of potential project site locations and to develop conceptual designs for potential projects.

The SOP was developed in support of the Santa Clara Valley Water District's (District) goal to develop a county-wide gravel augmentation and LWD augmentation Program. The Program is primarily intended to increase spawning and rearing opportunities for anadromous Central California Coast and South-Central California Coast Steelhead Trout.

The Program goes through several iterations of prioritization, with differing levels of effort executed at each stage and on a subset of reaches or sites. To clarify each of the products for each step, the terminology used is highlights in bold below, with definitions in the footnotes.

This SOP details several steps in the Program site selection and project design process. They are:

- Step 0: Conduct a desktop analysis to score and prioritize stream reaches using a multi-criteria decisional analysis (MCDA) matrix. The MCDA process employs geomorphic, hydrologic, biologic, and regulatory criteria to prioritize reaches in a number of criteria. The deliverable from this step is a score for both gravel augmentation and LWD augmentation for each **reach**[1] in the stream. From these scores, the highest **priority reaches**[2] are identified.
- Step 1: Evaluate existing information and spatial data sources to identify and prioritize study sites within the highest priority reaches for gravel/wood augmentation. Selection of priority sites should be carried out in concert with a geo-spatial desktop analyses. The deliverable from this step is a list of **priority sites**[3] for gravel or wood projects. These priority sites may further refined to include set of **priority field sites**[4] **depending on scope and budget allocated**.
- Step 2: Conduct channel and habitat surveys within the priority field site(s).
- Step 3: Summarize and document field surveys and findings.
- Step 4: Select **conceptual design sites**[5]**.**

[1] **Reaches** are defined as a stretch of each stream. The process for splitting a stream into a series of reaches is outlined in the Countywide Gravel and Large Wood Augmentation Program Report.
[2] **Priority reaches** are reaches that score high in either the gravel or LWD augmentation categories.
[3] **Priority sites** are sites located inside a priority reach that have been identified as ideal locations for gravel or wood projects, based on criteria listed in Step 1 below.
[4] **Priority field sites** are a subset of priority sites for which Steps 2 and 3 will be carried out. Steps 2 and 3 may not be carried out for all priority sites due to time or resource constraints.
[5] **Conceptual design sites** are sites that have been selected for further advancement of project conceptual designs. These sites are a subset of the priority field sites.

Step 1 represents desktop analysis to refine list of potential study reaches using spatial data, hard copy maps and reports. Step 2 is conducted in the field and is applied to high priority study sites identified in Step 1. Step 3 facilitates appropriate summarization and archiving of collected field data for future use. Data collected and processed following this SOP is intended to be used by geomorphic and fisheries professional to develop conceptual designs for gravel/LWD augmentation projects.

In 2017, the MCDA approach was pilot tested on eight high priority streams in Santa Clara County that support steelhead populations.

1.2 Step 1: Identify and Prioritize Study Sites

Prior to conducting channel and habitat surveys, desktop analysis of the high priority study reaches selected during the reach-by-reach MCDA will be conducted. The desktop analysis will utilize a range of data sources to evaluate site specific issues that may affect gravel/wood augmentation projects. The following steps should be taken:

- Evaluate LiDAR data for channel features (e.g., terraces and benches), land use and cover types;
- Review Federal Emergency Management Agency (FEMA) flood hazard maps and identify areas where 100-year flows are contained in channel, far away from houses and infrastructure;
- Review soils maps, examine watershed geology to understand potential groundwater flow paths and local sediment production rates and erodibility;
- Review relevant San Francisco Estuary Institute (SFEI) reports, where available, primarily historic channel maps and long profiles;
- Pull channel slopes from Program long profiles;
- Calculate reach sinuosity in Google Earth of a GIS;
- If a Hydraulic Engineering Center River Analysis System (HEC-RAS) model is available, pull cross-sections for reach;
- Review parcel data to determine property ownership; and
- Evaluate access to the site (e.g., roads and trails).

Prior to geomorphic and habitat surveys, a field crew (consisting of a fluvial geomorphologist, or geomorphologists, and perhaps with a fisheries biologist) will either use existing knowledge of the reach or walk the study reach to identify optimal location(s) for gravel or LWD augmentation. One or more potential project sites may be identified within the study reach. Several factors will be assessed to identify project site locations, including:

- Stream habitat lacking complex bed features
- Potential fish passage impediments (e.g. jumping barriers, or velocity barriers);
- Flood prone areas are present, thereby minimizing potential for flooding;
- Physical access for transporting gravel/wood to the channel.

Once identified, priority sites may either be identified for future potential improvement, or, if project designs are desired for a given site, field surveys and data summarization

(Steps 2 and 3) can be conducted. Prior to beginning Step 2, the following materials should be gathered and printed for use in the field:

- Long profile figures if hydraulic model or applicable lidar data if available, or reach-scale long-profiles pulled from 10-foot contour maps or other sources
- Figures or summary of storm history to bring into the field
- Fee and Easement maps
- FEMA 100-year floodplain and floodway maps
- Most recent California Protected Areas Database (CPAD) maps with ownership and open space
- Fish Passage impediment maps

1.3 Step 2: Conduct Field Surveys

1.3.1 Field Staff

Trained fluvial geomorphologists and fisheries biologists are required to conduct field surveys at project study sites to understand existing physical and biological conditions. The data collected in this step include field observations, qualitative assessments, and field measurements. The fluvial geomorphologist will collect "level 2" and/or "level 3" data on physical aspects of each stream reach, termed a geomorphic survey[6]. The fisheries biologist will a conduct detailed habitat survey, focusing on habitat characterization and presence of spawning and rearing habitat. Methods are summarized in this SOP. Finally, a survey crew should conduct a basic topographic survey recording the geometry of a representative cross section and a long profile sufficient to estimate channel slope at the site. The survey crew could be the geomorphologist and fisheries biologist, but it is not required. The survey crew does need to know enough about geomorphic principles to be able to collect survey data which captures geomorphic features such as channel thalweg, high water marks, and riffle-pool sequences.

1.3.2 Field Packing List

The following items should be taken into the field to conduct the field surveys. This packing list assumes the use of the enclosed field data forms, and the use of a total station for collecting topographical surveys. Alternate equipment may be used.

Materials/Equipment	**Geomorphic Survey**	**Habitat Survey**	**Channel Survey**
Long Profile figures	X		
Reach scores across all criteria	X	X	
Fee and Easement Maps	X		

[6] Level 2 and level 3 described in the CDFW Fish Restoration Design Manual, 1998 and 2010.

CPAD maps with polygon ownership and open space name	X		
FEMA GIS Maps with roads	X		
Fish Passage impediment maps (looking for incised barriers)	X	X	
Mannings N reference materials	X		
Storm history (aid with identification of high water marks)	X		
Total Station (including tripod, stadia rod, prism rod, prism, height of instrument tape, two rebars (per site), rebar safety caps, flagging, walkie talkies			X
Field Camera	X	X	X
GPS	X	X	X
Laser Sight or 300m tape measure	X	X	
Wolman Count rulers	X		
One-Gallon Plastic Bags	X		
Shovel	X		
Water Quality Meter(s) (temperature, conductivity, DO, pH and turbidity)	X	X	
Stadia Rod		X	
Gate Keys, Gate Codes, or Parking Passes	X	X	X

1.3.3 Priority Field Site Boundaries

Boundaries at each priority field site will be site-specific, depending on existing conditions (e.g., length of pool-riffle sequence) and type of project being considered (i.e., gravel or LWD augmentation). At the first field visit, either during the initial reconnaissance during Step 1, or during the field survey in Step 2, the field crew will mark the upstream and downstream extent of stream segment that includes the project site(s). The geomorphic and stream habitat surveys will be conducted within the defined stream segment.

1.3.4 Geomorphic Survey

The channel inventory survey should be conducted by a trained geomorphologist. The channel survey consists of both qualitative observations and quantitative measurements that will be recorded in the Channel Inventory Survey Data Collection Form (Attachment x). Procedures for conducting the channel survey are described below.

I. General Site Information
Information associated with date and location of the assessment is recorded in data collection form. Information about the site location includes: unique site identification, waterbody name, general description of project site

location (e.g., road crossings, parks and trails) and jurisdiction (city or agency). The GPS coordinates will be either collected in the field, or determined using desktop tools such as Google Earth or ArcGIS.

II. Access

Potential physical access points and staging areas should be identified on the data collection form. The presence and location of stormwater outfalls, utilities (e.g., overhead lines) and other structures should also be noted.

III. Water Quality Parameters

General water quality parameters will be measured within the project reach using a handheld multi-parameter sonde. Water quality parameters to be recorded on the data collection form (Attachment X) include water temperature, dissolved oxygen, pH, and specific conductance. Field staff will note water clarity, color, odors, and other visible conditions (e.g., oily sheen, trash).

IV. Geomorphic Observations

Field staff will record observations regarding the general structure of the channel. These may include:

- Presence of single- or multi-threaded channels
- Description of floodplain connectivity, including the presence floodplain terraces, high-flow side- or back-channels, or steep flood-control levees/banks,
- Lateral stability, including noting active erosion or bank failures, engineered slopes or other pertinent observations,
- The flow rate will be estimated, either visually or using float test, at a typical cross-section of stream,
- An estimate of Mannings N will be recorded and photos will be taken of both banks and the active channel bed,
- The armor ratio will be estimated, supported with observations about the recent mobility of surface sediments (i.e., “squishy” sediment), and whether substrate is gravel-or sand-matrix supported,
- Description of bed surface texture, including the type and presence/amount of fine sediments and an estimate of embeddedness,
- The bed surface and subsurface grain size distributions will be recorded, either taking Wolman pebble counts, grab samples to be processed after leaving the field, or by a visual estimation of the grain size distribution (e.g. 10% sand, 20% gravel, etc.), and
- Other channel survey information may include an estimate of the percentage of substrate types in important habitat units.

V. Inferred Channel History

Field staff will note observations related to historical channel function at the project site. Historical features include: presence and elevation of existing terraces, eroded roots, and high water marks. Provide description of a chronological account for channel incision based on lines of evidence previously noted, including tree age. Indicate if the stream bed is self-formed, or consists of historical substrate materials exposed due to channel incision.

VI. Channel Geometry Calculations

Field staff will identify "bankfull" stage at the project site. Bankfull is defined as the stage at which channel maintenance is most effective and occurs on average every 1-2 years. Indicators of bankfull (especially in larger systems) include the tops of point bars, staining and vegetation lines. Bankfull widths and depths will be used to measure the flood-prone width. These dimensions will be used to calculate the entrenchment ratio – and metric that can be used to estimate the level of channel incision.

Collect channel geometry data, such as channel cross-sections and longitudinal profile, where necessary. Data collected may be as simple as channel widths and depths, or as detailed as survey data collected with a total station. Channel geometry data may be supplemented by HEC-RAS modeling geometries where available.

VII. Pebble Count (Optional)

The field staff will conduct a Wolman-style pebble count when characterization of the surface grain size distribution (GSD) is required for project design. For example, a riffle or gravel bar at the priority field site may be a representation of the sizes of gravel that are present in existing hydrologic conditions, which could be quantified by a pebble count or grab sample.

VIII. Image/Sketch/Diagram of Project Site

The fluvial geomorphologist should create a detailed sketch of project site on data collection form. The sketch should include location of all grab samples, surface GSD, channel morphology (pools, riffles, bars, roots, recent incision, scour/deposition), large trees and/or dense patches of vegetation, local scour depths, pool spacing/depths, and riffle widths, length and spacing. Initial design concept ideas and options should be included in the sketch if applicable.

1.3.5 HABITAT SURVEY

The stream habitat survey should be conducted by a trained fisheries biologist. The habitat survey consists of both qualitative observations and quantitative measurements that are recorded on the Habitat Survey Data Collection Form (Attachment x). The methods used for the habitat survey are based on the California Salmonid Stream Habitat Restoration Manual Part III Habitat Inventory Methods (Flosi et al., 2010). A summary of these methods are described below.

I. General Site Information

Information associated with date and location of the assessment is recorded in data collection form. Information about the site location includes: unique site identification, waterbody name, general description of project site location (e.g., road crossings, parks and trails) and jurisdiction.

II. Habitat Types

Field staff will estimate and record the overall percentage of the predominant habitat types within the project site (i.e., riffle, pool, run). Collect several depth measurements at pool(s) within the project site and record maximum and average values. Measurements of the total reach length, as well as widths and depths taken at various transects for a reachwide average will be recorded on the data sheet. Additional habitat features will be noted, including:

- Pool Types;
- Presence (and description) of step/pools;
- Pool to pool spacing;
- Presence (and description of) point bars; and
- Pool length/riffle width.

The location and type of habitats should all be included in the sketch of project site reach.

III. Instream Cover

Field staff will collect qualitative information related to fisheries habitat quality including: estimated percentages of instream and riparian cover types, and habitat complexity.

IV. Substrate Composition

Field staff will estimate the percentages of predominant substrate types. Percentage of habitat smothering (i.e., sand/silt deposition (3-5 mm thick) on productive fish habitat) will recorded. Estimates of substrate embeddedness will be recorded.

V. Riparian Vegetation

Riparian condition will be assessed by estimating average buffer width and overall extent of area where riparian cover is present within the project site. The predominant riparian species observed within project site will be recorded. Additional notes on overall bank stability and potential for bank erosion will be summarized.
Adjacent land uses and potential point and non-point sources of pollution will be recorded.

VI. Artificial Channelization

Overall channel modification for the project site will be assessed and recorded using the following categories:

- ***Poor*** - A highly altered system with ALL the following; straightened stream channel, box-cut banks and a monotypic depth. Spoil banks or other indications of dredging may be visible.

- ***Marginal*** - An altered system with some sinuosity in stream channel, often developed within the old dredged area, OR some diversity in depth but no pools. Spoil banks may be visible.
- ***Suboptimal*** - Good sinuosity has developed within and outside of the old channelized area AND the bottom has a diversity of depths approaching what's expected of a non-dredged system (1 to 2 pools every 12 times the width of the stream). Spoil banks may be visible, but have established vegetation growing on them.
- ***Optimal*** - A system with good stream channel sinuosity AND a diversity of depths.

VII. Important Fisheries Habitat

Based on qualitative and quantitative survey data collected above, estimate the presence and amount of the following metrics:

- steelhead spawning habitat,
- presence and amount of adult holding cover,
- spacing of spawning and holding habitat**,**
- positioning of rearing habitat relative to spawning,
- rearing habitat constituents, including diversity and complexity, and
- fish species or communities present, including native/non-native distinction.

Determining the presence or absence of fish species, and the fish community thorough visual means is admittedly qualitative in nature. However, a qualified fish biologist should be able to generally assess the community structure and presence or absence of target fish species, such as salmonids. GPS coordinates and photographs of the sampling area will be collected as necessary to document habitat conditions and identify site-specific locations.

VIII. Sketch of Priority Field Site

The fisheries biologist should sketch the priority field site, including spawning habitat, feeding habitat, cover, and other pertinent features. In addition, the presence of potential fish passage barriers, and if they are flow dependent, should be indicated and sketched on the reach/station map.

1.3.6 Channel Survey

This section describes the procedures for collecting the necessary survey data required for sediment transport calculations for gravel augmentation. This step is project design-specific and may not be necessary.

For each priority field site, both a representative cross section and long profile should be collected.

I. Representative Cross-Section

A representative cross-section should be taken at each of the priority field sites. The cross-section may transect the proposed location of gravel augmentation or LWD augmentation, to be used to illustrate the effect of the proposed project. In addition, the cross section may be used for estimating cross sectional area for use in sediment transport calculations. As a result, the cross-section location should be selected with the intended purpose(s) in mind.

Points collected in the cross-section should include major slope changes or breaks in topography with enough detail to accurately define floodplains, terraces, and other geomorphically significant features. The survey should also include high water marks, water's edge, the thalweg, and any other relevant features.

II. Long Profile

A long profile should be collected at each priority field site to be able to characterize the location-specific channel slope, for use in sediment transport calculations. The long profile is collected along the channel thalweg, or high-velocity core, which is typically in the deepest portion of the channel. Like the cross-section, the long profile survey points should be collected at major slope breaks with enough resolution to resolve changes in topography. The long profile should be sure to call out morphology changes such as pool-to-riffle, riffle-to-pool, boulder steps, weirs, or other geomorphically relevant features. The channel slope should only be calculated using riffle crests. As a result, each survey should include at least two riffles.

This step may not be necessary if site-specific channel slope is available via other sources such as hydraulic model, lidar data, or previously collected survey data. In some cases, the representative long profile may be difficult to collect, such as large and deep center-channel pools. In these cases, alternative methods for quantifying the channel slope may be preferred.

III. Equipment

At each site, a minimum of two rebar benchmarks were installed and surveyed with each station set-up. Each benchmark rebar is topped with an OSHA-rated rebar cap for safety. Surveys were collected using an arbitrary datum, but benchmarks would allow for future surveys to be referenced to initial surveys, or to geo-reference initial surveys. Each cross-section and benchmark should be indicated on the field site sketches and photos should be taken.

Survey data was collected in 2017 using a total station Future surveys should use a total station or technique which can reproduce the relative accuracy of a total station survey. This may include survey-grade GPS or a well-executed measuring tape and auto-level survey.

1.4 Step 3: Summarize and Document Field Surveys and Findings

Upon returning to the office, the following activities should take place:

- Field notes and survey forms should be scanned and archived,
- Survey data, if collected, should be downloaded from the total station,
- GPS data, if collected, should be downloaded,
- Field photos should be downloaded and organized, and
- Grab samples labeled and documented.

Shortly after returning from the field, it is recommended to apply any necessary transformations to the survey data to make the data useful for the conceptual design process. If using a total station, this includes using field notes to adjust prism rod heights and calculating the representative elevations for the long profiles or cross-sections.

1.5 Step 4: Select Conceptual Design Sites

After the completion of the field data collection at each of the priority field sites, a gravel augmentation or LWD augmentation project may be conceived, and conceptual designs made. However, not all sites investigated in the field survey may be acceptable for gravel or LWD augmentation conceptual designs. This process is detailed in Countywide Gravel and Large Wood Augmentation Program Report, but outlined here.

Attachment 1

Data Collection Forms

Geomorphic Survey Data Collection Form

Date:____________________ **Time:** ______________________ **Surveyor:** _____________________

I. General Site Information

Site ID#:

Stream Name: ______________________________________ Jurisdiction:_________________________________

Location ____

GPS Coordinates (latitude/longitude):

Downstream: ____________/_____________ Upstream: ____________/_______________

II. Access

Describe access and apparent staging areas: ____

GPS of access point ______________/______________ Staging area ________________/_________________

Storm water outfalls: __________________________ Utilities: ____

III. Water Quality Parameters

Water Temp (°C) ________ pH ________ DO (mg/L) ________ (%) _________ Sp Cond (uS/cm) __________

Water Clarity: ________________________________ Water color: ____

Water Odor: _______________________________ Other Presence: *(oily sheen, foam, trash, etc)* _______________

IV. Geomorphic Observations

Single or multiple thread channel: ____

Describe floodplain connectivity: ____

Describe lateral stability: ____

Flow estimate, float test if possible (CFS or GPM): ___________________ Time of estimate: _______________

Estimate Mannings N: Active channel (Take photo): ______________

Left Bank (Take photo): _________________

Right Bank (Take photo): ________________

Estimate armor ratio: ____

Estimate grain size distribution: D_{16}: _______________ D_{50}: __________________ D_{84}: ____________________

Describe bed surface texture (embeddedness, interlocking, etc.) ______________________________________

____

____

Geomorphic Survey Data Collection Form

V. Inferred Channel History

Number of terraces, and relative elevations to thalweg: ____

Eroded roots? Elevation relative to thalweg: ____

Highwater Marks? Elevation relative to thalweg: ____

GSD estimate of recently mobile sediments: ____

Record a perceived chronology of incision based on the above lines of evidence and tree age:

____

____

Does bed appear to be self-formed or, if incising, does bed consist of ancient gravels, cemented silts, cemented clays, etc. ____

VI. Channel Geometry Calculations

Bankfull Geometry:

Bankfull Depth: _______________________

Bankfull Width: _______________________

Note: the remaining channel geometry calculations can be completed in the office, as long as bankfull width and depth are collected in the field

Entrenchment Determination:

Step 1: Maximum Bankfull Depth __________ X 2 = __________ (WFP Elev.)

Step 2: Determine Flood-Prone Width at WFP Elevation = _______ (WFP)

Step 3: Flood-Prone Width (WFP) / Bankfull Width (Wbkf) = Entrenchment

WFP __________ (ft.) / __________ (ft.) = __________ **(Entrenchment)**

Width/Depth Determination:

Step 1: Sum of Depths ______ / No. Depths ______ = Mean Bankfull Depth (dbkf) ______

Step 2: Bankfull Width (Wbkf) / Mean Bankfull Depth (dbkf) = Width/Depth Ratio

Wbkf ______ (ft.) / dbkf ______ (ft.) = ______ **(W/D Ratio)**

Water surface slope Determination:

Downstream Level – Upstream Level / Distance (D) = Energy Gradient

DSL ______ (ft.) – USL ______ (ft.) / (D) ______ (ft.) = ______

VII. Pebble Count *(Optional)*

S = sand; Measure all clasts along b-axis

Geomorphic Survey Data Collection Form

Date:____________________ **Site Name:** ____________________

VIII. IMAGE/SKETCH/DIAGRAM OF SITE

Include the following:

- **Location of grab samples**
- **Sketch of surface GSD and channel morphology (pools, riffles, bars, recent incision, scour/deposition, etc.)**
- **Locations of large trees, other dense vegetation patches**
- **Local scour depths**
- **Note pool spacing, depths; note riffle width, length, spacing**

Habitat Survey Data Collection Form

Date:____________________ **Time:** ______________________ **Surveyor:** _____________________

I. General Site Information :

Site ID#:

Stream Name: ____ Jurisdiction:_________________________________

Location ____

GPS Coordinates (latitude/longitude):

Downstream: ____________/_____________ Upstream: ____________/_______________

II. Habitat Types (refer to habitat codes on page 2):

Predominant Habitat at Types and Lengths: ____

Total Project Site Length: ____

Pool/Riffle/Run %	Pool depth: ______Ave ______Max	Reach Depth: ______Ave	Reach Width: ______Ave
Pool types:	Step Pools:	Pool to Pool Spacing:	Point Bars:

Notes:

III. Instream Cover:

Overhanging Veg (%):	Boulder (%):	Undercut (%):
Bubble curtain (%):	Wood (%):	Complexity (%):

Notes:

IV. Substrate Composition:

Silt/Clay (%):	Sands (%):	Gravels (%):	Cobbles (%):	Boulders (%):
Bedrock (%):	Concrete (%):	Levees (%):		
Habitat Smothering (sand/silt deposition (3-5 mm thick) on productive habitat) (%)				Embeddedness (%):

V. Riparian Vegetation:

Riparian Buffer Average Width (water edge to human alteration):		
Species Composition:		Extent of Coverage:
Adjacent Land-use:	Point and Non-point Source Pollution:	Bank Stability:

Habitat Survey Data Collection Form

VI. Artificial Channelization: (Not sure how scoring is done)

	Poor; straightened channel, box cut banks, monotypic depth
	Marginal; above, but with some sinuosity or depth diversity
	Suboptimal; spoil banks present with some vegetation, good sinuosity or depth diversity
	Optimal; good stream channel sinuosity AND a diversity of depths

VII. Important Fisheries Habitat:

Steelhead Spawning Habitat: ____________ (square feet) Adult Holding Cover: ________________ (square feet)

Location and type of fish passage barriers:

Fish species/community present: Native vs non-native dominant:

VIII. Sketch of Project Site Reach

Habitat Survey Data Collection Form

List of Habitat Types

LGR: Low gradient riffle	RUN: Run
HGR: High gradient riffle	SRN: Step run
CAS: Cascade	TRP: Trench pool
BRS: Bedrock sheet	MCP: Mid channel pool
POW: Pocket water	CCP: Channel confluence pool
GLD: Glide	STP: Step pool
	CRP: Corner pool
BPB: Backwater pool boulder formed	LSL: Lateral scour pool log enhanced
BPR: Backwater pool rootwad	LSR: Lateral scour pool root wade
BPL: Backwater pool log formed	LSBk: Lateral scour bedrock
DPL: Dammed pool	LSBo: Lateral scour bedrock
	PLP: Plunge pool
	SCP: Secondary channel pool

APPENDIX E

Conceptual Design Summary Sheets, Selected Twenty Sites

Coyote Creek 1-2

Santa Clara Valley Water District

Location
Downstream of Anderson Reservoir, adjacent to the Coyote Creek Trailhead, just upstream of the gage on Coyote Creek at Madrone.

Existing Conditions
- The Anderson Reservoir effectively traps all coarse sediment supplied from the upper watershed. As a result, Coyote Creek has incised. The channel bed is largely cobble with fine silt and sand interspersed.
- Exposed mature tree roots on the high-flow floodplain make up much of the channel banks. At least two terrace surfaces are present through the reach.
- Cobble and boulder riffles already present around channel-narrowing tree roots.
- Project site very near the limit of anadromy.
- Project reach is in a regulatory floodway.
- Reach is run-riffle-pool sequence with shallow pools and consistent and relatively flat slope. An SCVWD gaging weir is present at the downstream end of the reach.
- CEM stage 3. Pre-dam this site would was a sediment-rich, highly energetic alluvial fan head, and the stream would have frequently changed courses. Since construction of the dam, low-flow channel incision has occurred, mature trees and coarse bed material has slowed expansion of a lower floodplain.

Problem
Reach just downstream of Anderson Reservoir is gravel deprived, and LWD is not common. Riffles are present but are dominated by fines, and we anticipate they are transient features formed by recent floods. Other riffles are steep and coarse. Terraces are not frequently engaged during stormflows.

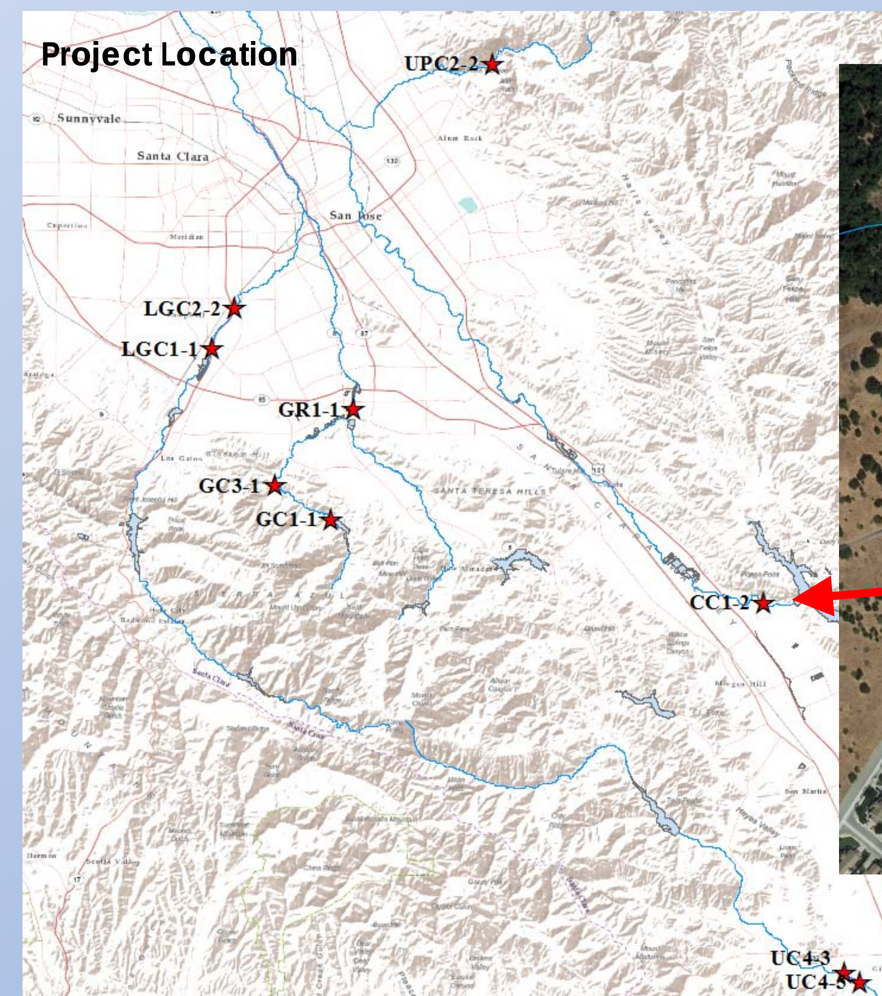
Project Approach
Two projects are proposed at this site:
1. A gravel injection pile on the left bank will supplement spawning gravels draped over the entire channel reach to supplement existing riffles and ameliorate channel incision. Because this site is near the limit of anadromy, the SCVWD may consider ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated.
2. Wood placement will be focused on enhancing floodplain connectivity and introducing high-flow cover.

Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase high-flow floodplain habitat	Anderson Reservoir, flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site

Existing riffle, smothered with fines, October 2017.

* Measured on Oct 17, 2017

Coyote Creek 1-2 Site Parameters	
Upstream (impounded) watershed area	*195 mi² (133 mi²)*
Channel roughness	*0.05*
Channel slope	*0.45%*
*Field temperature**	*19.5°C*
*Turbidity**	*2.1 ntu*
*Embeddedness**	*65%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*5/30/35/20/10/0 (%)*

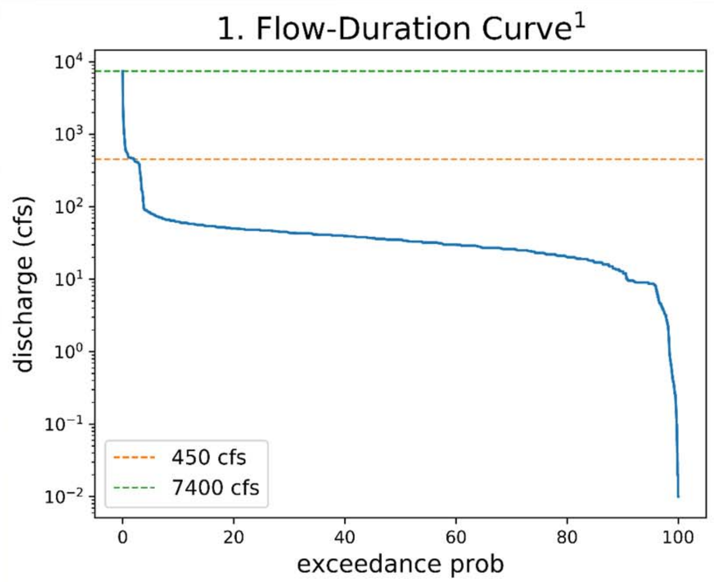


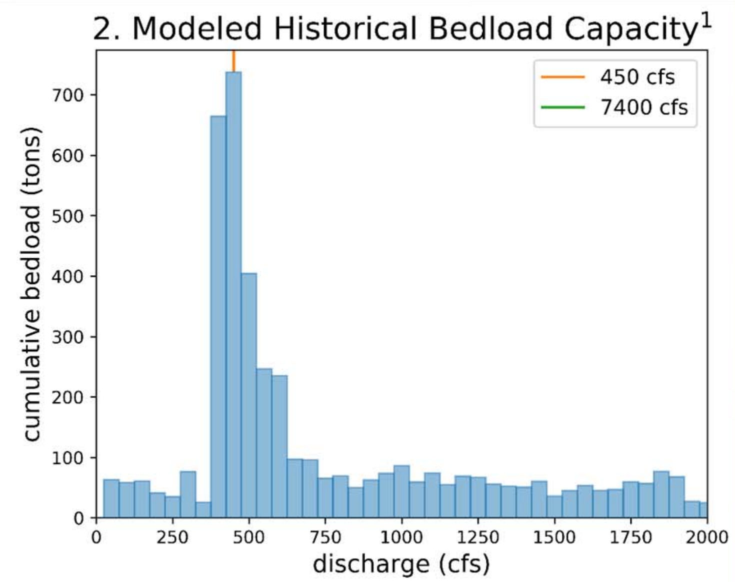
Balance Hydrologics, Inc.

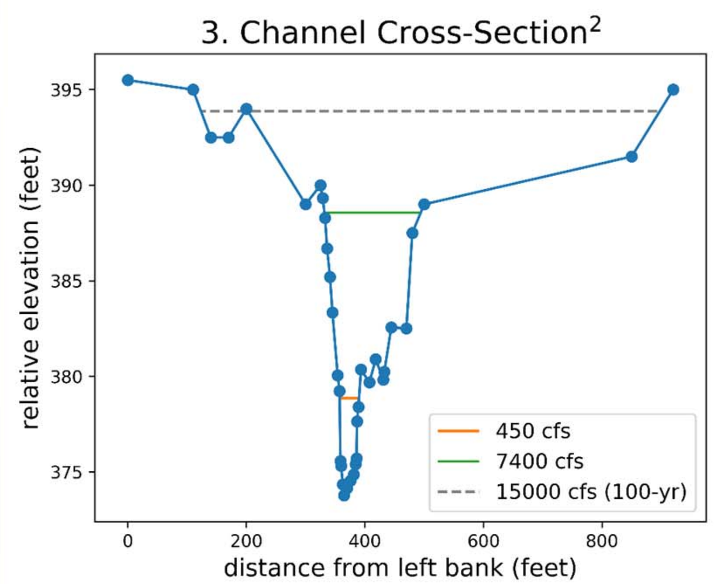
NOT FOR CONSTRUCTION

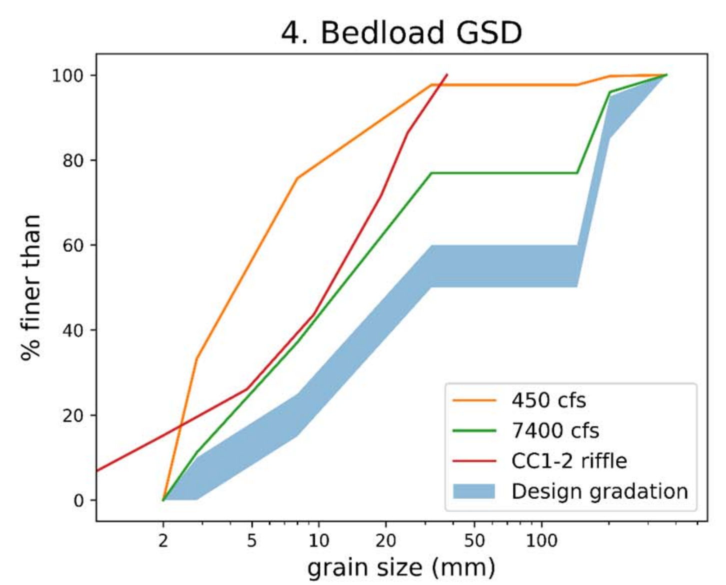
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

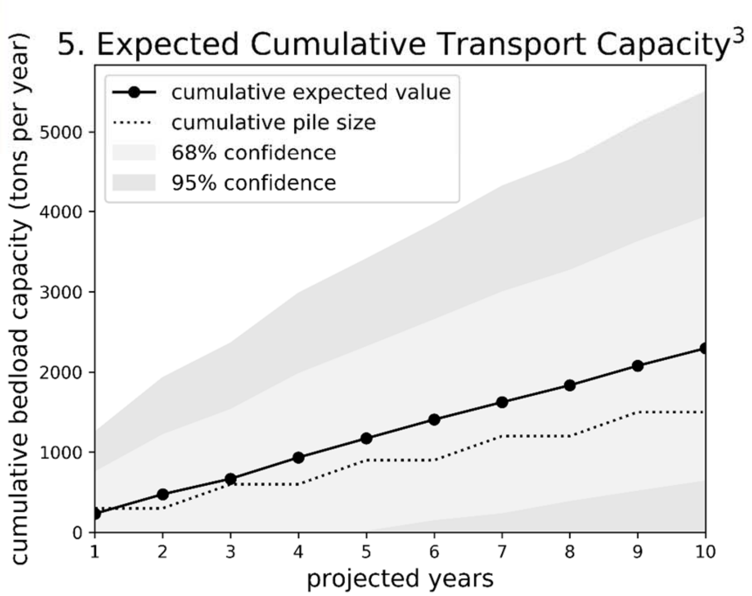
Coyote Creek 1-2: Sediment Transport











6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	1
2011 – wet	282
2012 – dry	1
2013 – dry	1
2014 – dry	0
2015 – average	0
2016 - average	46
2017 - wet	2007

[1]Flow record from 1988 – 2017
[2] See flood risk discussion on sheet 5
[3]Sampled only from years at least 95% complete
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	15 – 20%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	25 – 30%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	40 – 45%
Boulders *(> 265 mm, >10 in)*	5 – 10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data
Flow record used is the gage downstream of the site, Coyote Creek at Madrone, located 500 feet downstream of CC1-2. Contributing watershed size of the project site is essentially the same as the watershed size for the gage station, and so the flow record was used as reported.

Effective Discharge
The largest proportion of bedload is transported at approximately 450 cfs; 100-year flow near Madrone is 15,000 cfs. The maximum historical peak flow is approximately 7,400 cfs which was in WY2017, for which the data is still preliminary. The next-largest peak flow was 6,280 cfs in January 1997. Flows shown in plots 1-4 are effective discharge, and the peak flow of WY2017. Grab samples from an existing riffle are included in plot 4.

Gravel Gradation and Injection Plan
Because this site is approximately 1 mile downstream of the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. Downstream of a reservoir, almost all coarse sediment is sourced from the banks and bed surface, which has incised a base flow channel 4-7 feet below the lowest floodplain terrace.

Steady State/Episodic Cycles
In most years, Anderson reservoir attenuates flow fluctuations and associated sediment pulses expected from episodic events. During WY2017, Anderson reservoir overtopped into the spillway, flooding Coyote Creek, and mobilizing large amount of sediment on the floodplains and in the channel bed. As a result, the channel bed gradation during the surveys in October 2017 may represent episodic conditions, with large gravel bars striped of vegetation, and recently deposited gravels in riffles. After several years, steady state conditions will likely re-armor gravel supplies via selective transport and colonization of riparian vegetation. Despite the large amount of sediment mobilized in 2017, sediment transport capacity is assumed to be a good approximation of on-the-ground transport in average years because there is very limited sediment supplies from upstream.

Lifetime Expectancy
This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment. The design gradation is bi-modal, with approximately 50% spawning gravels, and 50% large cobbles and boulders to counter-act the large transport capacity in this reach of Coyote Creek. To maintain consistent sediment supply, the design injection amount is 300 tons every 2 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. As designed, injected sediment may be out-paced by even 10-year average transport capacities. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Coyote Creek 1-2, Project 1: Gravel

Santa Clara Valley Water District

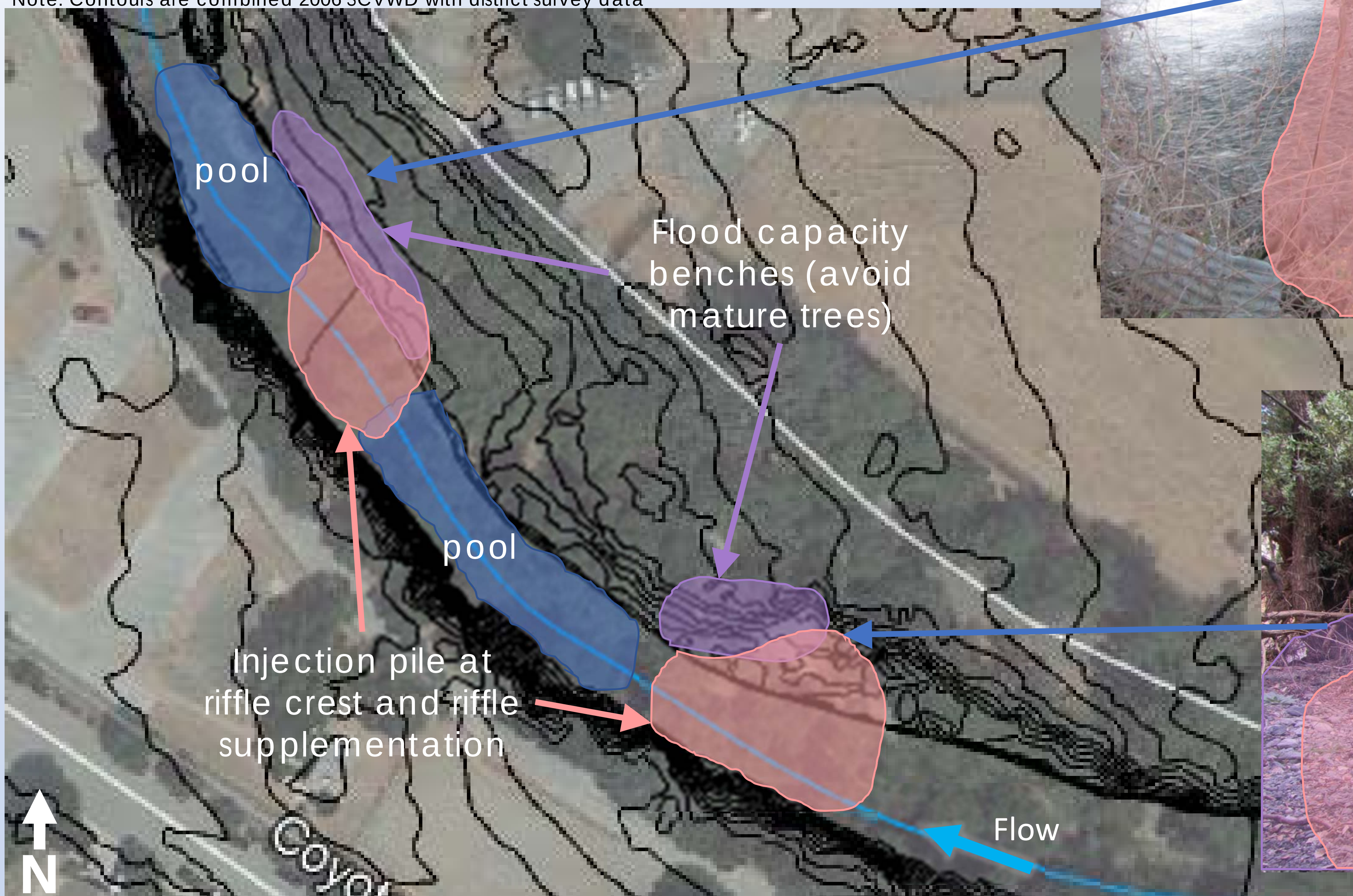
Description

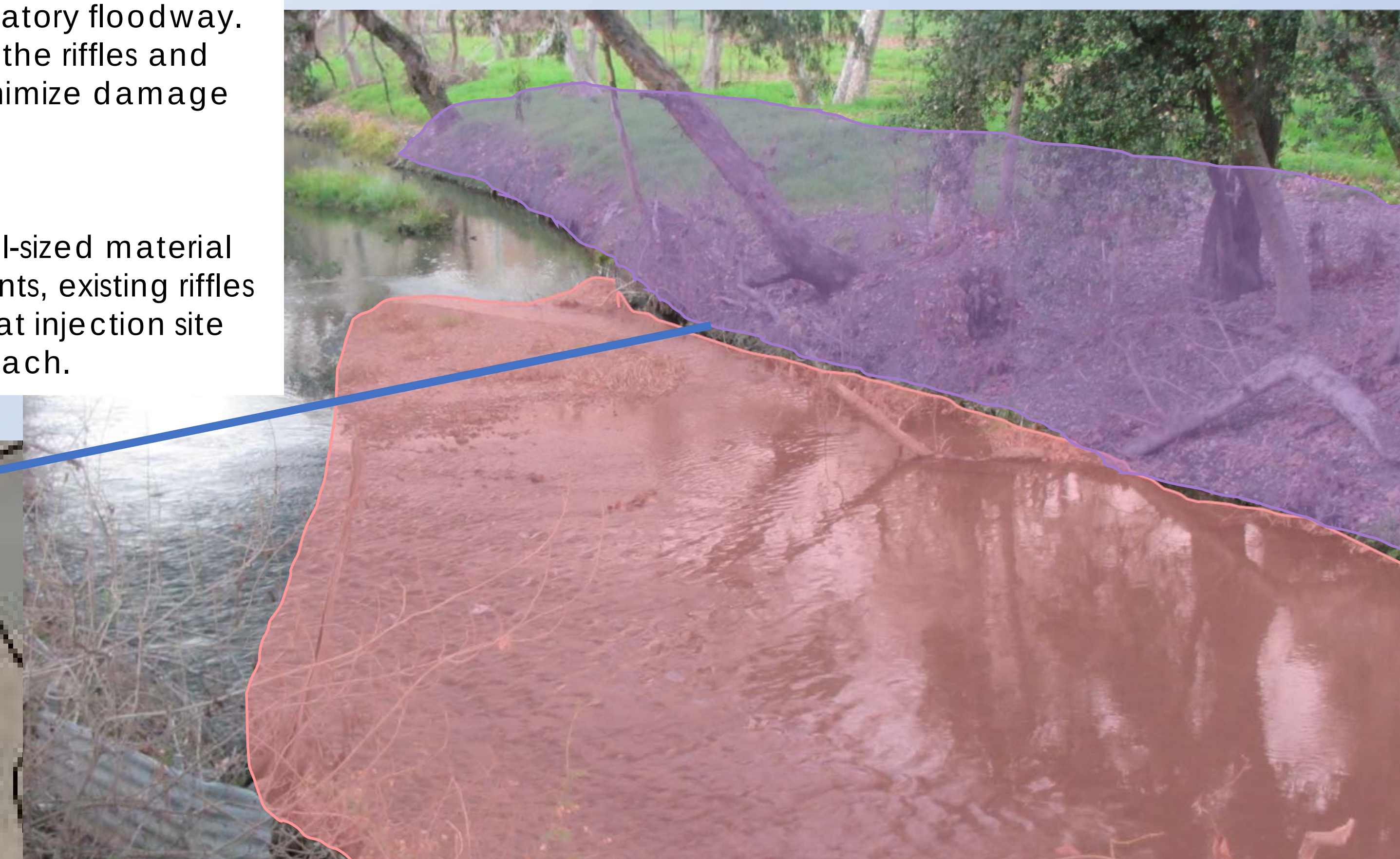
This project proposed of supplement two existing riffles with spawning size gravels from an existing floodplain terrace (indicated in pink). At both gravel augmentation sites, a flood capacity bench (indicated in purple) may need to be carved out of the right bank to meet flood water level requirements within the regulatory floodway. High-flow injection piles will be positioned on flood bench on the right bank to help supplement the riffles and downstream reaches. Design of flood capacity benches will be refined with a tree survey to minimize damage to roots.

Stability Recommendations

Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events, existing riffles implies flow patterns that preferentially deposit gravels here, which may retain sediment supply at injection site over a longer period. LWD augmentation downstream will help retain gravels in the upstream reach.

Note: Contours are combined 2006 SCVWD with district survey data





View of right bank, looking downstream, February 2018.

View of upstream riffle and bank, looking upstream, October 2017.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

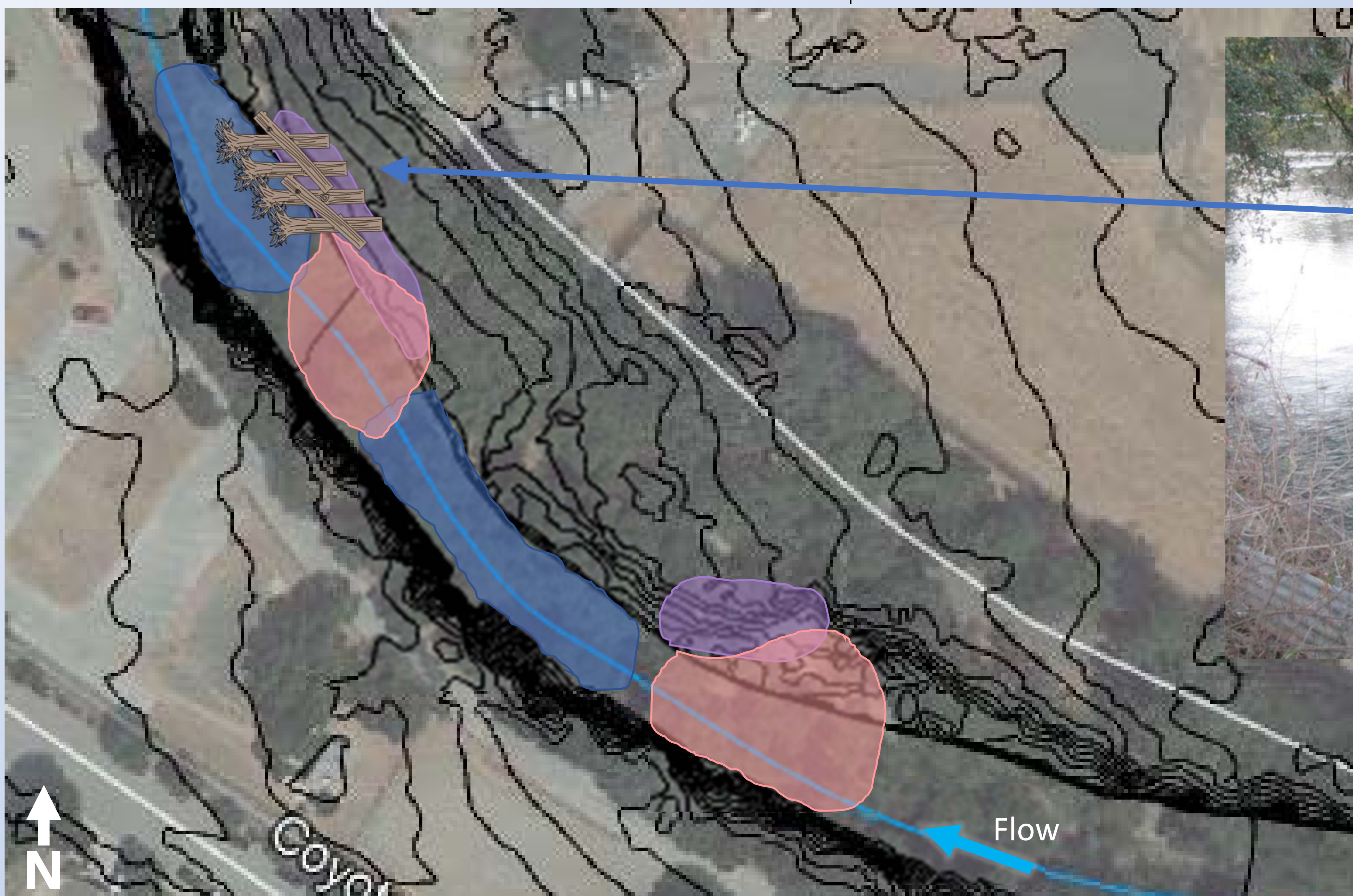
Balance Hydrologics, Inc.

Coyote Creek 1-2, Project 2: Wood

Description
The project will be located in an existing pool downstream of a shallow gravel bar. Wood will be placed at an angle pointed downstream and with rootwads into the center of the pool. The channel under the proposed wood placement is shallower than the left bank, with a small vegetated bar. Gravels would be filled under the placed wood, connecting the existing bars, but maintaining the pool on the left bank and downstream

Stability Recommendations
The right bank will be excavated to anchor the wood, and a flood capacity bench will be carved in the right bank. Burial and ballasting with large boulders may be required and will be sized once log sizes are known using a log stability and root/soil shear strength capacity once logs have been selected or a desired specification. Cabled duckbills may not perform to spec; large amounts of cobbles and boulders in the banks my prevent adequate driving.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



View of right bank, looking downstream, February 2018.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Coyote Creek 1-2

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increase spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Potential Flood Risks

Potential flood risks are significant and require that stream capacity be maintained for 100-year flows. Detailed modeling will be required for design refinement to meet zero-rise flood requirements imposed within regulatory floodways. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints

- Renovations of the Anderson Dam are forthcoming and may alter this portion of the creek or restrict access for some time.
- Access will need to be arranged with Santa Clara County Probation Department (William F. James Ranch) or SCCP.

Anticipated Geomorphic and Engineering Next Steps

- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and design refinement
- Sediment procurement
- Wood procurement
- Mercury testing of existing sediments, which are likely to be mobilized.

Access and Staging

- Access will need to be arranged with Santa Clara County Probation Department (William F. James Ranch) and or SCCP. There is good access directly adjacent to both sides of the creek, however the weight capacity of the William F. James Ranch bridge is unknown. Staging opportunities will likely need to be coordinated with SCCP, but appear to be very good.

Undercut left bank in pool, October 2017.

Picnic bench in tree upstream of CC1-2 after WY2017 floods, October 2017

Balance Hydrologics, Inc.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe Creek 1-1

Location
Just downstream of Guadalupe Reservoir and SCVWD gaging station 5017, within SCVWD fee ownership.

Existing Conditions
- The Guadalupe Reservoir effectively traps all coarse sediment supplied from the upper watershed. As a result, Guadalupe Creek has incised. The channel bed is largely cobbles and boulders with fine silt and sand interspersed. Historically, channel would have been subjected to frequent debris flows.
- Exposed mature tree roots on the high-flow floodplain make up much of the channel banks.
- Cobble and boulder riffles already present around channel-narrowing riparian trees.
- Low floodplain about 3 feet higher than channel thalweg, some exposed bedrock, but little floodplain roughness or refuge.
- Project site just downstream of the limit of anadromy.
- Reach is run-riffle-pool sequence with shallow pools and consistent and relatively flat slope.
- CEM stage 3, low-flow channel incision has occurred, mature trees and bedrock has slowed expansion of a lower floodplain.

Problem
Reach just downstream of Guadalupe Reservoir is gravel deprived. Riffles constructed with cobble or boulder, and no patches of spawning habitat were present. Floodplain is engaged during high-flow events, but high-flow refuge is minimal.

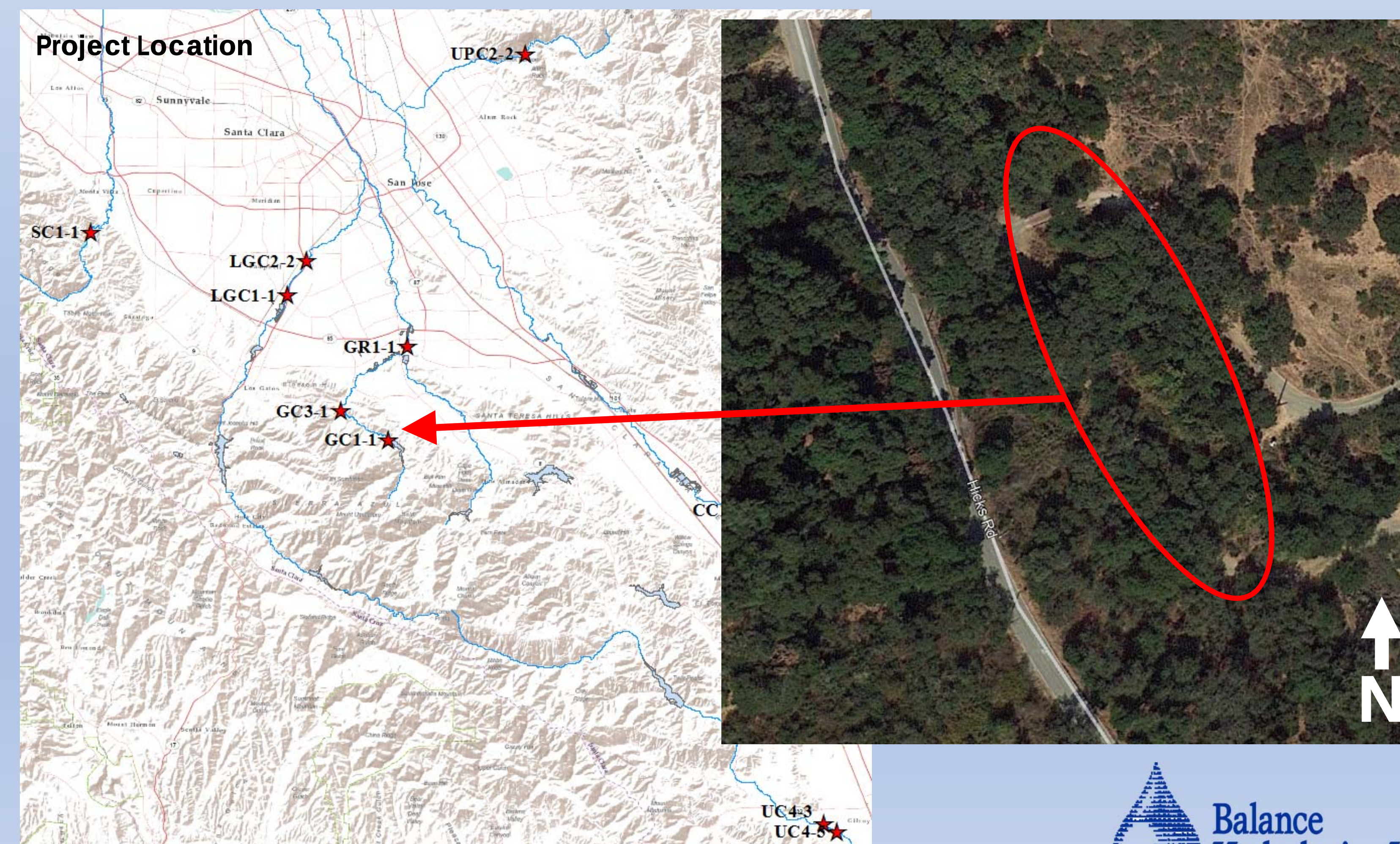
Project Approach
Two projects are proposed at this site:
1. A gravel injection pile on the left bank will supplement spawning gravels draped over the entire channel reach to supplement existing riffles and ameliorate channel incision. Because this site is the limit of anadromy, recommend considering as ongoing gravel augmentation site, after initial injection program and monitoring are completed and evaluated (5-10 years).
2. Wood placement will be focused on enhancing floodplain connectivity and introducing high-flow cover.

Mature trees in incised channel, October 2017.

Santa Clara Valley Water District

* Measured on Oct 17, 2017

Guadalupe Creek 1-1 Site Parameters	
Upstream (impounded) watershed area	*6 mi^2 (6 mi^2)*
Channel roughness	*0.04*
Channel slope	*1.3%*
*Field temperature**	*18.2°C*
*Turbidity**	*9.2 ntu*
*Embeddedness**	*35%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*15/5/20/20/35/5 (%)*



Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase high-flow floodplain habitat, and in channel cover	Guadalupe Reservoir	Add instream wood; establish repeat gravel augmentation injection site

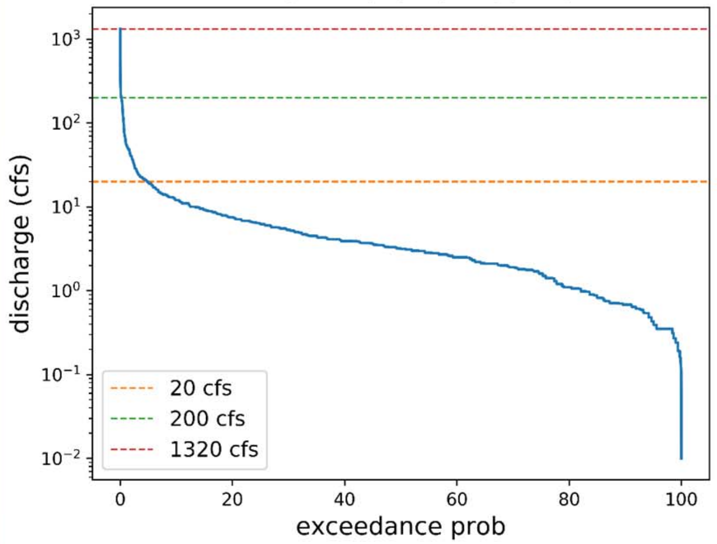
NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

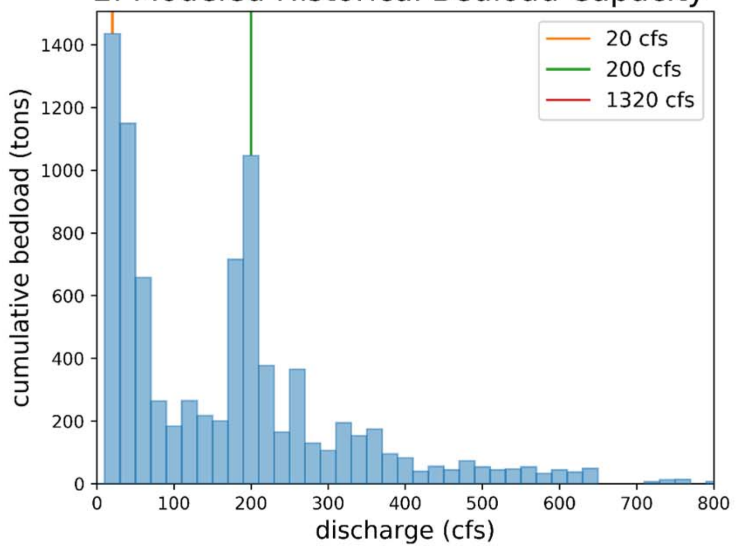
Balance Hydrologics, Inc.

Guadalupe Creek 1-1: Sediment Transport

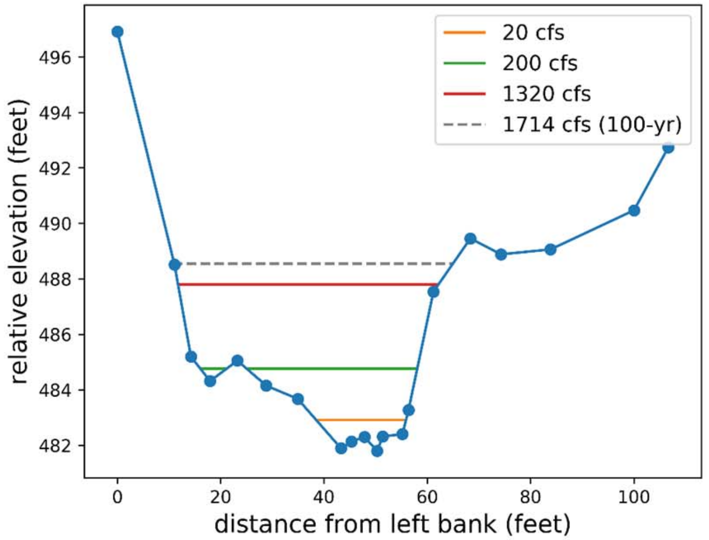
1. Flow-Duration Curve[1]



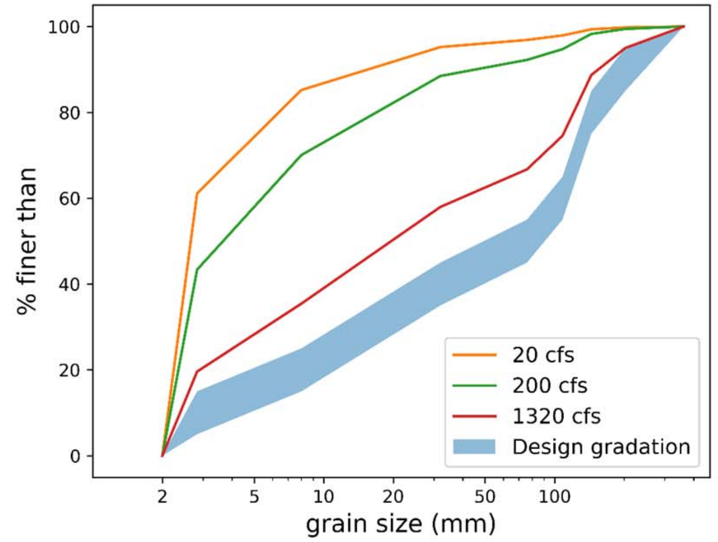
2. Modeled Historical Bedload Capacity[1]



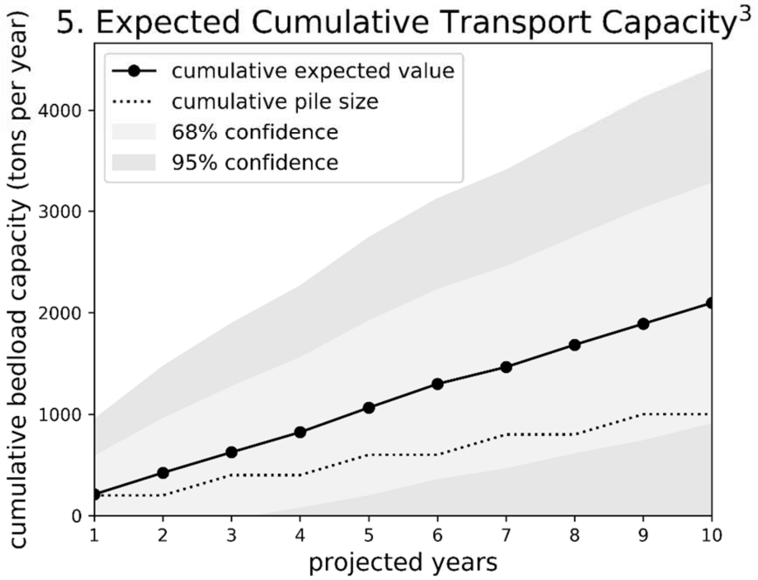
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	34
2011 – wet	245
2012 – dry	0
2013 – dry	35
2014 – dry	0
2015 – average	0
2016 - average	66
2017 - wet	1264

[1]Flow record from 1965 – 2017
[2]Flow record from 1965 – 2017
[3]Sampled from 1990-2017 flow record
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	15-25%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	20 - 25%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	30 – 35%
Boulders *(> 265 mm, >10 in)*	5-10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data
Flow record used is the gage downstream of the Guadalupe Reservoir, which is located just upstream, and so the flow record was not adjusted for use in this analysis.

Effective Discharge
The largest proportion of bedload would be transported at approximately 200; The 100-year flow for this reach is 1,714 cfs and the flow of record was 1,320 cfs in March 1982. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (20 cfs), and the peak flow of record. Preliminary peak flow in 2017 was approximate 220 cfs which is similar to the calculated effective flow for the design gradation.

Gravel Gradation and Injection Plan
Because this site is the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. The steep terrain surrounding Guadalupe Creek downstream limits access for gravel augmentation between GC1-1 and GC3-1. Just downstream of the reservoir, almost all coarse sediment is sourced from the banks and bed surface, which has incised a base flow channel 2-3 feet below the floodplain. Combined injection pile and riffle supplementation should have local and downstream benefits.

Steady State/Episodic Cycles
Guadalupe reservoir upstream of the project site tends to attenuate flow fluctuations. Sediment trapping by the reservoirs also significantly impacts the pulses of sediment associated with episodic events. As a result, steady state process (hydrologic and geomorphic) assumptions are appropriate. Furthermore, sediment transport capacity is assumed to be a good approximation of on-the-ground transport because there is very limited sediment supplies from upstream.

Lifetime Expectancy
This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. The design gradation is coarser than other transported gradations because GC1-1 has a relatively steep slope. To maintain consistent sediment supply, the expected injection amount is 200 tons every 2 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe Creek 1-1, Project 1: Gravel

Santa Clara Valley Water District

Description
At the limit of anadromy, introduction of spawning size gravels are likely to have benefits for downstream reaches. This project recommends introducing spawning-sized gravels from the left bank(indicated by the blue star) to build a high-flow injection pile. The injection pile position was selected to provide easy access to the channel and with the goal of decreasing the gradation of the adjacent cobble and boulder riffle. The District may also wish to consider draping the channel with approximately 6-12 inches of design gradation, which we anticipate will be quickly re-worked during moderate flows to form beneficial habitat.

Stability Recommendations
Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events. The channel widens at the gravel pile injection location, promoting deposition and formation of the riffle, which may retain sediment supply over a longer period. LWD augmentation downstream at the ramp will help retain gravels in the upstream reach.

Note: Contours are combined 2006 SCVWD with district survey data

View of left bank, looking downstream, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

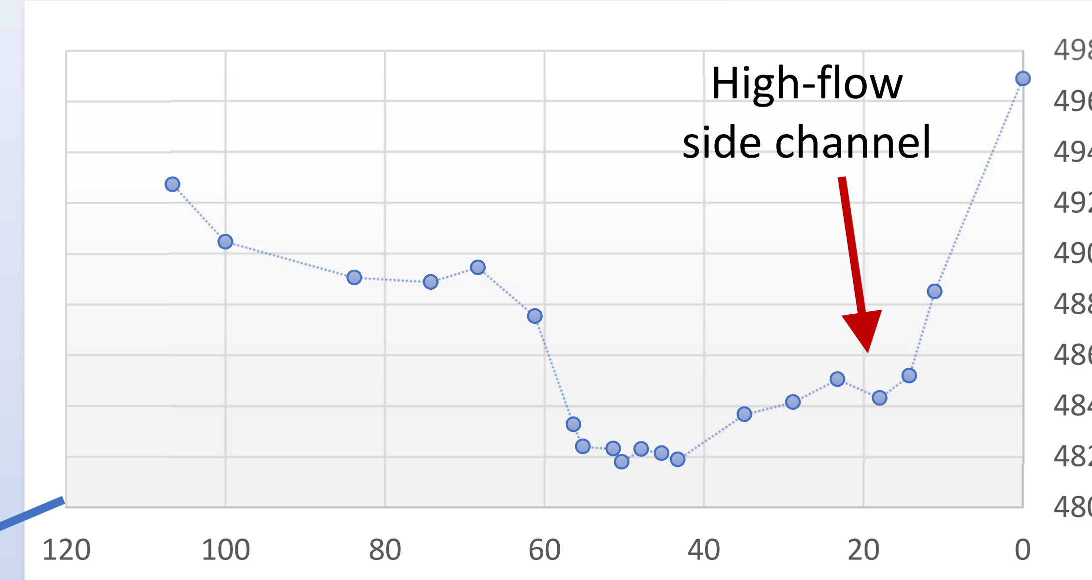
Balance Hydrologics, Inc.

Guadalupe Creek 1-1, Project 2: Wood

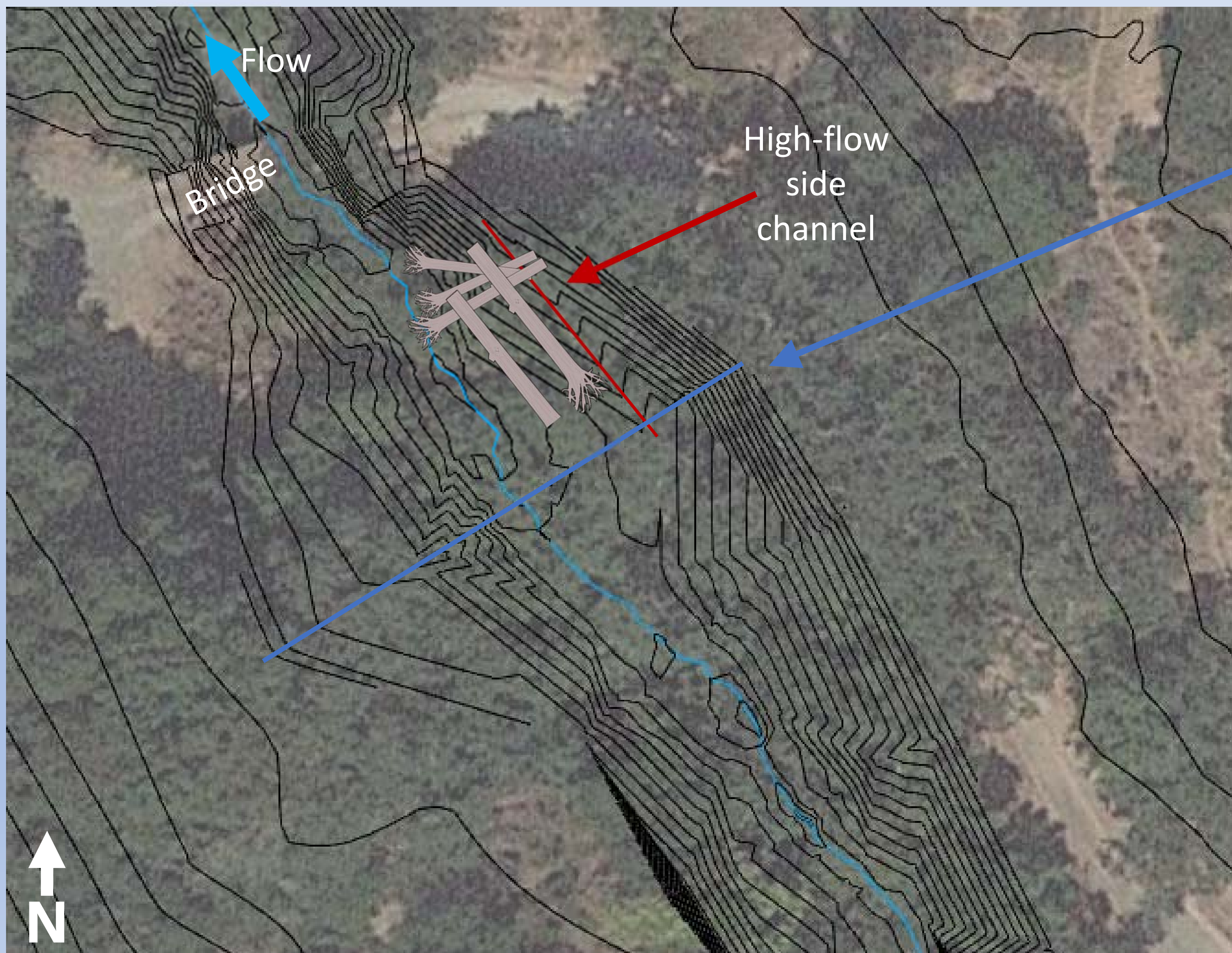
Santa Clara Valley Water District

Description
The intended function of wood at this site is three-fold. First, wood placed at the positions pictured below may help trap sediments on the right bank downstream of the injection pile, potentially providing high-flow refuge. Second, the wood pieces as positioned will likely develop scour downstream enhancing a deep pool and providing channel complexity even with additional sediment supplied from upstream. Third, placement of floodplain wood will likely slow floodplain velocities during flood events, directing more flow into an existing high-flow side channel. Piles of fallen trees were observed adjacent to the project site, and although may not be suitable for wood placement project, its presence suggests wood may be available in the area.

Stability Recommendations
Existing trees could serve as the primary anchor for wood placement. It is likely that additional ballast may be warranted. Duckbill anchors are not likely to be effective at this location due to the callible



Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Looking downstream, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Guadalupe Creek 1-1

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increased spawning and rearing habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection pile shrinks, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Potential Flood Risks

The FEMA SFHA 100-year floodplain is contained in the channel banks from the site to the confluence with Alamitos Creek at Lake Almaden. Anticipated increases in flood water surface elevations are anticipated to be contained within SCVWD fee ownership. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints

- Renovations of the Guadalupe Dam are forthcoming and may alter this portion of the creek or restrict access for some time.
- Removal of channel-spanning riparian vegetation may temporarily release a pulse of fine sediment downstream and may need to be mitigated for.

Anticipated Geomorphic and Engineering Next Steps

- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and CLOMR, if necessary
- Sediment procurement
- Wood procurement
- Mercury testing of existing sediments, which are likely to be mobilized

Access and Staging

Access is excellent via a dam access road off Hicks Road. With the appropriate equipment, access to the channel can likely be achieved without removing any large trees. Staging areas are available adjacent to the project site on SCVWD fee property.

Exposed tree roots as evidence of channel incision, October 2017.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Guadalupe Creek 3-1

Santa Clara Valley Water District

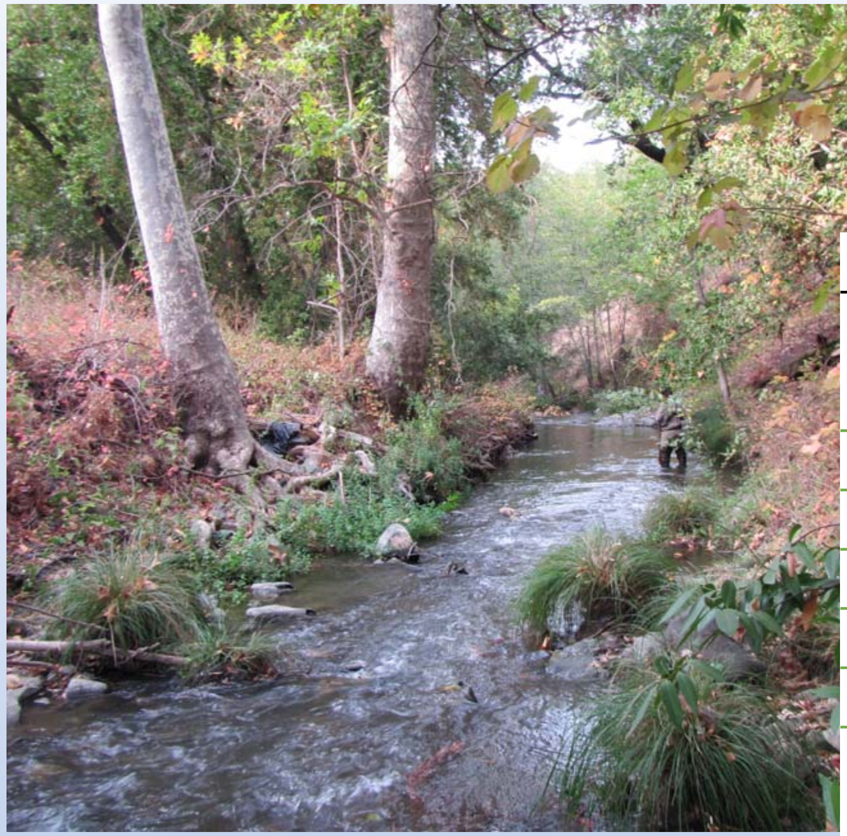
Location
Downstream of Guadalupe Reservoir, adjacent to the intersection of Hicks and Wagner Roads.

Existing Conditions
- The Guadalupe Reservoir effectively traps all coarse sediment supplied from the upper watershed. Even though sediment supply from Hicks and Pheasant Creeks is intact, the channel has incised. The channel bed is largely cobble with fine silt and sand interspersed. Some bedrock outcrops in the channel.
- Reach is straight, with floodplain connectivity only at the highest flows.
- Cobble and boulder riffles already present, possibly preserved by resistant bedrock.
- Project site is 2.5 miles from the limit of anadromy.
- Pools have undercut banks anchored by mature tree roots.
- CEM stage 3, low-flow channel incision has occurred, mature trees and bedrock has slowed expansion of a lower floodplain.

Problem
Reach just downstream of Guadalupe Reservoir is gravel deprived. Riffles are present but armored. Incision has reduced floodplain connection, and high-flow refuge is minimal.

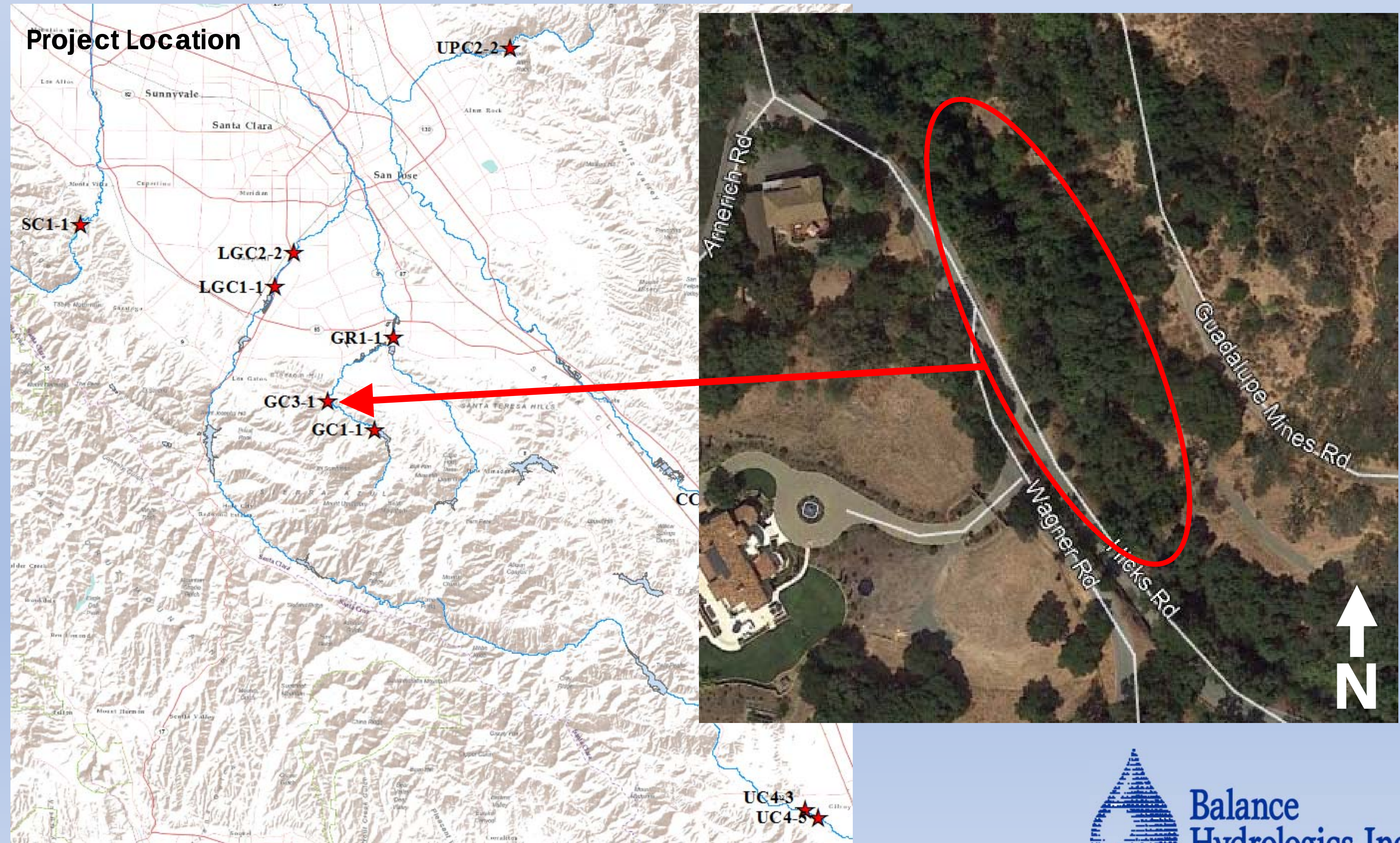
Project Approach
Two projects are proposed at this site:
1. A gravel injection pile on the right bank will supplement spawning and rearing gravels and ameliorate channel armoring. Recommend considering as ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated.
2. Wood placement will be focused on enhancing floodplain connectivity and introducing high-flow cover.

Looking downstream, October 2017



* Measured on Oct 17, 2017

Guadalupe Creek 3-1 Site Parameters	
Upstream (impounded) watershed area	*13 mi² (6 mi²)*
Channel roughness	*0.04*
Channel slope	*0.8%*
*Field temperature**	*17.3°C*
*Turbidity**	*4.1 ntu*
*Embeddedness**	*40%*
*Existing est. silt/sand/gravel/cobble/boulder**	*10/10/20/30/20/10 (%)*



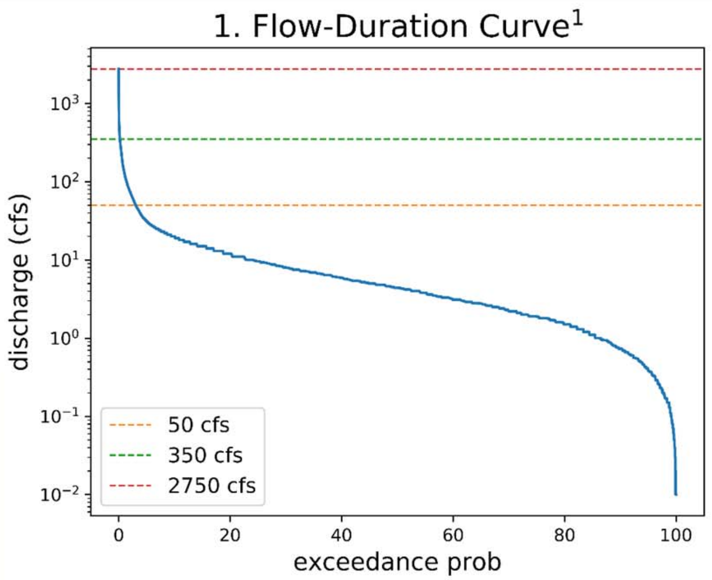
Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase cover, high-flow floodplain habitat	Guadalupe Reservoir	Add instream wood; establish repeat gravel augmentation injection site

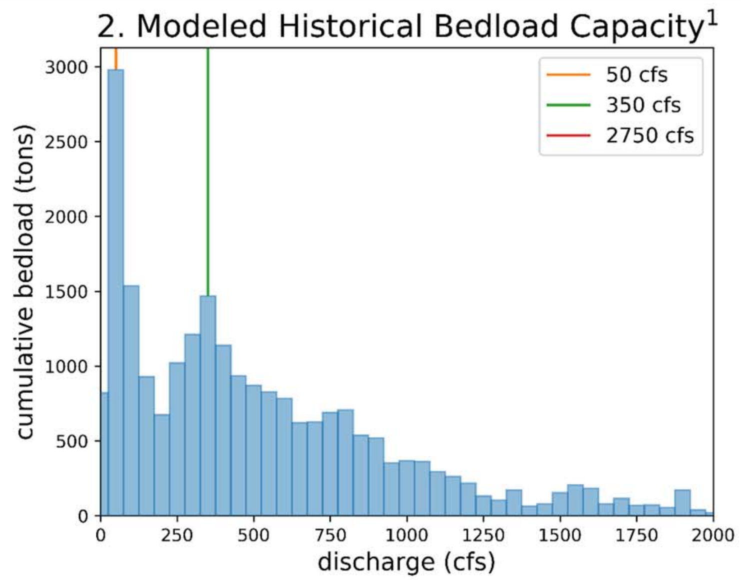
NOT FOR CONSTRUCTION

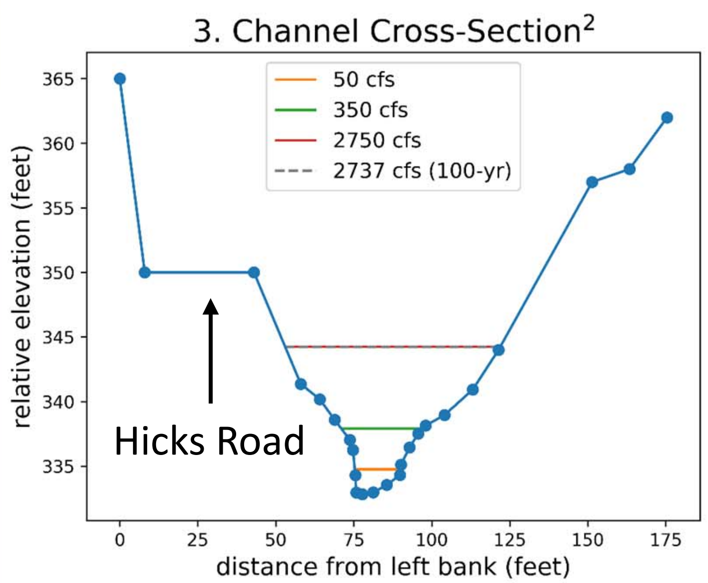
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

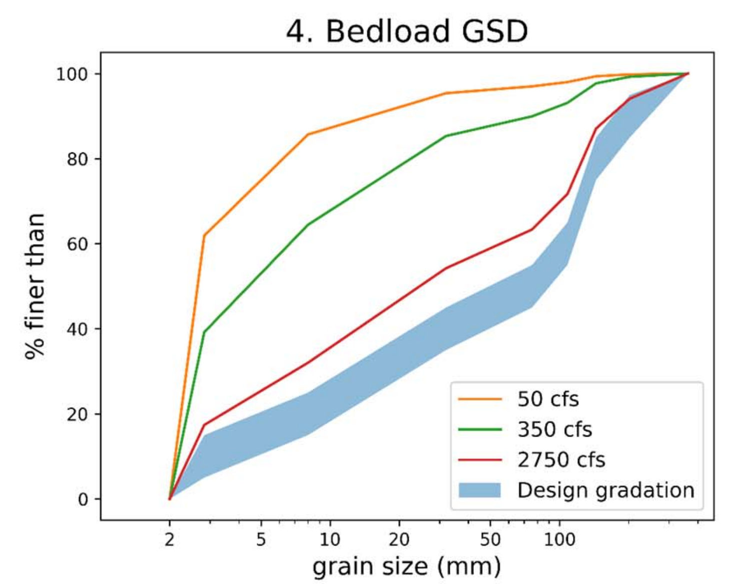
Balance Hydrologics, Inc.

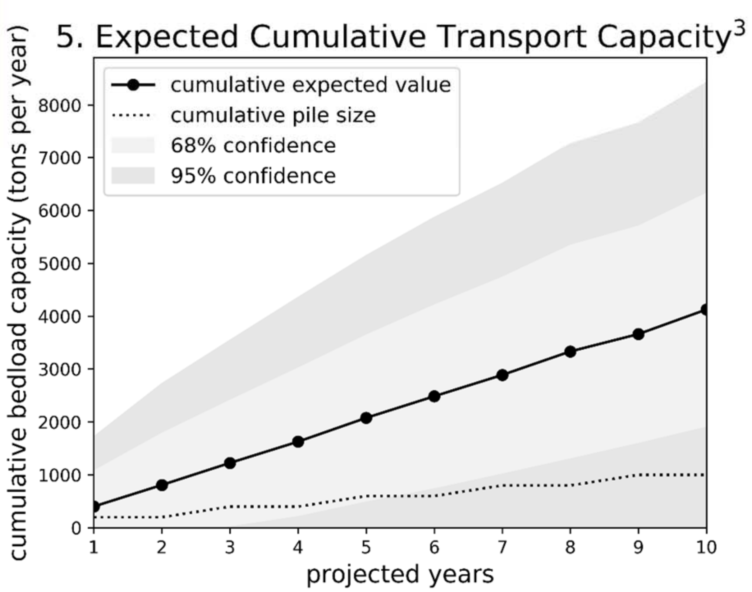
Guadalupe Creek 3-1: Sediment Transport











6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	153
2011 – wet	453
2012 – dry	2
2013 – dry	47
2014 – dry	0
2015 – average	28
2016 - average	69
2017 - wet	1730

[1]Flow record from 1959 – 2017
[2]See discussion of flood risk on page 5
[3]Sampled only from years at least 95% complete
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	20 – 25%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	20 – 25%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	40 – 45%
Boulders *(> 265 mm, >10 in)*	5-10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data

Flow record used is the gage on Guadalupe Creek off Hicks Road, which is located just downstream and so the flow record is used as reported. The gage record is a high-flow only gage and so base flows are reported, but not calibrated. Because relatively small amounts of gravels are transported a lower flows, we are using the gage data as available. The record should be refined as necessary as the design progresses.

Effective Discharge

The largest proportion of bedload would be transported at approximately 50 cfs; The 100-year flow in this reach is 2,737 cfs, nearly equivalent to the flow of record, 2,750 cfs in March 1995. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (350 cfs), and the peak flow of record. Preliminary peak flow in 2017 was approximate 850 cfs.

Gravel Gradation and Injection Plan

Because this site is approximately 2.5 miles from the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. Combined injection pile and riffle supplementation should have local and downstream benefits.

Steady State/Episodic Cycles

Approximately half of the contributing watershed is behind Guadalupe Reservoir, where the dam attenuates flow fluctuations and traps sediment pulses associated with large flow events. The other half of the contributing watershed is sourced from Hicks and Pheasant Creeks which are both relatively undeveloped, maintaining natural flow and sediment fluctuations. In combination, episodes at GC3-1 would have a muted effect compared to a fully natural watershed. However, since base flows from Guadalupe Reservoir are regulated, only the largest sediment pules from either tributary are likely to induce episodic conditions at GC3-1. Observation in October 2017 suggest that WY17 should not be considered episodic.

Lifetime Expectancy

This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. An injection pile of approximately 200 tons can be accommodated in the reach. Because access will require coordination with the landfill, injection is schedule every 2 years. Expected sediment transport capacity at GC3-1 includes sediment supplied from upstream (Hicks and Pheasant Creeks) plus sediment entrained from the injection pile. Sediment inputs from tributaries can be further constrained as the design progresses. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe Creek 3-1, Project 1: Gravel

Santa Clara Valley Water District

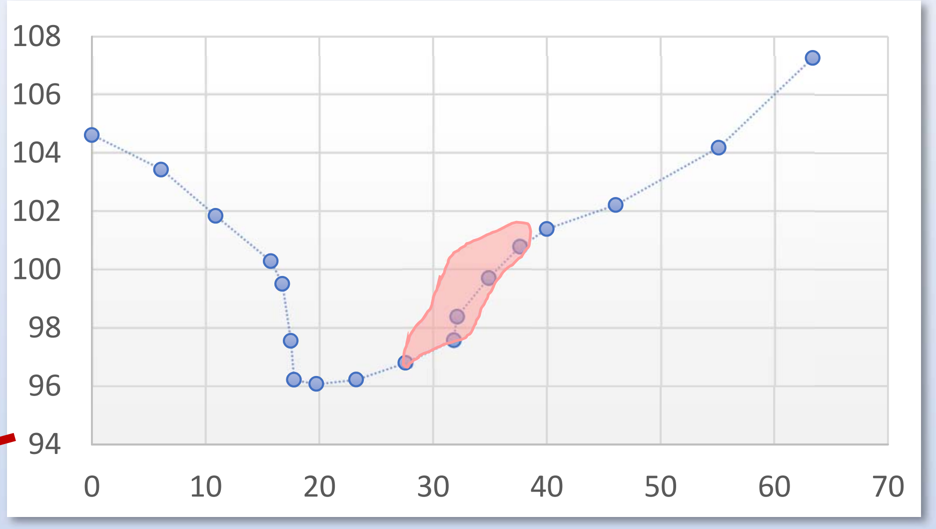
Description

GC3-1 is approximately 2.5 miles downstream from the limit of anadromy. Access is good at site GC1-1, but planned seismic upgrades of the Guadalupe Dam may preclude implementation of GC1-1 for some time. Thus, GC3-1, may be the upstream-most injection access point in the near term. In addition, we do not anticipate gravels injected at GC1-1 would be transported to GC3-1 for many years.

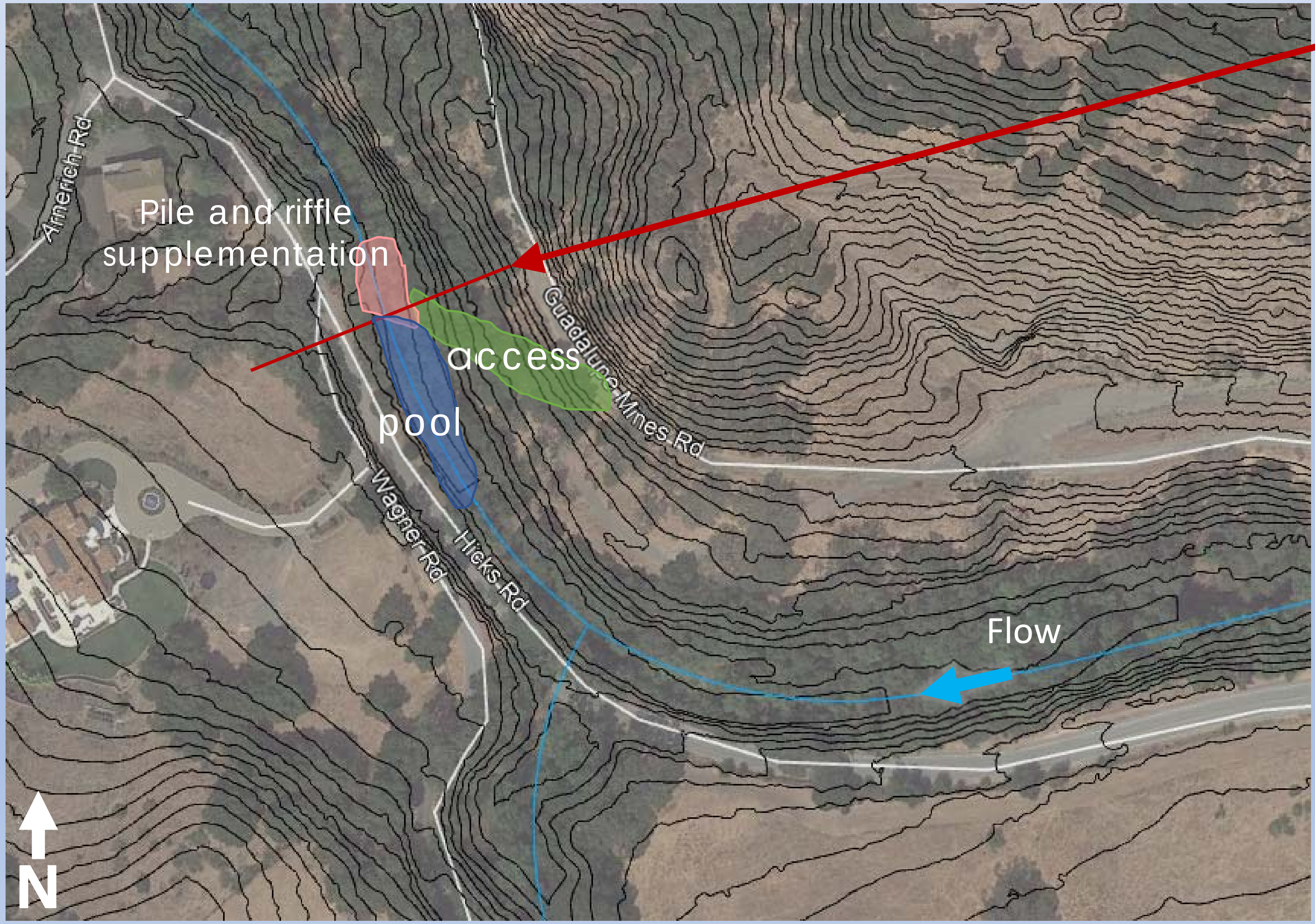
Gravel injection has maximum benefits for downstream reaches. This project recommends introducing spawning-sized gravels from the right bank(indicated by the pink shading) to build a high-flow injection pile. The injection pile position was selected to provide easy access to the channel and with the goal of decreasing the gradation of the adjacent cobble and boulder riffle. We also recommend draping the channel with approximately 6-12 inches of design gradation to provide short-term channel enhancement.

Stability Recommendations

Cobbles and boulders should be added to the gradation to reduce mobility. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events.



Note: Contours are combined 2006 SCVWD with district survey data



View of right bank, looking downstream, October 2017.

Balance Hydrologics, Inc.

NOT FOR CONSTRUCTION

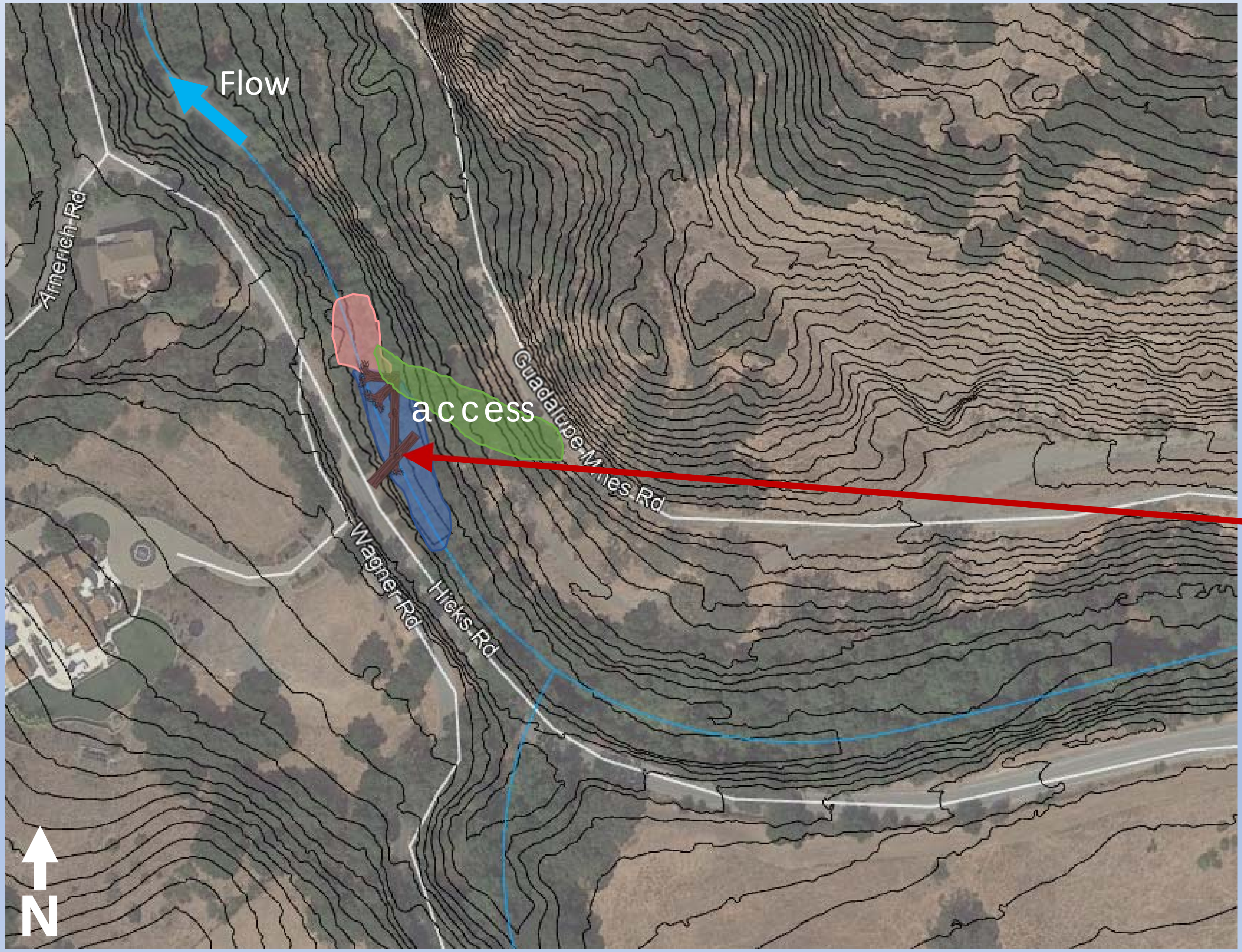
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe Creek 3-1, Project 2: Wood

Description
Channel-spanning wood in this reach is intended to slow flood flows, raising the water surface elevation and engage the right floodplain, which is disconnected from the incised channel. If hydraulic models reveal flood capacity concerns, a flood capacity bench could be created on the right bank prior to gravel injection. Root wads will be placed in the existing pool to enhance pool and provide habitat cover.

Stability Recommendations
Burial and ballasting with large boulders may be required and will be sized once log sizes are known using a log stability and root/soil shear strength capacity once logs have been selected or a desired specification. Duckbills are likely to be very difficult to drive based on our observation that the bed and banks are very coarse, and in places, bedrock is shallowly buried.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Looking upstream, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe Creek 3-1

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increase spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Channel access on right bank via landfill, looking upstream, October 2017.

Potential Flood Risks
The FEMA SFHA 100-year floodplain is contained in the channel banks from the site to the confluence with Alamitos Creek at Lake Almaden. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints
- No access through SCVWD fee or easement. Access will need to be arranged through the Guadalupe Rubbish Disposal Facility
- Steep slope to Hicks road on the left bank warrants consideration of potential velocities and shear stresses during design refinement
- The Guadalupe River TMDL does not show mapped calcines in this reach, however additional evaluation and testing for mercury may be warranted.

Anticipated Geomorphic and Engineering Next Steps
- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and CLOMR, if necessary
- Sediment procurement
- Wood procurement
- Potential testing existing sediments for mercury, which may be mobilized.

Access and Staging
Access and staging both would need to be arranged with the Guadalupe Rubbish Disposal Facility from the north side of the channel. Access via Hicks Road is steep and potential staging areas are minimal on the two-lane road.

Gravel, cobble, and bedrock in channel banks, October 2017.

Balance Hydrologics, Inc.

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Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe River 1-1

Looking downstream, October 2017.

Location

Guadalupe River directly downstream of the Alamitos Drop Structure, approximately 1500 ft downstream of the confluence of Guadalupe and Alamitos creeks.

Existing Conditions

- The Alamitos Drop Structure is just upstream of the site. It is our understanding that bedload sediment can pass the drop structure.
- Lake Almaden captures bedload from Alamitos Creek, and we hypothesize that some sediment from Guadalupe Creek is also captured at the Lake Almaden outlet.
- Gravels are depleted and bars are sparse, and moderately embedded with some habitat smothering.
- Low flow channel has incised and floodplain appears to be inundated less frequently. CEM stage III-IV.

Problem

The engineered channel corridor and sediment-deprived conditions offers little channel heterogeneity or LWD, which promotes higher velocities in large storm events compared with natural channels.

Project Approach

Two projects are proposed at this site:

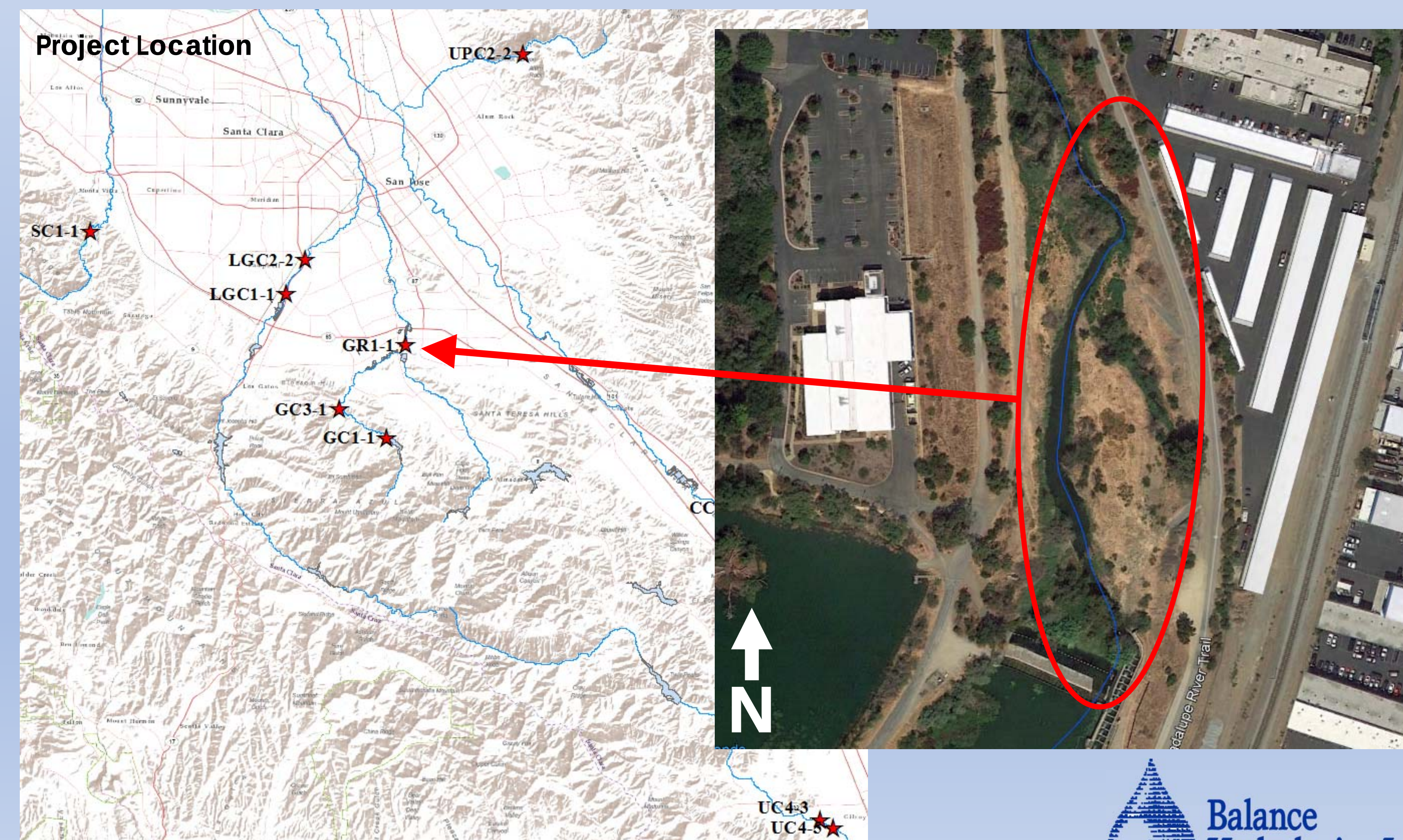
1. A gravel injection pile introduced near the Alamitos Drop Structure, and riffle supplementation. Gradation has been selected with downstream transport in mind to nourish gravel bars and help arrest incision. Recommend consideration as ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated. Injection of gravel here is likely to benefit restored reached downstream.
2. Wood placement downstream will help retain gravels and provide structural cover, increasing channel complexity, and encourage more frequent backwatering of existing secondary channel.

Santa Clara Valley Water District

* Measured on Oct 18, 2017

Guadalupe River 1-1 Site Parameters	
Upstream (impounded) watershed area	*53 mi^2 (53 mi^2)*
Channel roughness	*0.045*
Channel slope	*0.35%*
*Field temperature**	*15.1°C*
*Turbidity**	*8.9 ntu*
*Embeddedness**	*10-20%*
*Existing est. silt/sand/gravel/cobble/boulder**	*10/35/25/25/5 (%)*

Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase sediment supply downstream	Several dams and sediment sinks upstream; flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site



NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation terminology, calculations and conceptual designs

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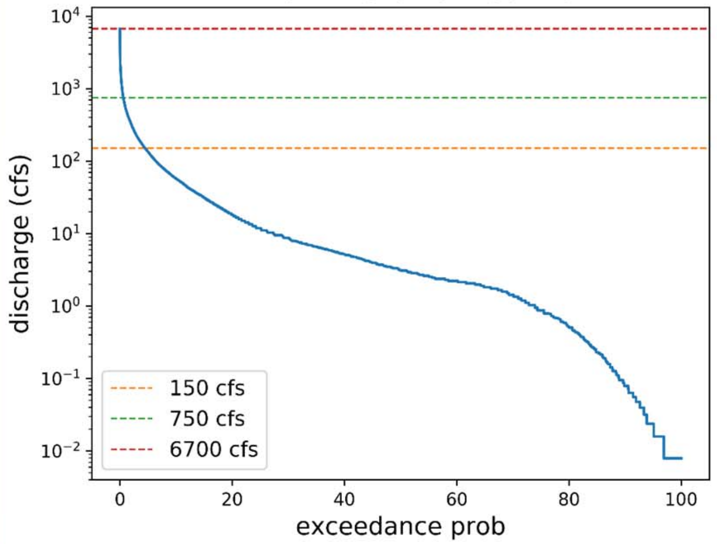
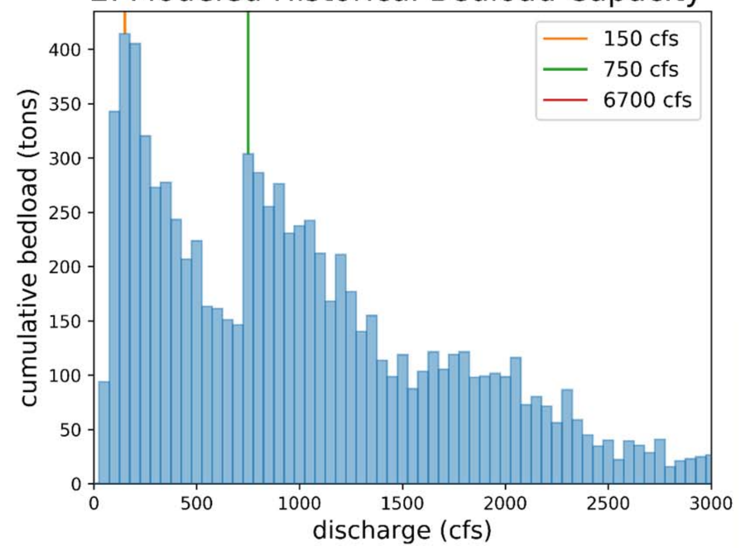
Guadalupe River 1-1: Sediment Transport

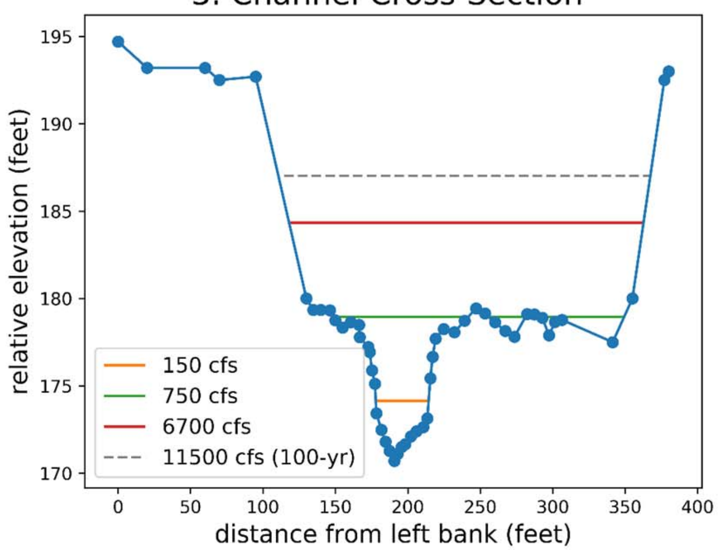
1. Flow-Duration Curve[1]



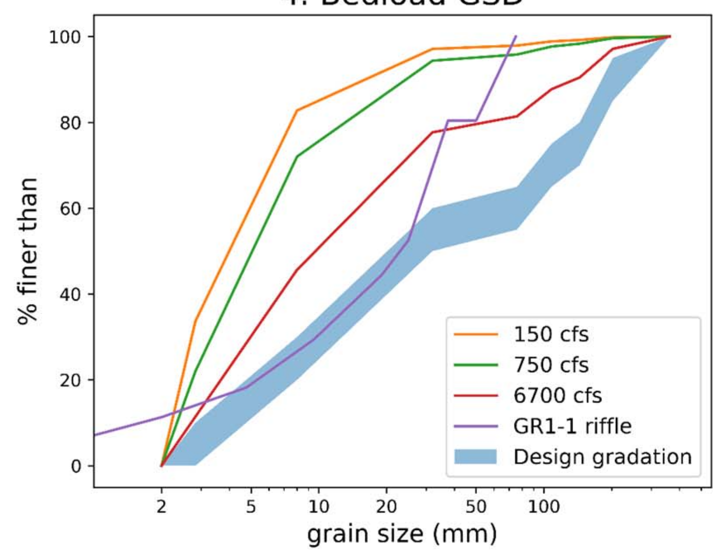
2. Modeled Historical Bedload Capacity[1]



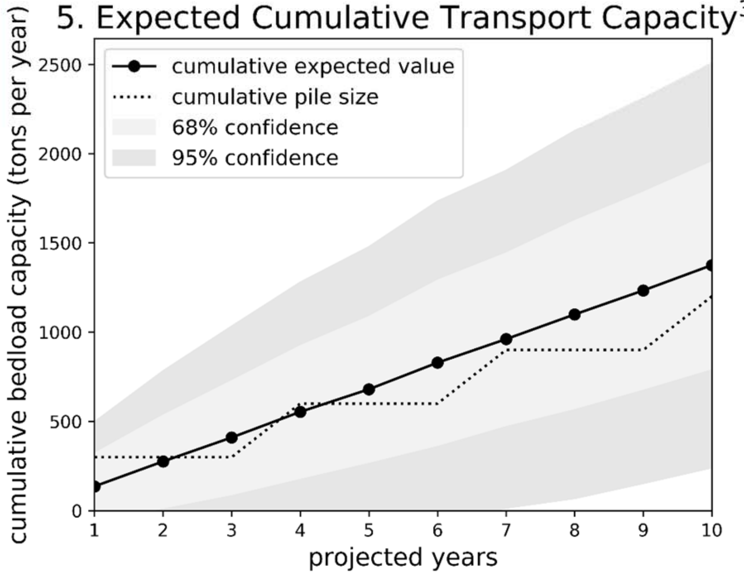
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	NA
2011 – wet	NA
2012 – dry	7
2013 – dry	52
2014 – dry	9
2015 – average	60
2016 - average	34
2017 - wet	677

[1]Flow record from 1956 – 2017
[2]Sampled from 1990-2017 flow record
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	25 – 30%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	30 - 35%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	30 – 35%
Boulders *(> 265 mm, >10 in)*	5 – 10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data

Flow record used is the Almaden Expressway gage which is located approximately 1.6 miles downstream. Approximate watershed size downstream of the Alamitos fish ladder is 53 square miles. The watershed size at the Almaden Expressway gage is approximately 66.8 square miles. Therefore, the flow record was reduced by 21%.

Effective Discharge

The largest proportion of bedload is transported at approximately 150 cfs; 100-year flow at Blossom Hill Road is 11,500 cfs. The maximum historical peak flow is approximately 6,700 cfs in January 1995. Peak discharge during WY2017 was 2,480 cfs. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (750 cfs), the peak historical flow, and the 100-year flow.

Gravel Gradation and Injection Plan

Because this site is the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. However, the gradation includes cobbles and boulders to reduce the mobility and hold some the spawning-size material in place for longer periods. Reach scores downstream of GR1-1 suggest low flood risk, but limited access makes injection downstream difficult. Introduction of new sediments at regular intervals will give allow longer-term benefits for sediment supply downstream. Channel forming flows (150, 750 cfs) tend to transport finer sediments (plot 4) than proposed gradation, promoting early mobility of spawning and rearing gravels. Riffle supplementation will use a similar gradation, but perhaps spatially varied to mimic a natural riffle.

Steady State/Episodic Cycles

While 2017 had large flow events, the presence of the reservoirs and percolation ponds upstream tends to attenuate flow fluctuations. Sediment trapping by the reservoirs also significantly impacts the pulses of sediment associated with episodic events. As a result, steady state process (hydrologic and geomorphic) assumptions are appropriate. Furthermore, sediment transport capacity is assumed to be a good approximation of on-the-ground transport because there is limited transport from upstream. This assumption should be refined after initial augmention and monitoring occur.

Lifetime Expectancy

This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. To maintain consistent sediment supply, the expected injection amount is 300 tons every 3 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Guadalupe River 1-1, Project 1: Gravel

Santa Clara Valley Water District

Description
Downstream of the Alamitos Drop Structure, in the plunge pool transition to the “natural” channel, place an in-channel injection pile of spawning-sized gravels from the top of bank. At the limit of anadromy, gravels introduced here will have maximum benefits when transported downstream. Therefore, gravels should be placed in the channel for maximum mobility downstream. In addition, supplement downstream riffle to maximize volume and gradation for spawning if and when the channel is dewatered for LWD placement.

Stability Recommendations
The gradation selected has a similar proportion of small gravels as the existing riffle, but with a coarser fraction added to retain some gravels over the injection cycle period of 3 years. Wood will be placed downstream (see project 2) may retain gravels in the reach for local benefits.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.

Existing riffle, looking downstream, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Guadalupe River 1-1, Project 2: Wood

Santa Clara Valley Water District

Description

LWD placed at the positions pictured below will disrupt flow lines and create pockets of deposition and scour. At GR1-1, LWD also provides additional cover, which is somewhat limited in the incised channel.

Engineered log jam (ELJ) #1 is intended to help maintain the existing pool to riffle transition. ELJ #2 will position root wads into a deep portion of the pool, promoting scour and helping to transport gravel injected upstream through the pool and into the downstream reaches. ELJ #3 will primarily serve to slow the scour and transport of all gravels in moderate events to maximize local benefits.

Stability Recommendations

Burial and Ballasting. Engineered log jams should be bolted or cabled together. Ballast and cabling requirements can be sized once log sizes are known, as part of design refinement. In the absence of mature trees on the bank, burial of wood can be accomplished with minimal long-term impacts.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Guadalupe River1-1

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increased spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Gravel is being mobilized as anticipated.	Quantify volume mobilized through measurement of injection pile depletion
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Looking east across the Alamitos Drop Structure

Potential Flood Risks
The FEMA SFHA 100-year floodplain is contained between the banks at the project site, and our initial results corroborate that finding. There are no regulatory floodways downstream of the proposed site, however FEMA SFHA 100-year floodplain is not contained in the channel banks at a number of locations between the site and the San Francisco Bay. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints
- Potential flood risks
- Access and construction may need to work around recent District riparian revegetation project on the right bank

Anticipated Geomorphic and Engineering Next Steps
- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development, including log stability calculations
- Detailed flood analysis and CLOMR, if necessary
- Vegetation removal plan
- Sediment procurement
- Potential coordination with Caltrans for access or other roadway/freeway issues
- Mercury testing of existing sediments, which is likely to be mobilized.

Access and Staging
Access for gravel pile injection can occur from left or right banks. District Headquarters is on the left bank, as such, excellent staging resources are available. Access to wood placement at the downstream site is via ramps on either side of the channel.

High-flow channel on the right bank just downstream of the Alamitos Drop Structure. High flows likely connect this channel less regularly, however when the high-flow channel is engages, waters flow from the foreground to the background.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Los Gatos 1-1

Santa Clara Valley Water District

Location

Los Gatos Creek downstream of Camden drop structure near intersection of Camden Avenue and Highway 17.

Existing Conditions

- The Camden drop structure is the last piece of infrastructure in a series of reservoirs and percolation ponds, and is the limit of anadromy. The upstream sediment sinks have depleted this section of Los Gatos Creek of nearly all coarse bed material. Additional sediment cannot be sourced from the engineered concrete banks and so the channel bed is very silty. The wide, flat channel bottom keeps water velocities slow across a range of moderate flow, conducive to colonization of aquatic vegetation such as tule and cattail. Many California Roach were observed in field visits.
- CEM stage not applicable as channel banks are engineered.
- Beaver dam located about 2500 ft. downstream of Camden Drop Structure is backwatering the reach at low to moderate flows.

Problem

While riparian vegetation offers cover for steelhead, the reach is lacking in fast-water feeding habitat and channel bed gradation ideal for spawning and rearing. The engineered channel and sediment-deprived conditions offers little channel heterogeneity or LWD, which promotes higher velocities in large storm events compared with natural channels. Beaver dam backwaters reach, and thus aquatic vegetation is channel-spanning in some locations, likely trapping fine sediments.

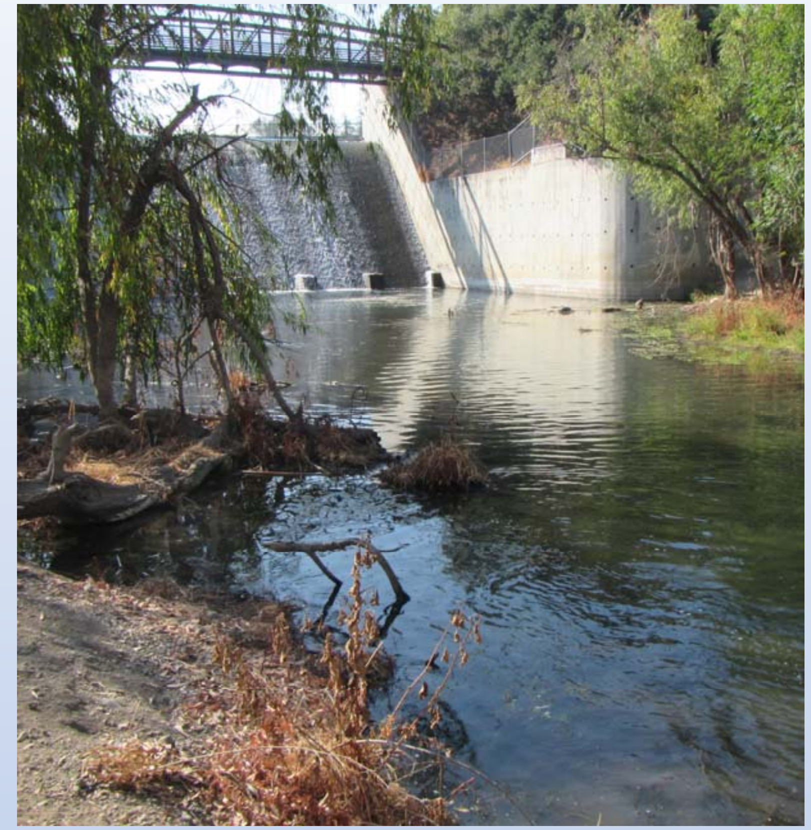
Project Approach

Two projects are proposed at this site:

1. A gravel injection pile introduced from the top of bank onto an existing gravel bar. Because this site is the limit of anadromy, gradation is selected with downstream transport in mind. Recommend considering as ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated.
2. Wood placement downstream at the ramp will help retain gravels and provide structural cover, increasing channel complexity.

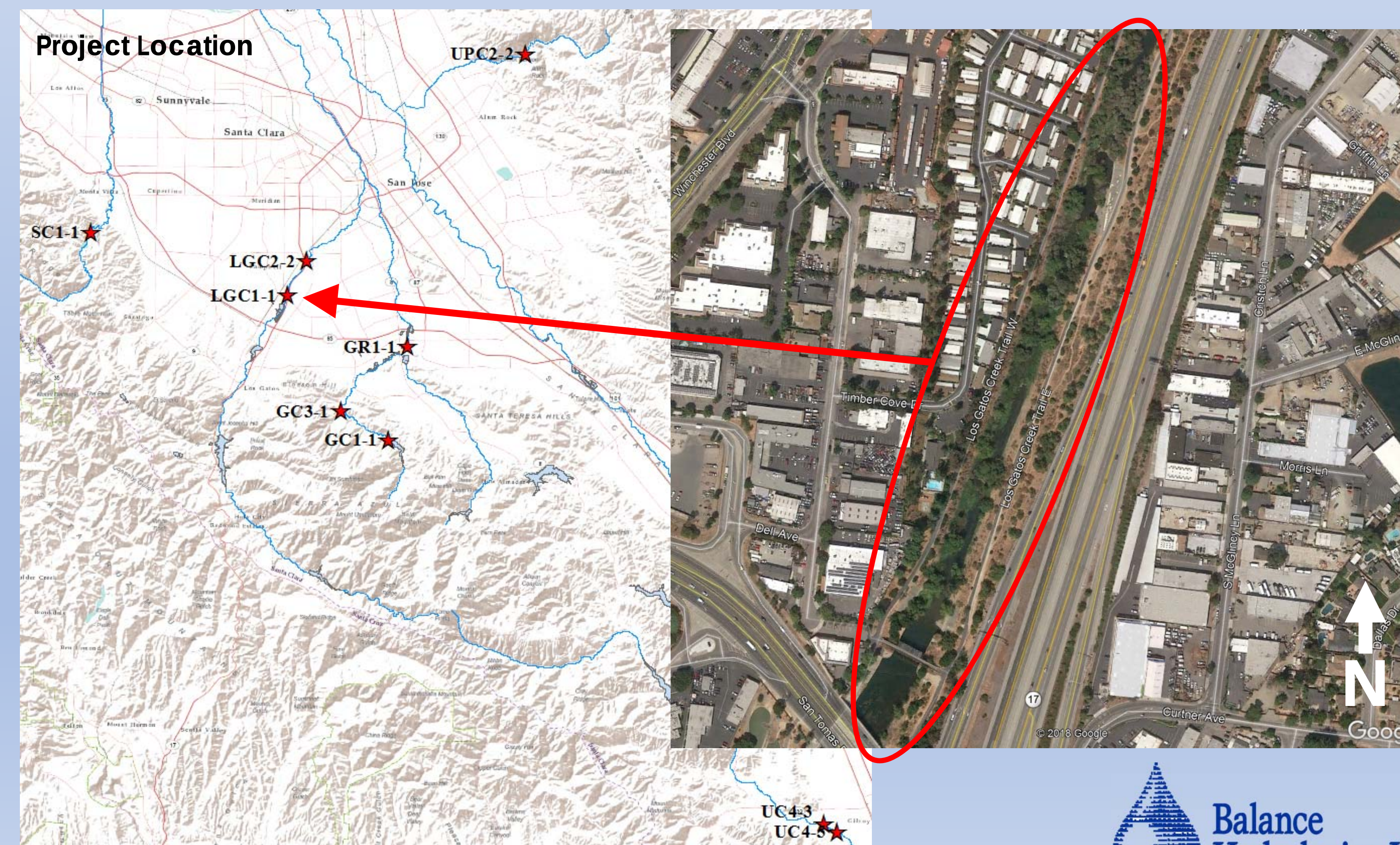
Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase sediment supply downstream	Several dams upstream on Los Gatos Creek; flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site

Start of long silt-bottom pool-run, October 2017.



* Measured on Oct 18, 2017

Los Gatos 1-1 Site Parameters	
Upstream (impounded) watershed area	*42 mi^2 (42 mi^2)*
Channel roughness	*0.04*
Channel slope	*0.71%*
*Field temperature**	*18.4°C*
*Turbidity**	*2.5 ntu*
*Embeddedness**	*0% (silty bed)*
*Existing est. silt/sand/gravel/ cobble/boulder**	*60/30/8/2/0 (%)*



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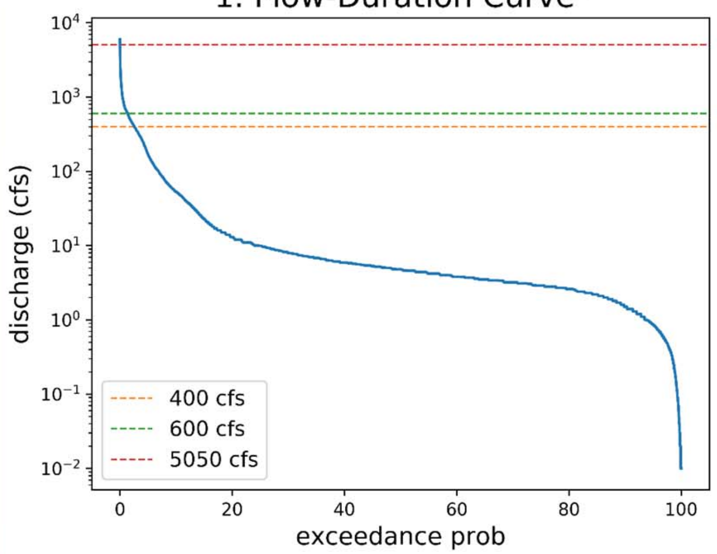
NOT FOR CONSTRUCTION

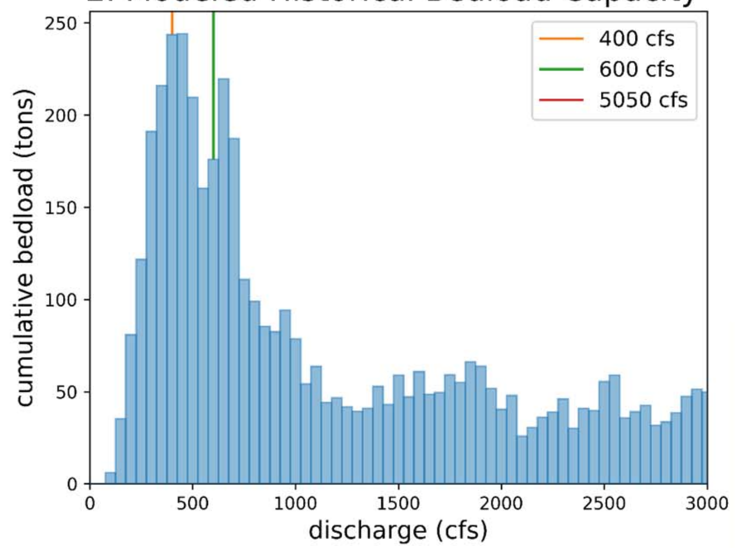
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Los Gatos 1-1: Sediment Transport

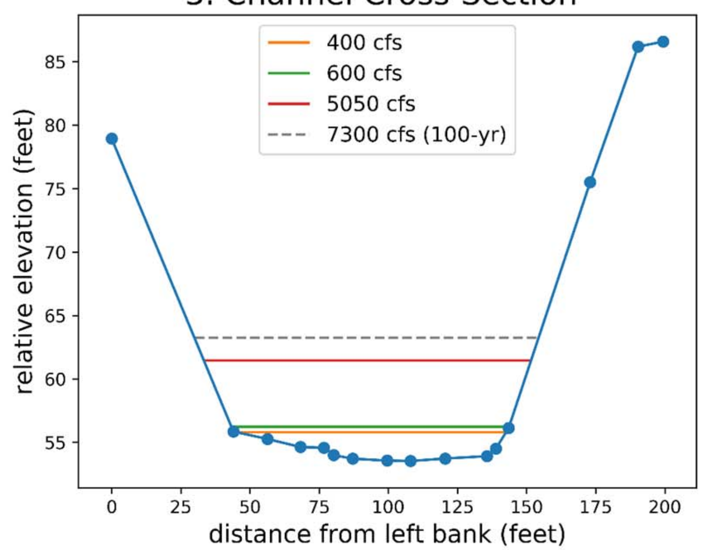
1. Flow-Duration Curve[1]



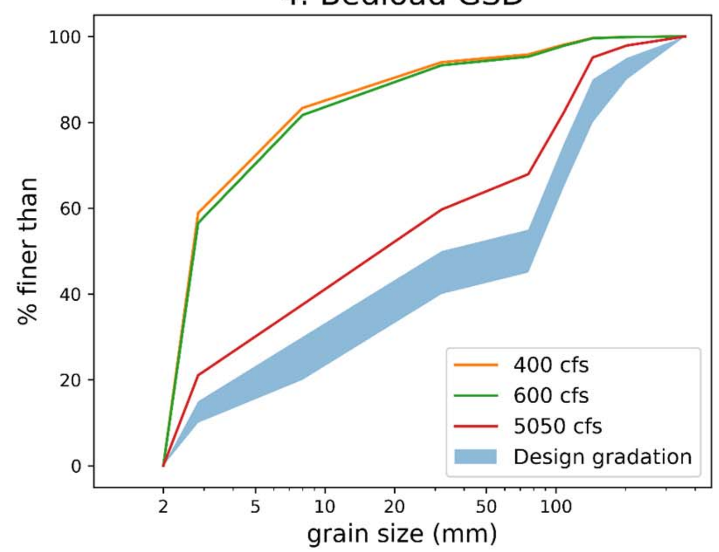
2. Modeled Historical Bedload Capacity[1]



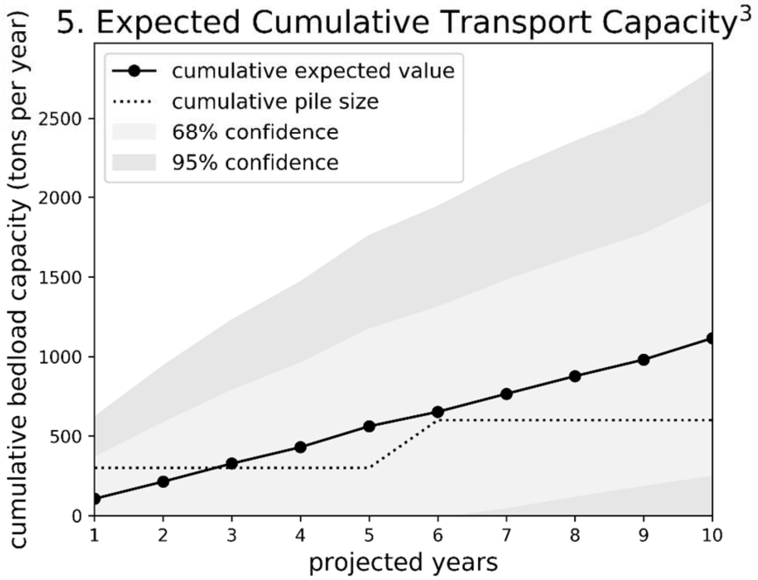
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	10
2011 – wet	99
2012 – dry	1
2013 – dry	5
2014 – dry	2
2015 – average	13
2016 - average	4
2017 - wet	1321

[1]Flow record from 1956 – 2017
[2]Flow record from 1965 – 2017
[3]Sampled from 1990-2017 flow record
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	20 – 25%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	20 - 25%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	30 – 35%
Boulders *(> 265 mm, >10 in)*	5-10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data

Flow record used is the Lincoln Avenue gage which is located approximately 4 miles downstream. Approximate watershed size downstream of the Camden drop structure is 46 square miles. The watershed size at the Lincoln Ave gage is approximately 50 square miles. Therefore, the flow record was reduced by 8%. Flow values presented below are scaled. Further refinement may be necessary as the design progresses.

Effective Discharge

The largest proportion of bedload is transported at approximately 400 cfs; 100-year flow at Highway 17 is 7,300 cfs. The maximum historical peak flow prior to WY2017 is approximately 5,050 cfs. Preliminary peak discharge during WY2017 was 6,000 cfs. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (600 cfs), and the pre-WY2017 peak historical flow. Historical aerial photos and persistent aquatic vegetation suggest a beaver dam 2500 ft. downstream of the Camden Drop Structure has persisted, in various states of repair, since the 1980s. We anticipate that the beaver dam reduces sediment transport at low to moderate flows.

Gravel Gradation and Injection Plan

Because this site is the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. Reach scores downstream of LGC1-1 suggest low flood risk, but limited access makes injection downstream difficult. While there is adequate space for a large injection pile, introduction of new sediments at regular intervals will give allow longer-term benefits for sediment supply downstream. Channel forming flows (400, 600 cfs) tend to transport finer sediments (plot 4) than proposed gradation, promoting early mobility of spawning and rearing gravels.

Steady State/Episodic Cycles

While 2017 had the largest flow peaks at the Lincoln Ave gage, the presence of the reservoirs and percolation ponds upstream tends to attenuate flow fluctuations. Sediment trapping by the reservoirs also significantly impacts the pulses of sediment associated with episodic events. As a result, steady state process (hydrologic and geomorphic) assumptions are appropriate. Furthermore, sediment transport capacity is assumed to be a good approximation of on-the-ground transport because there is very limited transport from upstream.

Lifetime Expectancy

This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. To maintain consistent sediment supply, the expected injection amount is 300 tons every 5 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Los Gatos 1-1, Project 1: Gravel

Santa Clara Valley Water District

Description

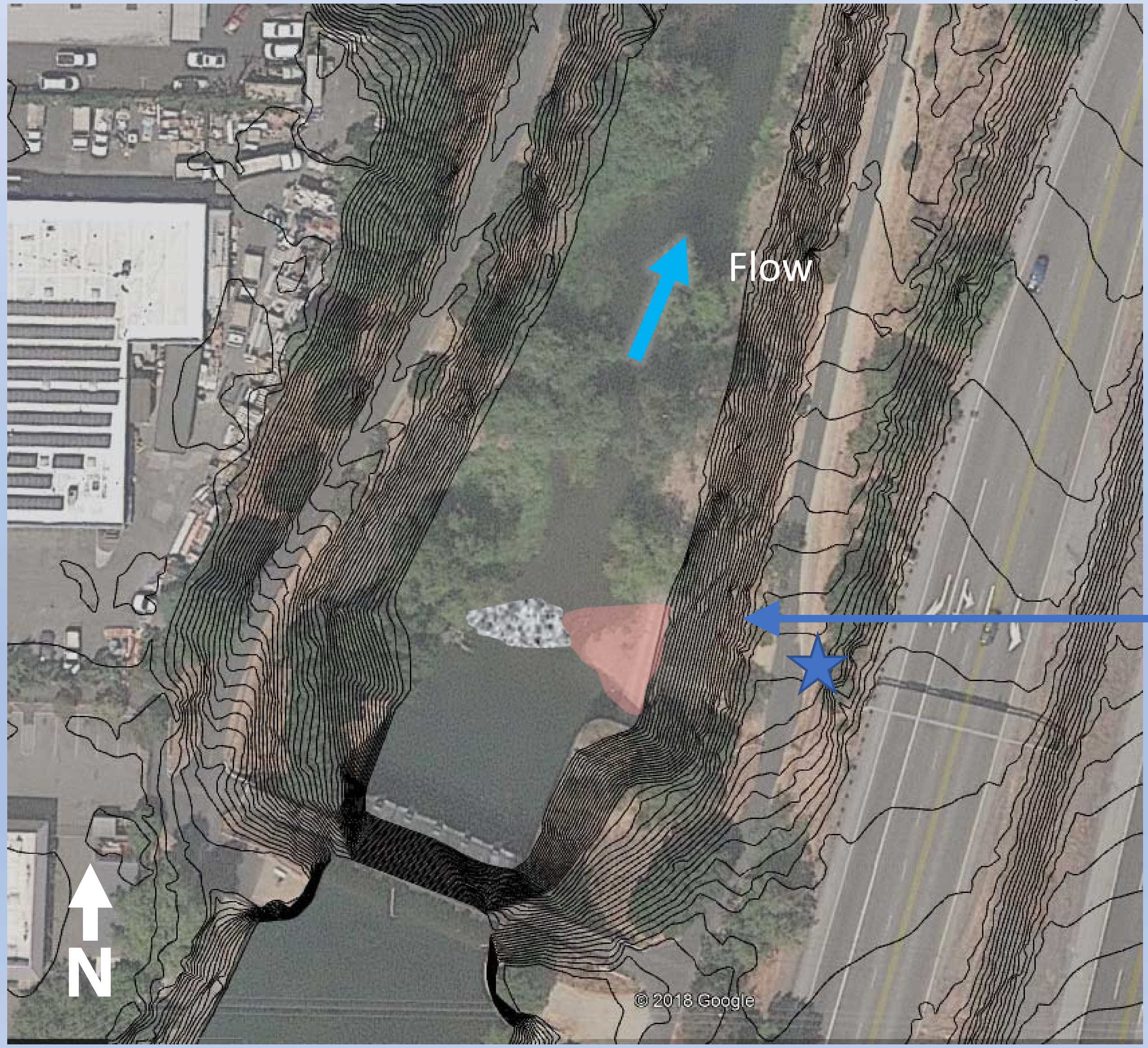
At the limit of anadromy, introduction of spawning size gravels are likely to have benefits for downstream reaches. This project recommends introducing spawning-sized gravels from top of bank (indicated by the blue star) to supplement an existing gravel bar with the goal of repeat injection for transport downstream. The injection pile will be adjacent to an existing cobble and gravel riffle with high embeddedness. The injection pile has the added benefit of supplying the existing riffle with additional spawning gravel sizes, which may reduce embeddedness. The pile will also serve as a source of sediment in high-flow events. Additional coarse sediments may help to reduce the amount of channel-spanning riparian vegetation and increasing access to the upstream reach. Access may be more favorable on the left bank, though existing morphology is more conducive to placement on the right bank.

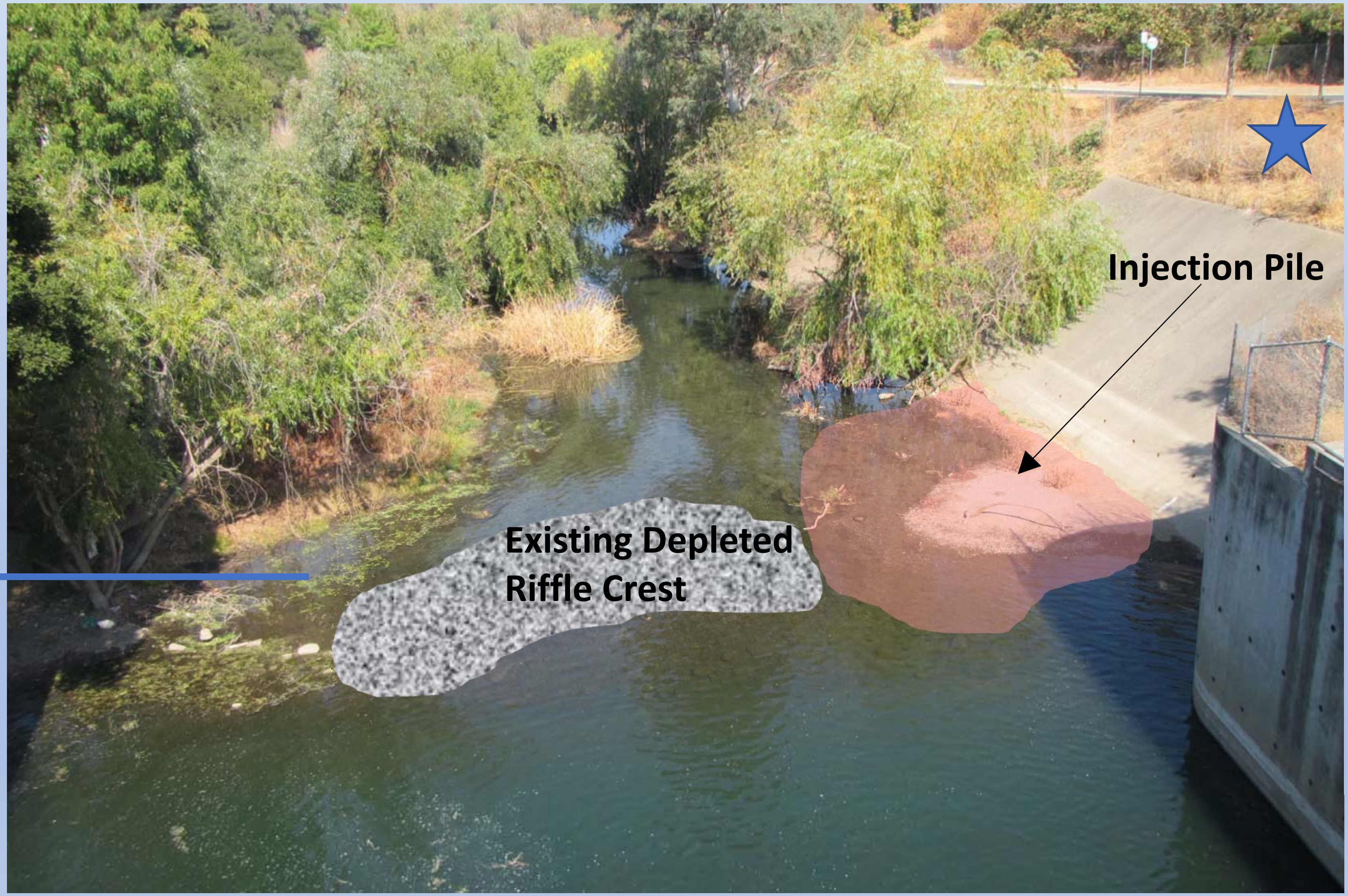
Stability Recommendations

Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events, existing gravel bar implies flow patterns that preferentially deposit gravels here, which may retain sediment supply at injection site over a longer period. LWD augmentation downstream at the ramp will help retain gravels in the upstream reach.

Long pool adjacent to ramp, looking upstream, October 2017.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.





Los Gatos Creek, looking downstream from the pedestrian bridge at Camden drop structure, October 2017.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

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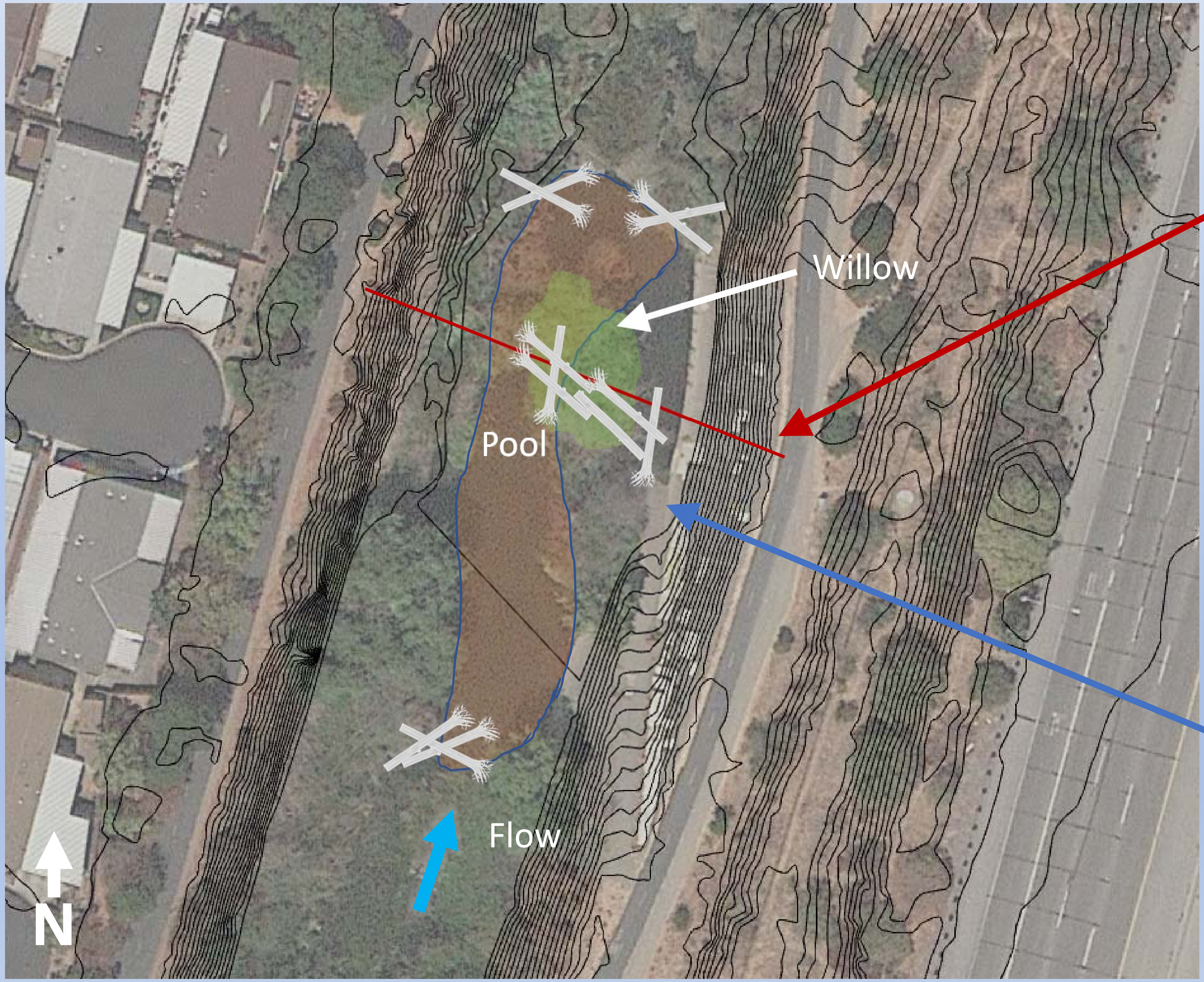
Los Gatos 1-1, Project 2: Wood

Description
The intended function of wood at this site is two-fold. First, wood placed at the positions pictured below may help trap sediments on the right bank downstream of the ramp, potentially providing high-flow refuge. Second, the wood pieces as positioned will likely develop scour downstream carving a deep pool and providing channel complexity. Concept is designed to maximize positive habitat impacts while minimizing construction impacts to aquatic vegetation.

Stability Recommendations
An existing willow tree with several major trunks could serve as the primary anchor for wood placement upstream. The downstream wood could be installed in the earthen banks downstream of the concrete slope. Because of the fine, and easily mobile bed sediments, a ballasted rock may be required and will be sized once log sizes are known.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



View from right bank at bottom of ramp, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Los Gatos 1-1

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increased spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Decreased embeddedness in riffles	Sediment tracers or sediment deposition surveys downstream
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Habitat surveys – cover, embeddedness,
	Reduce velocity, slowing sediment transport	Sediment accumulation upstream of wood	Channel morphology surveys

Potential Flood Risks

The FEMA SFHA 100-year floodplain is contained in the channel banks from the site to the confluence with Guadalupe River, and from the confluence downstream to the San Francisco Bay and so flood risks are lower than other reaches. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints

- Staging areas may be somewhat limited and will need to be used efficiently.
- Removal of channel-spanning riparian vegetation may temporarily release a pulse of fine sediment downstream and may need to be mitigated for.

Anticipated Geomorphic and Engineering Next Steps

- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and CLOMR, if necessary
- Vegetation removal plan
- Sediment procurement
- Potential coordination with Caltrans for access or other roadway/freeway issues
- Mercury testing of existing sediments, which is likely to be mobilized.

Access and Staging

Access for gravel pile can be introduced from top of bank from the Los Gatos Creek trail. Access to wood placement at the downstream site is via a concrete ramp into the channel. Some staging areas are available near the pedestrian bridge downstream of the Camden drop structure.

Beaver activity on Los Gatos Creek.

Beavers

Historical aerial photos and persistent aquatic vegetation suggest a beaver dam 2500 ft. downstream of the Camden Drop Structure has persisted, in various states of repair, since the 1980s. We anticipate that the beaver dam reduces sediment transport at low to moderate flows.

Recommendations

We recommend not disturbing the beaver dam. Sediment and wood placed above the beaver dam may take longer than expected to wash downstream, however, during large flows, which are likely to, wash away the beaver dam, augmented gravels would likely transport as predicted.

If short term mitigation is required, moving gravel augmentation and LWD augmentation downstream of the beaver dam as part of refining this concept may be the most suitable option. Access and staging considerations are not expected to change significantly.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Los Gatos 2-2

Location
Los Gatos Creek downstream of Highway 17 bridge and upstream from the Creekside Way Bridge.

Existing Conditions
- Three cobble riffles interspersed with cobble pools; Baseflow channel incised below remnant terraces; Some existing in-stream cover; much of reach very straight. Chinook spawning activity under Highway 17 bridge has historically been observed. Existing gravels sourced from channel bars and banks upstream of site but downstream of Camden Drop Structure.
- CEM stage: IV. Implies bank erosion can be expected, where the creek is not hemmed in by erosion control, as is the case with boulder rip rap on the right bank, at the downstream end of the site.
- Downstream conditions suggest future vertical incision is limited, and thus headcuts and knickpoints migrating through the site are not likely, or may be of limited magnitude.

Problem
While some riparian vegetation offers cover for steelhead, the reach is lacking in fast-water feeding habitat and spawning gravels can be improved. There is existing LWD, but the perennially wetted riparian corridor is a relatively new development (since the 1980s) and mature trees are not loading at rate anticipated in the future as the riparian corridor matures.

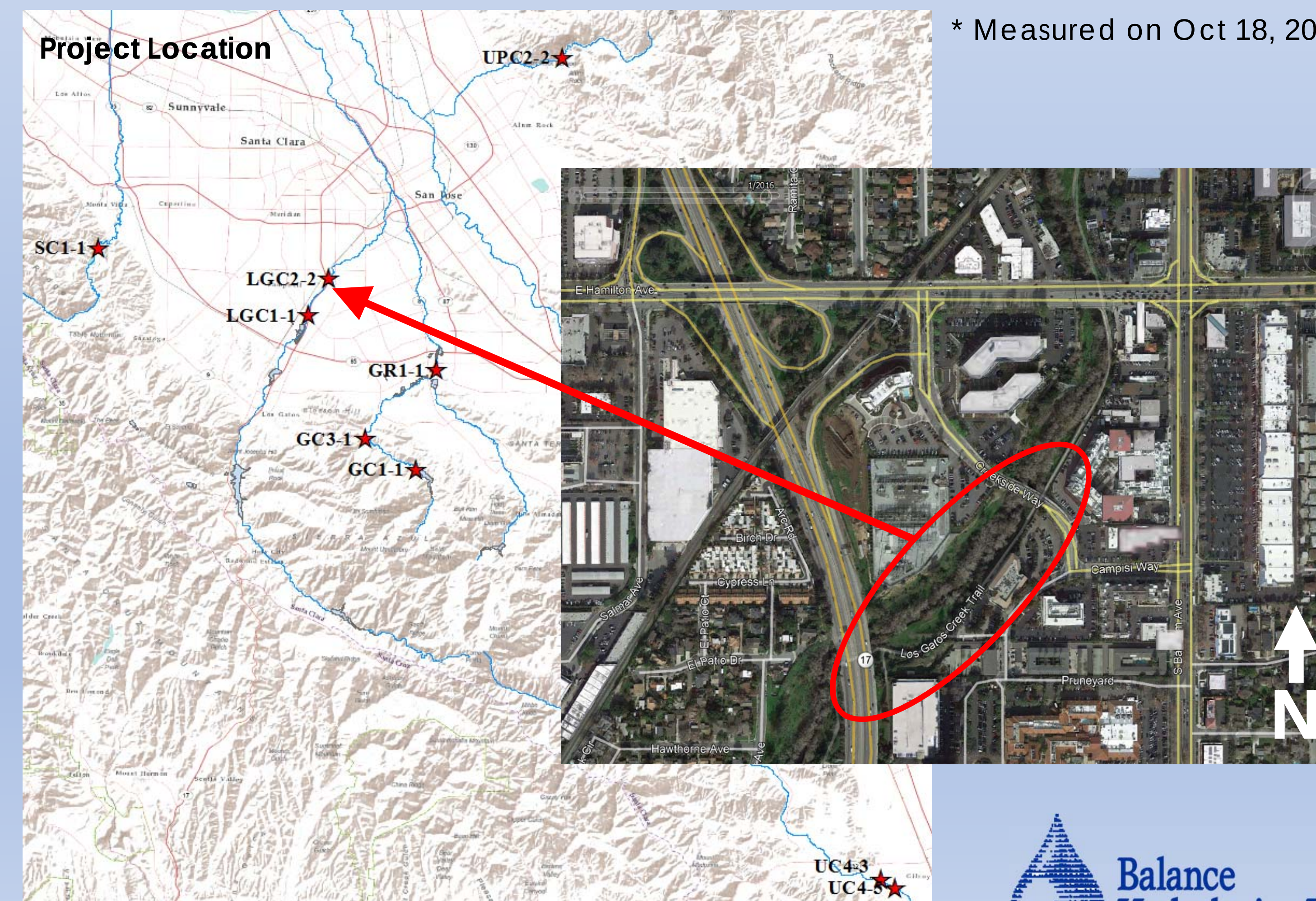
Project Approach
Two "projects" are proposed at this site:
1. Two gravel injection piles are proposed to be introduced from the top of bank. Gradation is selected with appropriate spawning sizes in mind, and downstream transport is anticipated. Recommend considering as ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated. In addition, two riffle supplementations are proposed. Coarse material are recommended to reduce gravel mobility.
2. Wood placement at three locations is intended to supplement existing LWD present in the reach, encourage channel complexity.

Los Gatos Creek, looking upstream, October 2017

Santa Clara Valley Water District

Los Gatos 2-2 Site Parameters	
Upstream (impounded) watershed area	*49 mi^2 (42 mi^2)*
Channel roughness	*0.055*
Channel slope	*0.41%*
*Field temperature**	*18.3°C*
*Turbidity**	*1.3 ntu*
*Embeddedness**	*20%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*10/10/15/25/5 (%)*

* Measured on Oct 18, 2017



Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase sediment supply downstream	Several dams upstream on Los Gatos Creek, flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site, maximize positive impacts with additional riffle supplementation

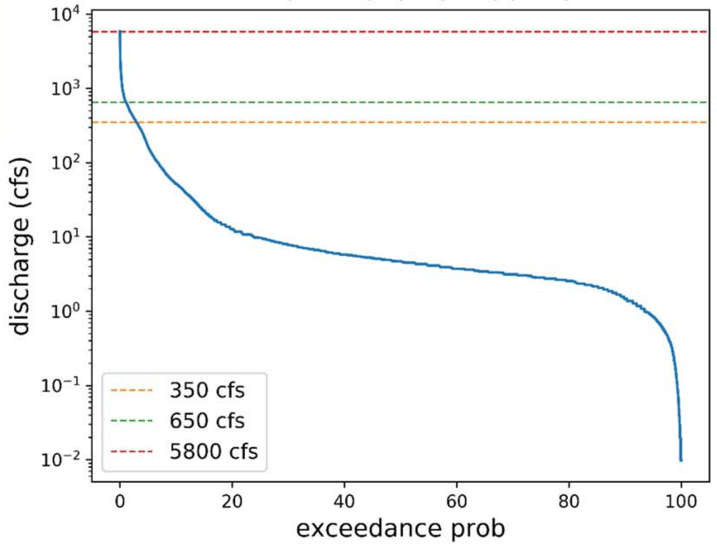
NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

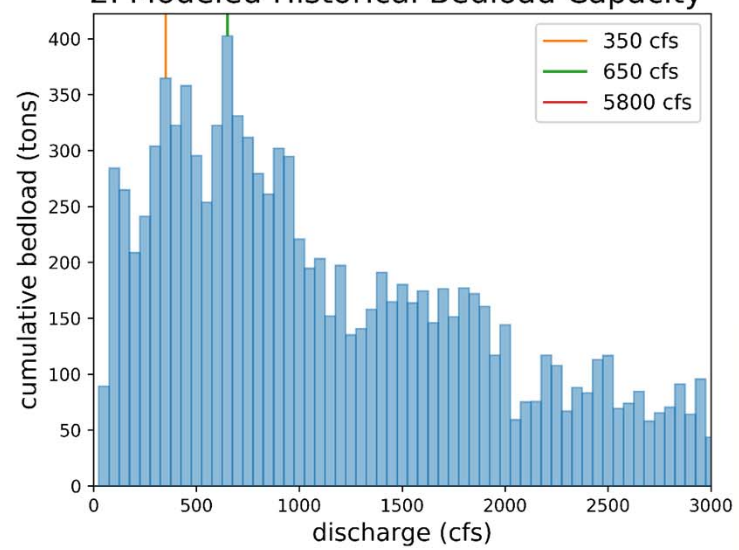
Balance Hydrologics, Inc.

Los Gatos 2-2: Sediment Transport

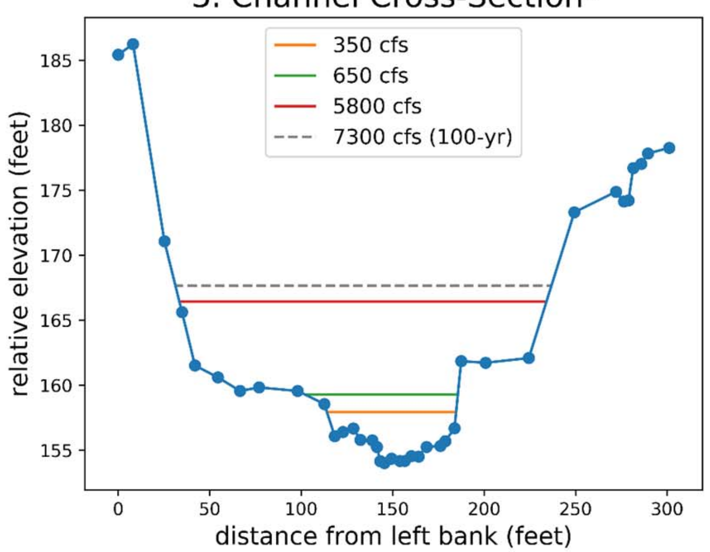
1. Flow-Duration Curve[1]



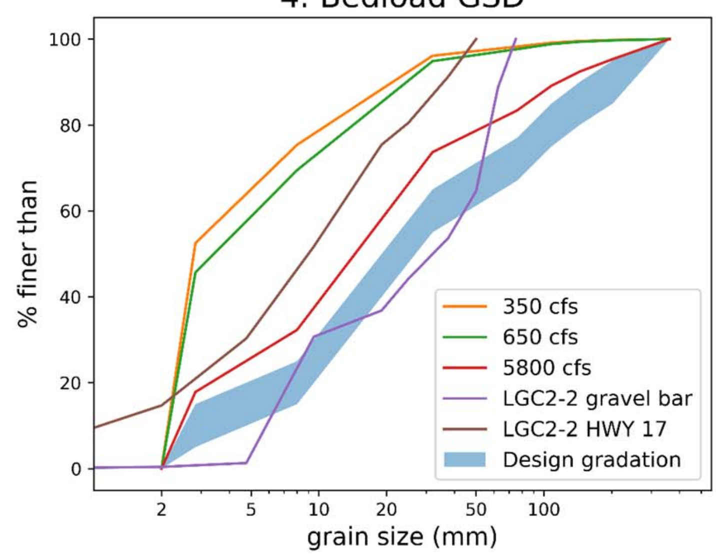
2. Modeled Historical Bedload Capacity[1]



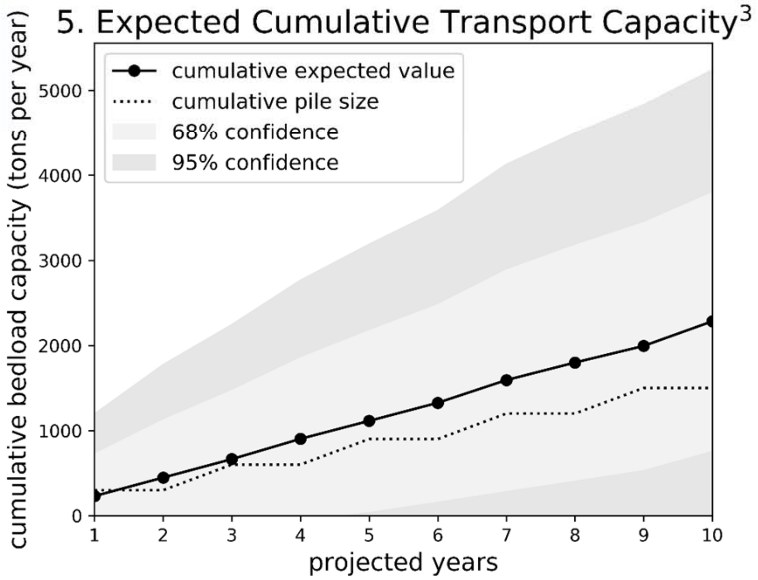
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	32
2011 – wet	260
2012 – dry	2
2013 – dry	9
2014 – dry	4
2015 – average	35
2016 - average	10
2017 - wet	2637

[1]Flow record from 1956 – 2017
[2]See discussion of flood risk on page 5
[3]Sampled only from years at least 95% complete
2017 data is preliminary

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	20 – 25%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	35 – 40%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	25 – 30%
Boulders *(> 265 mm, >10 in)*	5 – 10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data

Flow record used is the Lincoln Avenue gage which is located approximately 2.7 miles downstream. Approximate watershed size upstream of LGC2-2 is 49 square miles. The watershed size at the Lincoln Ave gage is approximately 50 square miles. Therefore, the flow values presented here are reduced by 2%. Further refinement may be necessary as the design progresses.

Effective Discharge

The largest proportion of bedload is transported at approximately 650 cfs; 100-year flow at Highway 17 is 7,300 cfs. The maximum historical peak flow is approximately 5,800 cfs which was in WY2017, for which the data is still preliminary. The next-largest peak flow was 4830 cfs in March 1995. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (350 cfs), and the peak flow of WY2017. Grab samples from an existing gravel bar and riffles under Highway 17 are included in plot 4.

Gravel Gradation and Injection Plan

This site is only 1.5 miles downstream from LGC1-1, which is the limit of anadromy, and sediment introduced here will have the added benefit for downstream reaches and so gradation was selected to transport downstream. While there is adequate space for a large injection pile, introduction of new sediments at regular intervals will give longer-term benefits for sediment supply downstream. Channel forming flows (350, 650 cfs) tend to transport finer sediments (plot 4) than proposed gradation, promoting early mobility of spawning and rearing gravels.

Steady State/Episodic Cycles

While preliminary 2017 data had the largest flow peaks at the Lincoln Ave gage, the presence of the reservoirs and percolation ponds upstream tends to attenuate flow fluctuations. Sediment trapping by the reservoirs also significantly impacts the pulses of sediment associated with episodic events. As a result, steady state process (hydrologic and geomorphic) assumptions are appropriate. Furthermore, sediment transport capacity is assumed to be a good approximation of actual transport because there is very limited sediment being transported from upstream.

Lifetime Expectancy

This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. To maintain consistent sediment supply, the predicted total injection amount is 300 tons every 2 years (plot 5). Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

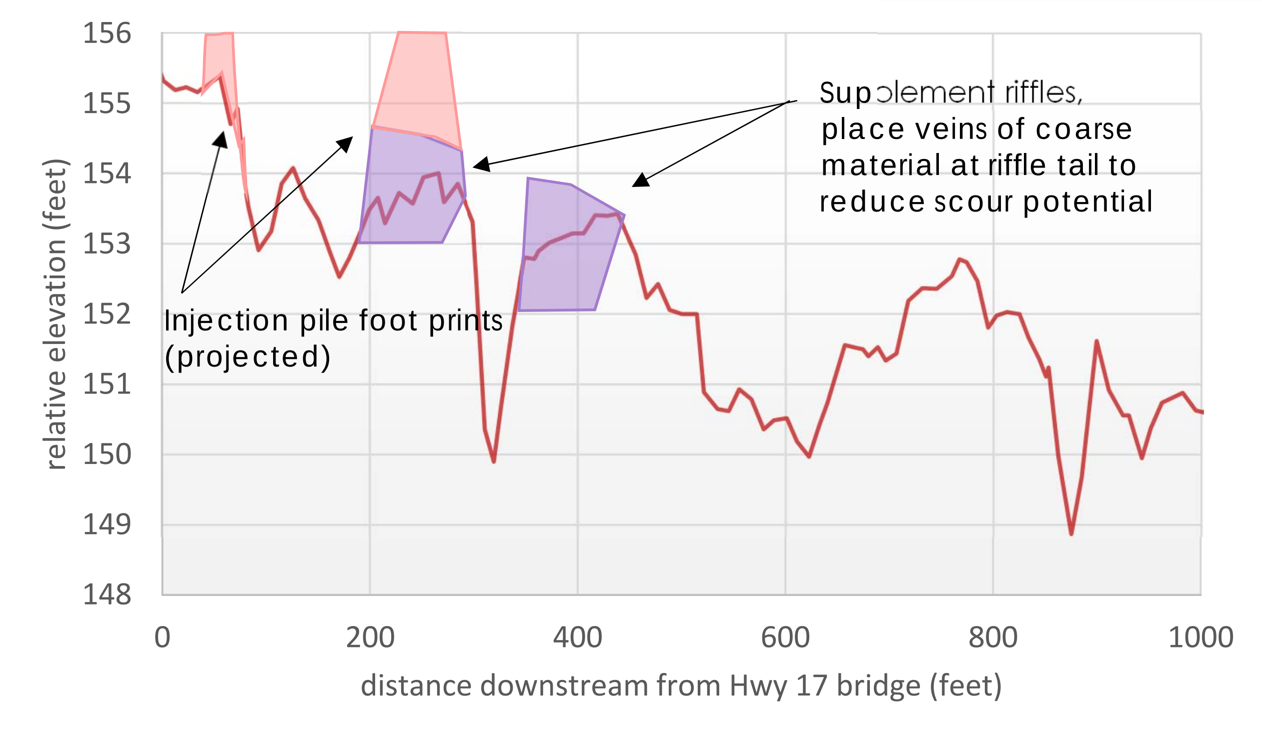
NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

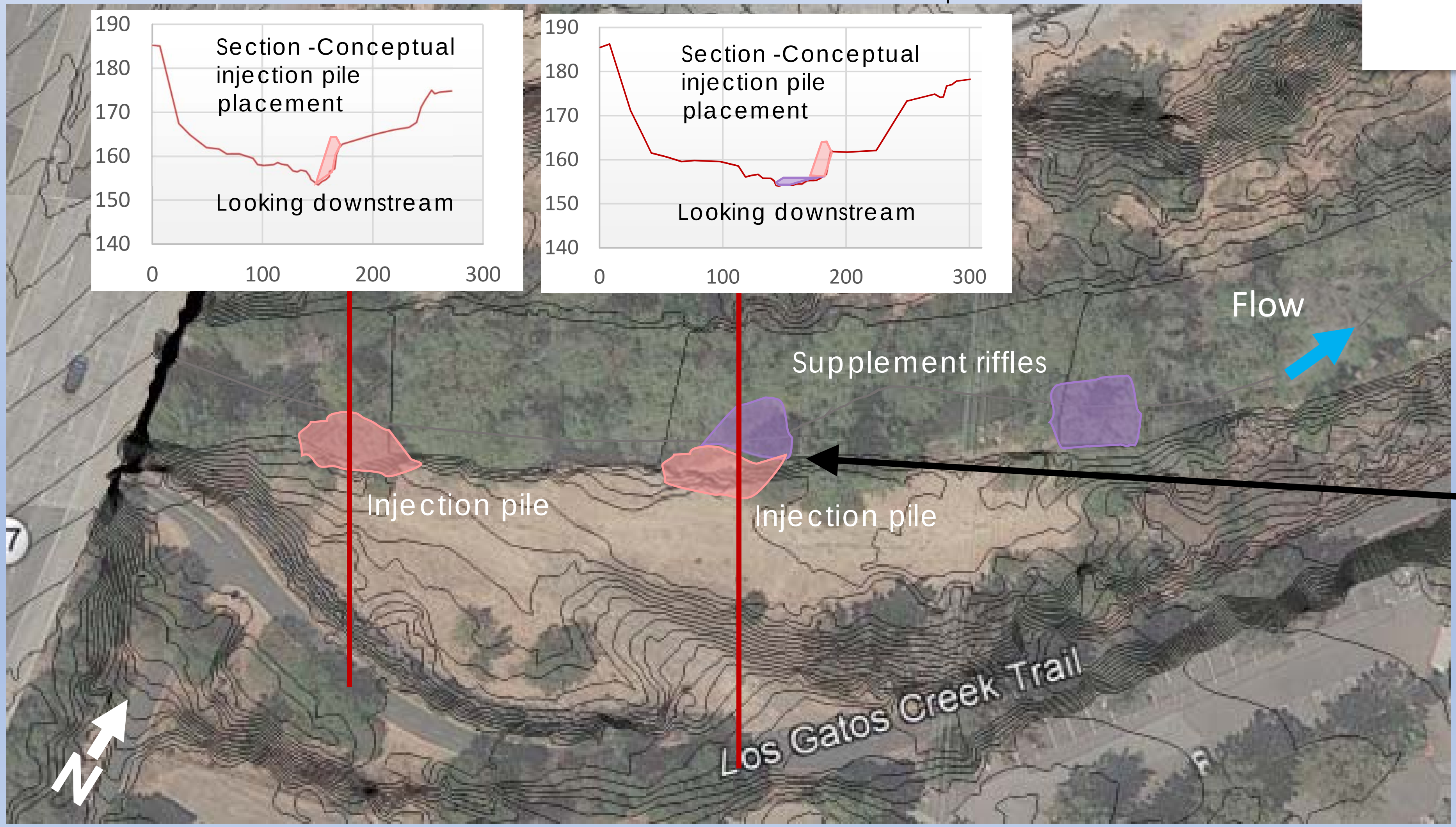
Los Gatos 2-2, Project 1: Gravel

Description
This project recommends introducing spawning-sized gravels from top of bank (indicated in pink), combined with excavation and placement of gravels at a series of two gravel bars. Two injection piles are proposed to increase the amount of gravel available for transport while minimizing obstruction during flood events. Injection piles are anticipated to be subject to repeat injection for transport downstream. The injection piles will be adjacent to an existing cobble and gravel riffles with high embeddedness, and low mobility. Additional coarse sediments at supplemented riffles is planned (indicated in purple), and is anticipated to hold augmented materials in place.

Stability Recommendations
Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events, existing gravel bars implies flow patterns that preferentially deposit gravels in these locations, which may retain sediment supply at injection site over a longer period. LWD augmentation downstream will help retain gravels in the upstream reach. Riffle supplementation will include veins of coarser material to help retain gravels.



Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Los Gatos 2-2, Project 2: Wood

Description
LWD placed at the positions pictured below will disrupt flow lines and create pockets of deposition and scour.

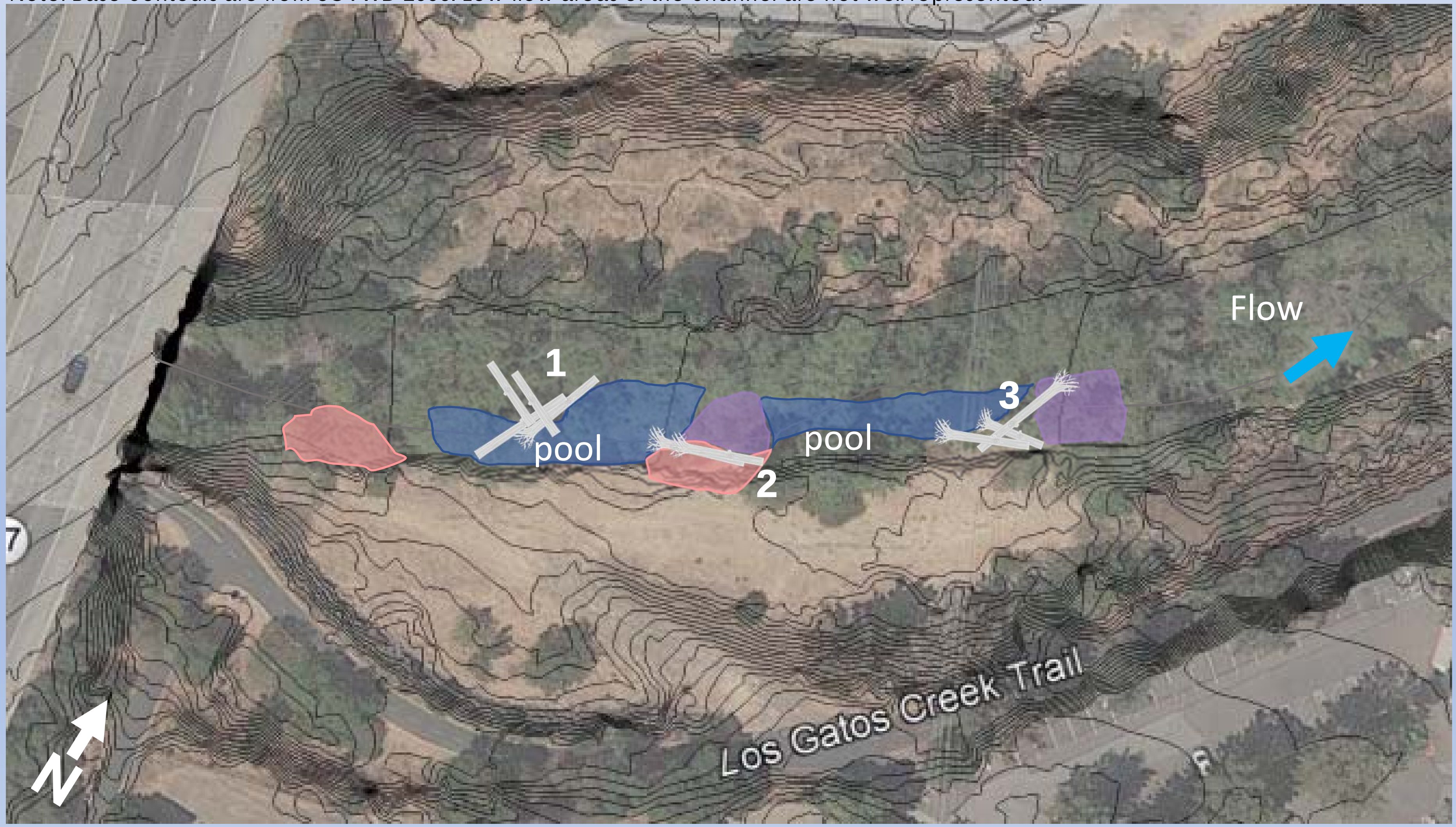
Engineered log jam (ELJ) #1 is intended to help maintain the existing pool, and force flows to erode the right back, adding in-stream sinuosity.

ELJ #2 takes advantage of a copse of riparian alders that will be used to stabilize rootwads. This ELJ is intended to maintain the pool tail at a pool-riffle transition. We anticipate the ELJ #2 will encourage desirable erosion of the right bank, which may increase available cover, and help sustain a riffle at this location by reducing overall shear.

Similar to ELJ #2. ELJ #3 takes advantage of a copse of riparian alders that will be used to stabilize rootwads. This ELJ is intended to maintain the pool tail at a pool-riffle transition.

Stability Recommendations
Existing riparian trees with major trunks could serve as the primary anchor for wood placement. Burial and ballasting with large boulders may be required and will be sized once log sizes are known using a log stability and root/soil shear strength capacity once logs have been selected or a desired specification.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Looking downstream, October 2017.

Looking upstream, October 2017.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Los Gatos 2-2

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increase spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Reported chinook spawning riffle under Highway 17. Project is designed to minimize the risk of impacting this resource.

Potential Flood Risks

The FEMA SFHA 100-year floodplain appears to be contained in the channel banks from the site to the confluence with Guadalupe River, though current FEMA mapping indicate there is not an effective detailed study. Our modeling, though not designed to be a comprehensive tool for evaluate flood risk, corroborates this finding (See Panel 3, page 2) and suggests ample freeboard. More detailed flood risk analysis using HEC-RAS will be required to confirm our initial findings. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints

- Existing moderate- to high-quality gravel bar under Highway 17. Project should minimize impacts to that resource. Monitoring for negative impacts may be required.

Anticipated Geomorphic and Engineering Next Steps

- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development, coordination with regulatory agencies
- Detailed flood analysis and CLOMR, if necessary
- Sediment and LWD procurement

Access and Staging

Staging is excellent on the right bank via existing ramp. Minimal vegetation impacts are anticipated. Access through office park parking lot needs to be arranged.

Riparian "fence" upstream of proposed projects. Persistent flows support dense riparian.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Stevens Creek 1-1

Santa Clara Valley Water District

Location
In Stevens Creek County Park, just upstream, and adjacent to Bay Tree Picnic area.

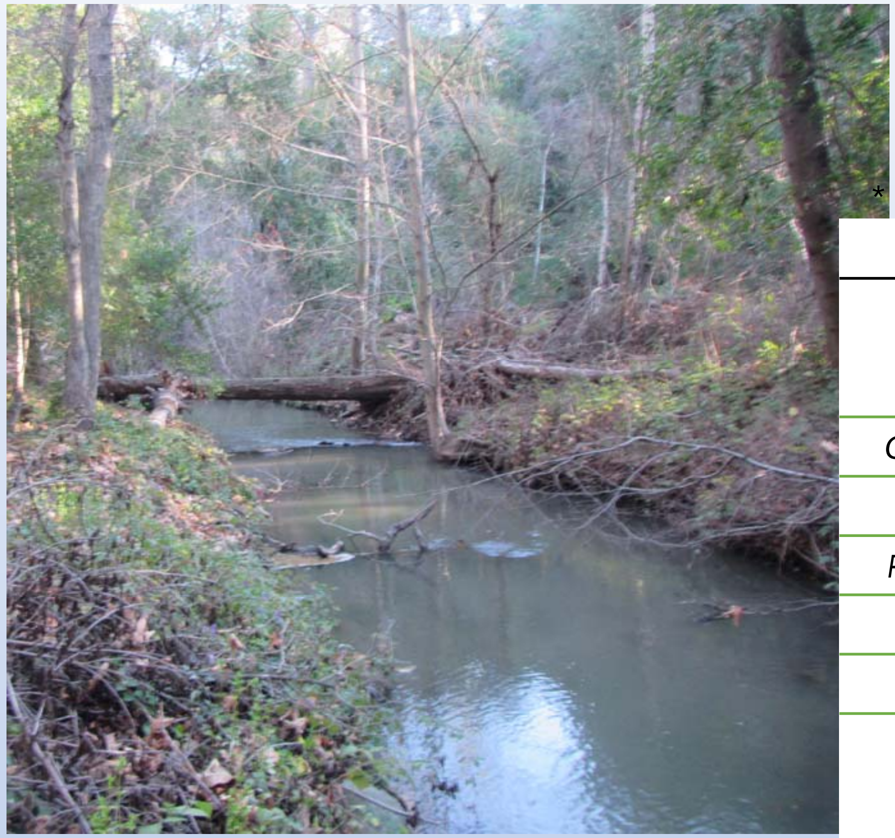
Existing Conditions
- The Stevens Creek Reservoir effectively traps all coarse sediment supplied from the upper watershed. As a result, Stevens Creek has incised. The channel bed is largely cobble with fine silt and sand interspersed.
- Exposed mature tree roots on the high-flow floodplain make up much of the channel banks.
- Cobble and boulder riffles already present around channel-narrowing tree roots appear to be well armored .
- Two sets of terraces are present at the site, one approx. 3-8 feet above the thalweg and another approximately 5-10 feet above the thalweg. A low, narrow, inset floodplain is present about 1-3 feet higher than channel thalweg, some exposed bedrock.
- Project site is just downstream of the limit of anadromy.
- Reach is run-riffle-pool sequence with shallow pools and consistent and relatively flat slope.
- CEM stage 3, low-flow channel incision has occurred, mature trees and bedrock has slowed expansion of a lower floodplain.

Problem
Reach just downstream of Stevens Creek Reservoir is gravel deprived. Riffles are present but armored. Incision has reduced floodplain connection, and high-flow refuge is minimal. Long midchannel pools are present.

Project Approach
Two projects are proposed at this site:
1. A gravel injection pile on the right bank will supplement spawning and rearing gravels and ameliorate channel armoring. Riffle supplementation is also recommended to improve conditions in the short-term. Recommend considering as ongoing gravel augmentation site, after initial injection and monitoring completed and evaluated.
2. Wood placement will be focused on enhancing floodplain connectivity and introducing high-flow cover.

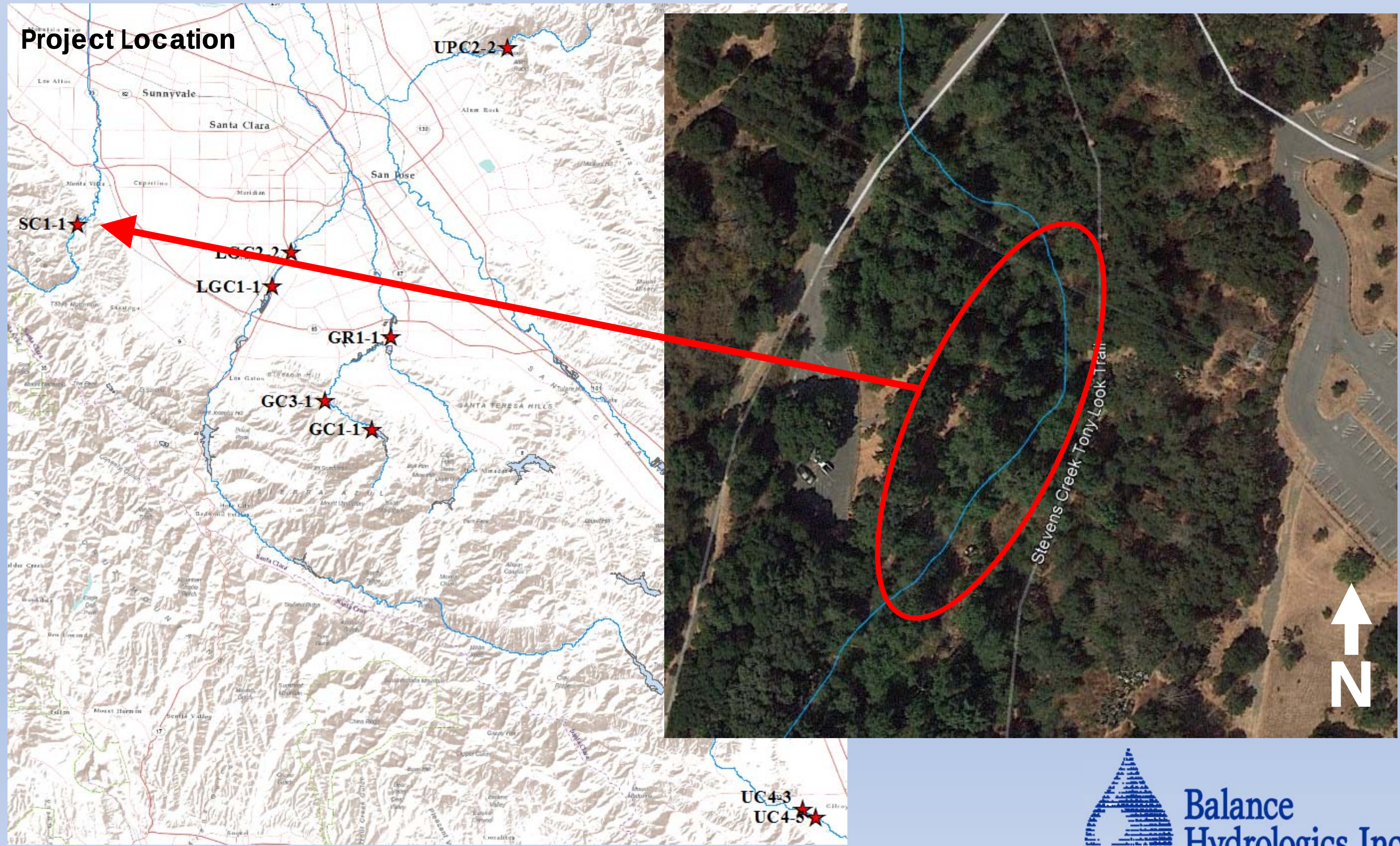
Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning and rearing habitat; increase high-flow floodplain habitat	Stevens Creek Reservoir, flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site

Looking downstream, October 2017.



* Measured on Oct 17, 2017

Stevens Creek 1-1 Site Parameters	
Upstream (impounded) watershed area	*18 mi² (17 mi²)*
Channel roughness	*0.05*
Channel slope	*0.32%*
*Field temperature**	*16.2°C*
*Turbidity**	*42.6 ntu*
*Embeddedness**	*30%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*15/10/15/35/25 (%)*



NOT FOR CONSTRUCTION

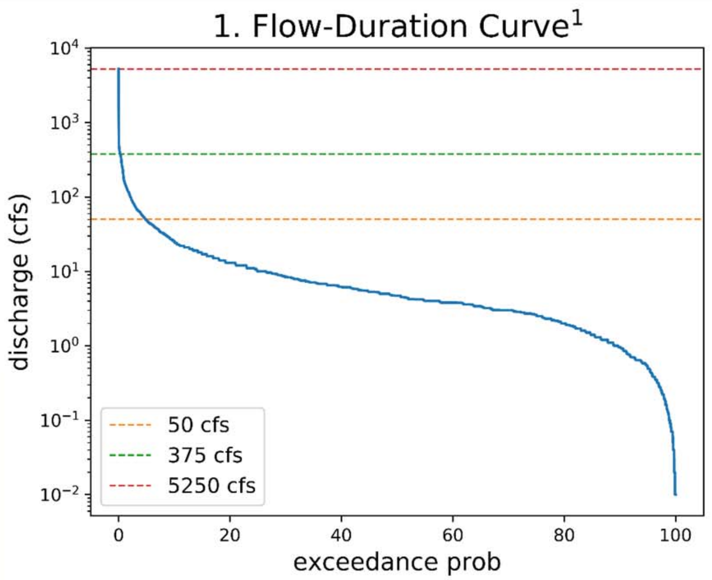
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

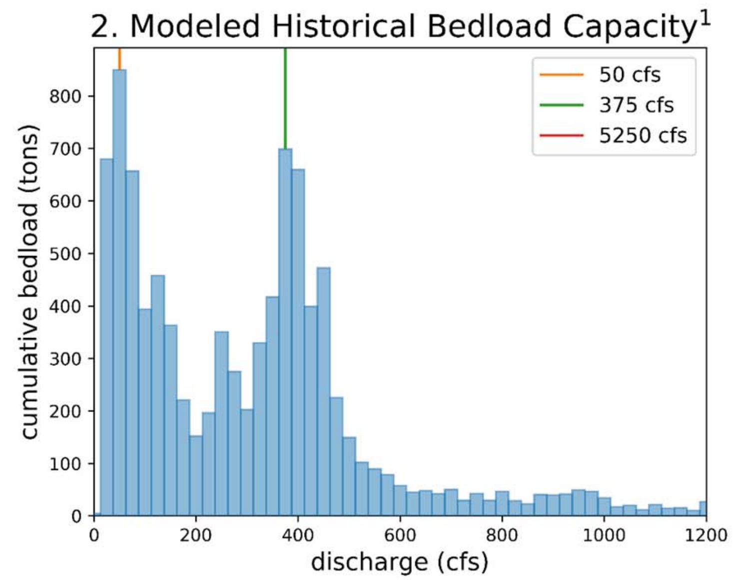
Balance Hydrologics, Inc.

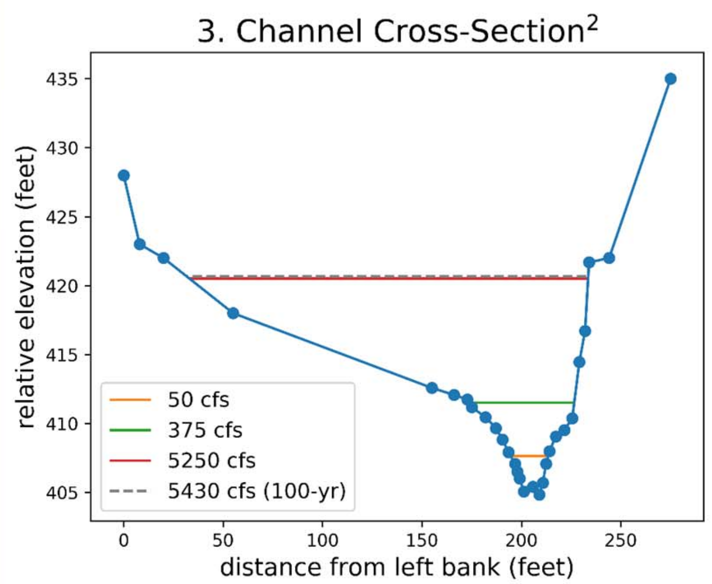
Stevens Creek 1-1: Sediment Transport

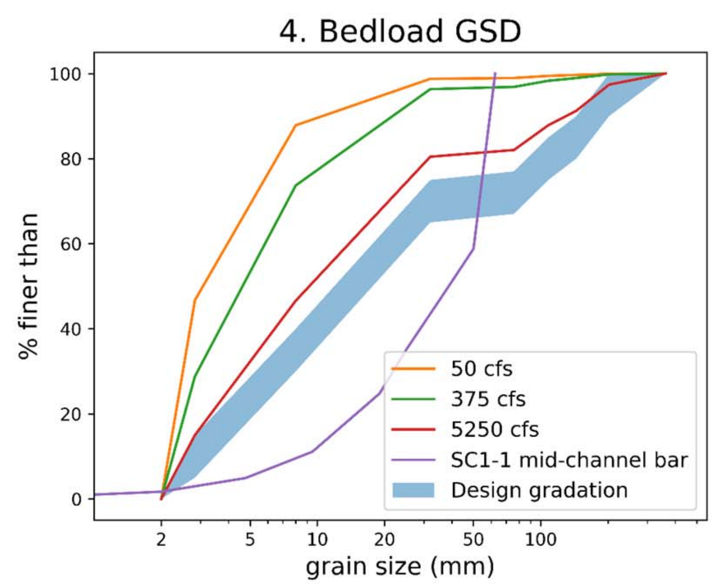
Santa Clara Valley Water District

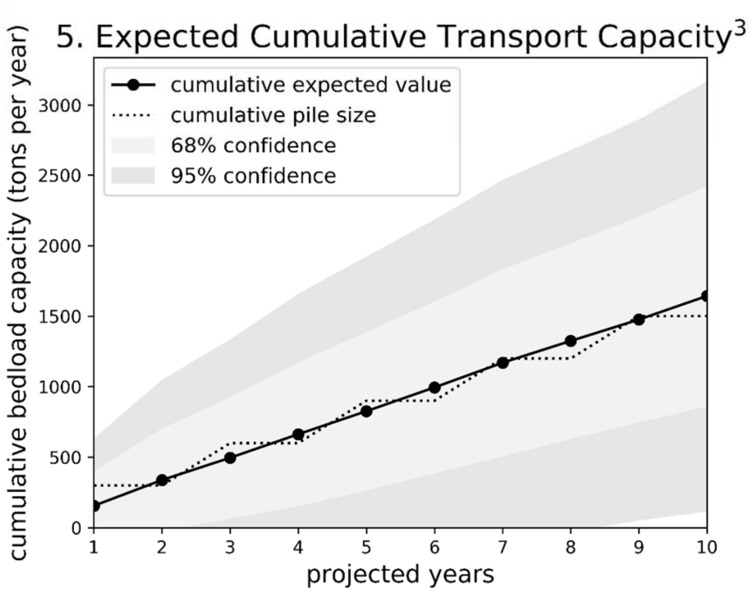
Balance Hydrologics, Inc.











6. Bedload Capacity	
Water Year	(tons/year)
2010 - wet	50
2011 – wet	186
2012 – dry	0
2013 – dry	17
2014 – dry	0
2015 – average	1
2016 - average	82
2017 - wet	886

[1]Flow record from 1961 – 2017
[2]See discussion of flood risk on page 5
[3]Sampled only from years at least 95% complete
2017 data is preliminary

Recommended Gradation	
Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	30 - 35%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	35 - 40%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	25 – 30%
Boulders *(> 265 mm, >10 in)*	0 – 5%

Hydrologic Data
Flow record used is the gage on Stevens Creek below Stevens Creek Reservoir. The gage is located just downstream of the project site and so the flow record is not altered.

Effective Discharge
The largest proportion of bedload would be transported at approximately 50 cfs. Flows shown in plots 1-4 are effective discharge, the next-most effective discharge (375 cfs), the peak flow of record, and the 100-year flow. The 100-year flow is 5,430 cfs and the flow of record is 5,250 cfs and occurred in February 1986. Preliminary peak flow in 2017 was approximately 975 cfs.

Gravel Gradation and Injection Plan
Because this site is near the limit of anadromy, sediment introduced here will have the maximum benefit for downstream reaches and so gradation was selected to transport downstream. With a low channel slope, a finer gradation can be used compared with other design sites.
Just downstream of the reservoir, almost all coarse sediment is sourced from the banks and bed surface, which has incised a base flow channel 2-3 feet below the floodplain. Combined injection pile and riffle supplementation should have local and downstream benefits.

Steady State/Episodic Cycles
Stevens reservoir upstream of the project site tends to attenuate flow fluctuations. Sediment trapping by the reservoirs also significantly impacts the pulses of sediment associated with episodic events. As a result, steady state process (hydrologic and geomorphic) assumptions are appropriate. Furthermore, sediment transport capacity is assumed to be a good approximation of on-the-ground transport because there is very limited sediment supplies from upstream.

Lifetime Expectancy
This gradation was specifically selected to be transported downstream into reaches that are depleted of sediment, but where access is difficult. To maintain consistent sediment supply, the expected injection amount is 300 tons every 2 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

Stevens Creek 1-1, Project 1: Gravel

Santa Clara Valley Water District

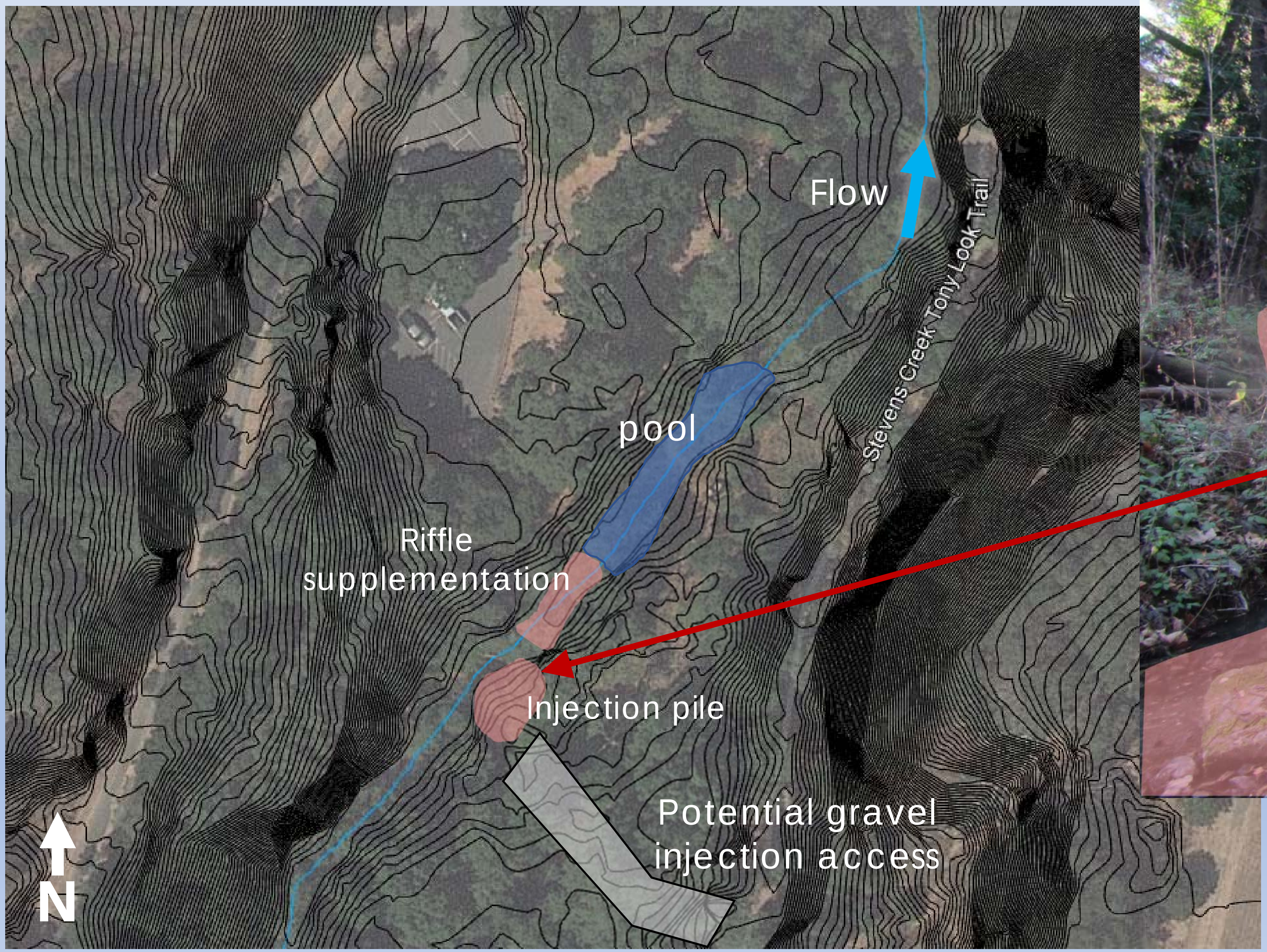
Description

Near the limit of anadromy, introduction of spawning size gravels are likely to have benefits for downstream reaches. We propose introducing spawning-sized gravels from the left bank(indicated by the pink shading) to build a high-flow injection pile. The injection pile position was selected to provide easy access to the channel via the trail on the right bank and with the goal of restoring the adjacent riffle. We also recommend draping the channel with approximately 6-12 inches of design gradation to provide short-term channel enhancement and to slow channel incision.

Stability Recommendations

Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events. The channel widens at the gravel pile injection location, promoting deposition and formation of the riffle, which may retain sediment supply over a longer period. LWD augmentation downstream will help retain gravels in the upstream reach.

Note: Contours are combined 2006 SCVWD with district survey data



Potential gravel injection site, looking upstream, February 2018

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

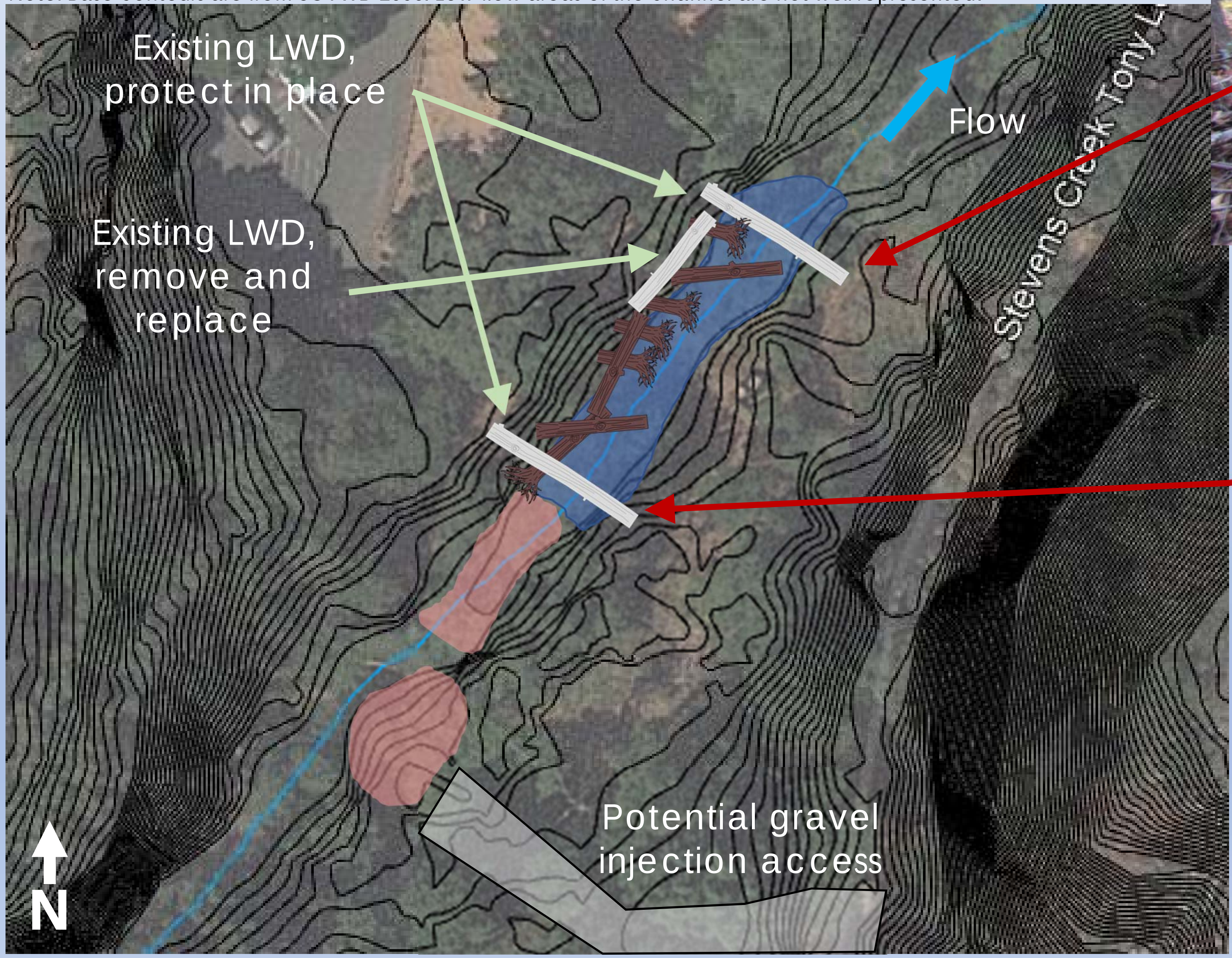
Balance Hydrologics, Inc.

Stevens Creek 1-1, Project 2: Wood

Description
Wood placed on the left bank will be designed around existing channel-spanning wood positioned 4-5 feet above the channel bottom. Root wads will be positioned to maintain pool depths, provide cover and introduce channel complexity. Placement of logs may promote erosion of the right bank, into a large and heavily vegetated floodplain.

Stability Recommendations
Existing trees, boulders, or bedrock on the floodplain could serve as the primary anchor for wood placement. Burial and ballasting with large boulders will likely be required and will be specified once log sizes are known using a log stability and root/soil shear strength capacity once logs have been selected or a desired specification.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Looking downstream, October 2017.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Stevens Creek 1-1

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increased spawning and rearing habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails, reduced embeddedness of cobbles and boulders	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 1: Gravel	Increase spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys

Potential Flood Risks
The FEMA SFHA 100-year floodplain floods the Bay Tree Picnic Area but it appears that no vital infrastructure are threatened. Thus tolerance of potential flooding and design approach should be closely coordinated with SCCP. The gravel injection site has been selected in a location where direct flooding effects of the injection pile should be minimized. The site is not in a regulatory floodway. In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints
- SCCP property, potential to increase frequency and duration of flooding of Bay Tree Picnic Area during high flows

Anticipated Geomorphic and Engineering Next Steps
- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and CLOMR, if necessary
- Sediment procurement
- Wood procurement
- Mercury testing of existing sediments, which are likely to be mobilized.

Access and Staging
Access and staging both would need to be arranged with SCCP. Both access and staging appear to be excellent.

Looking downstream, February, 2018.

Potentially salvageable wood on-site. February, 2018.

Balance Hydrologics, Inc.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Uvas Creek 4-3

Location
Downstream of Santa Teresa Boulevard, upstream of Eliot School.

Existing Conditions
- In reach UC4-3, riffles appear to be self-formed, with appropriate riffle spacing (approximately 6 bankfull widths apart). Riffles gradation is good size for spawning habitat, but an abundance of fines has smothered much of the gravel patches.
- Reach is narrow run-riffle-pool sequence overgrown with aquatic vegetation. Channel bed gradation ranges from sandy gravel in riffles to sand and silt in pools. Some smothering of riffle gravels.
- Left bank is approximately 300-foot wide gravel and sand high-flow braided floodplain. Floodplain is highly vegetated. Base flow channel incised 4-5 feet, but some potential for channel avulsion inside floodplain.
- CEM stage 4, low-flow channel incision has occurred, dense riparian and regulated base flows have slowed expansion into floodplain. Prior to upstream dams cutting off sediment and supplying water the channel year-round, this reach was a broad braided corridor. It is likely that large flow events will reset the channel geometry, as was the case in 1995 (Kondolf and others, 2001).
- The proposed site is located adjacent to logs and boulders placed during the failed restoration project constructed in 1995.
- Regulatory floodway

Problem
While riffles are present at the geomorphically appropriate intervals, smothering suggests an over-abundance of fines relative to gravel supplies. Young riparian limits LWD contributions to channel.

Project Approach
Two projects are proposed at this site:
1. A gravel injection pile on the right bank will supplement spawning gravels and ameliorate channel incision. Riffle supplementation will enhance existing riffle for short-term benefits. Injected gravels will have added benefits at UC4-5 which has a single, 2000-foot long mid-channel pool.
2. Wood placement will be focused on enhancing floodplain connectivity and introducing high-flow cover.

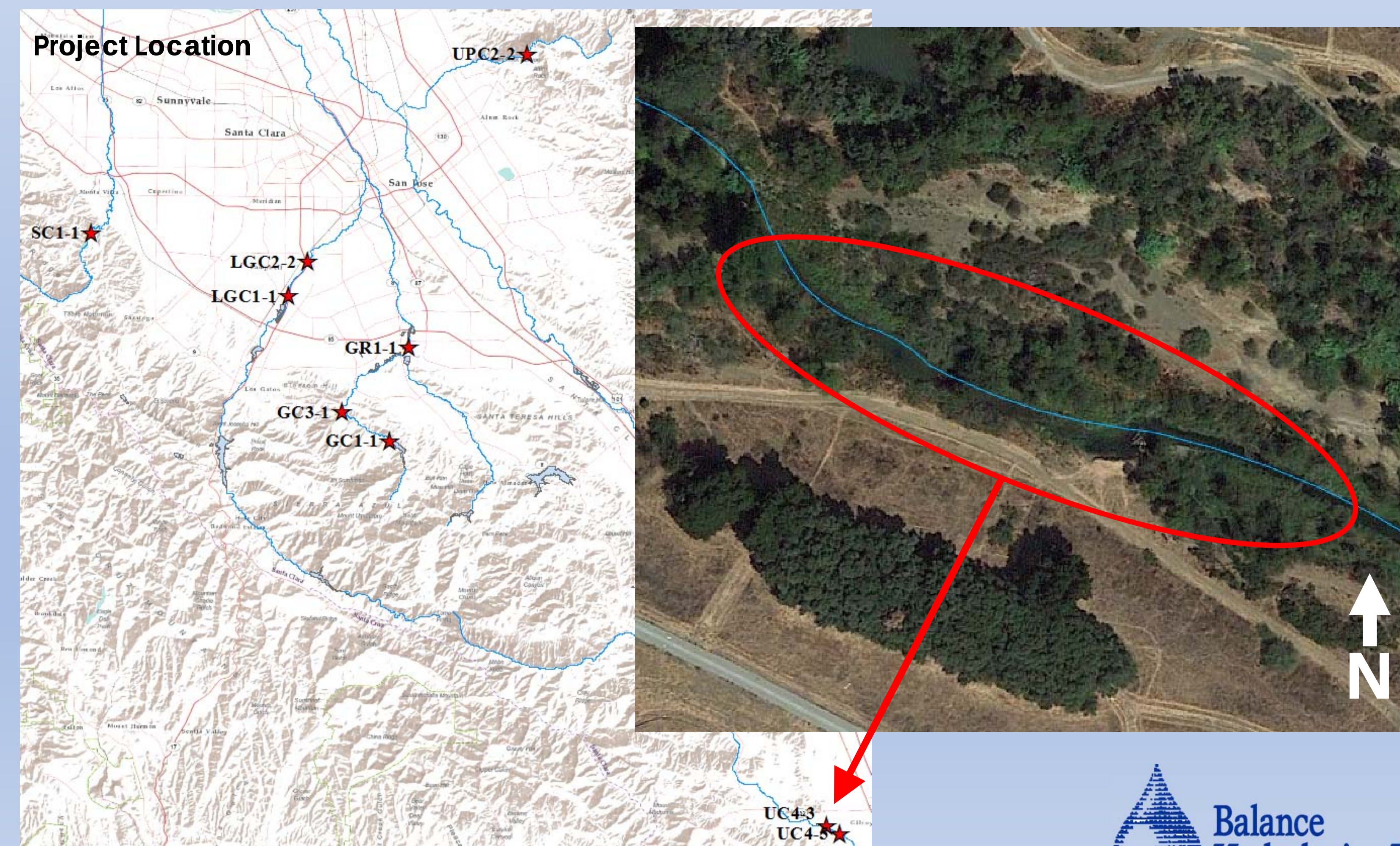
Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; increase channel complexity and cover	Uvas Reservoir	Add instream wood; establish repeat gravel augmentation injection site

Existing riffle/run tail, February 2018.

Santa Clara Valley Water District

* Measured on Oct 17, 2017

Uvas Creek 4-3 Site Parameters	
Upstream (impounded) watershed area	*69 mi² (16 mi²)*
Channel roughness	*0.06*
Channel slope	*0.35%*
*Field temperature**	*15.8°C*
*Turbidity**	*0.9 ntu*
*Embeddedness**	*10%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*5/25/55/18/2 (%)*



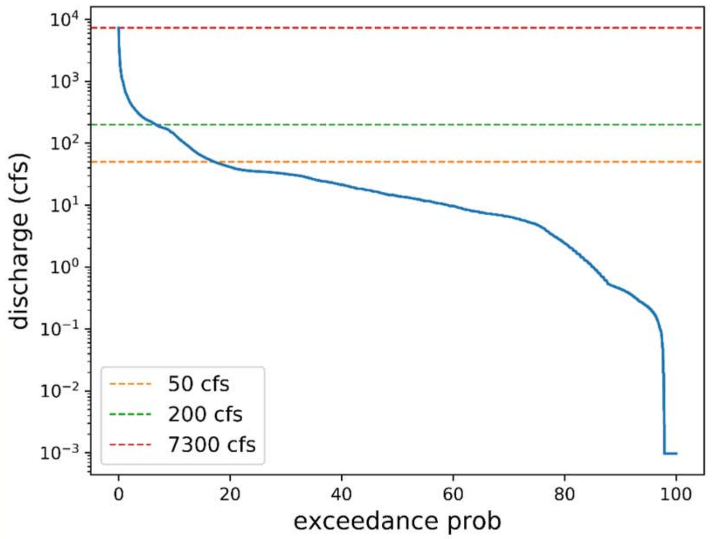
Balance Hydrologics, Inc.

NOT FOR CONSTRUCTION

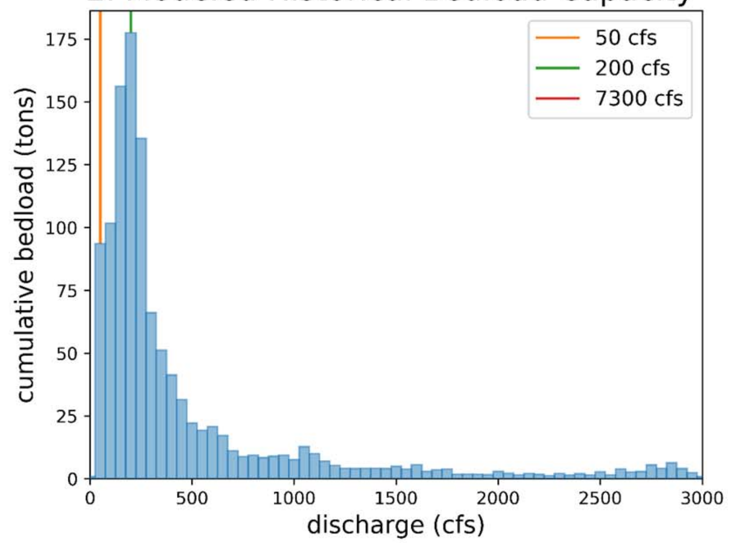
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Uvas Creek 4-3: Sediment Transport

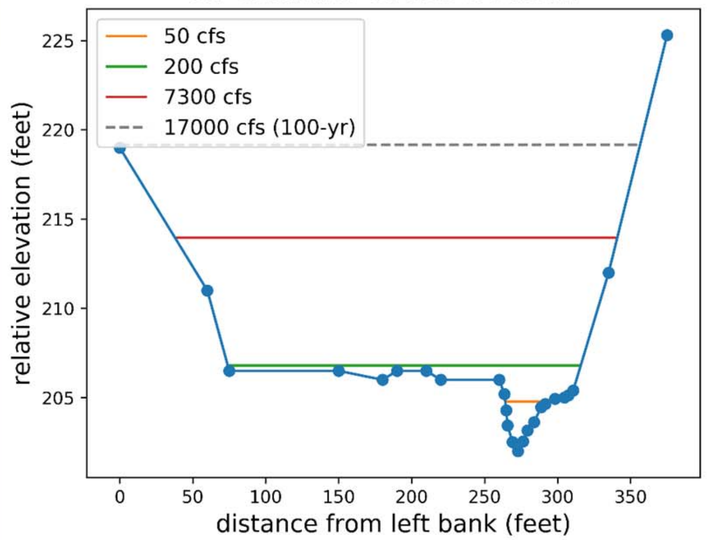
1. Flow-Duration Curve[1]



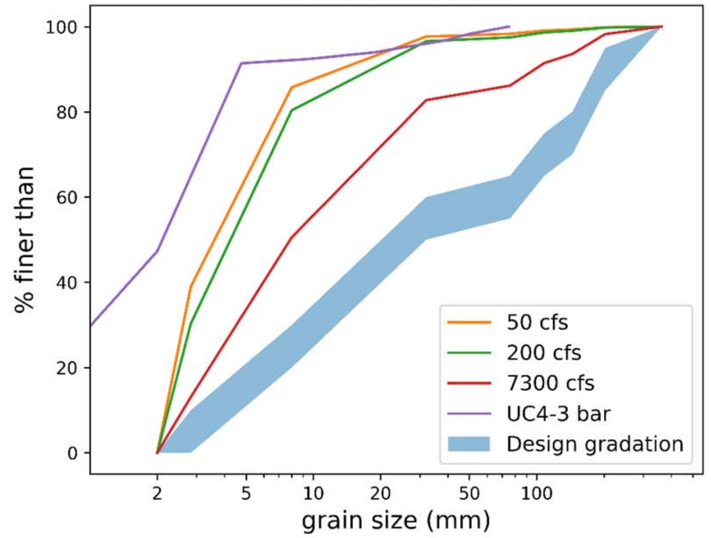
2. Modeled Historical Bedload Capacity[1]



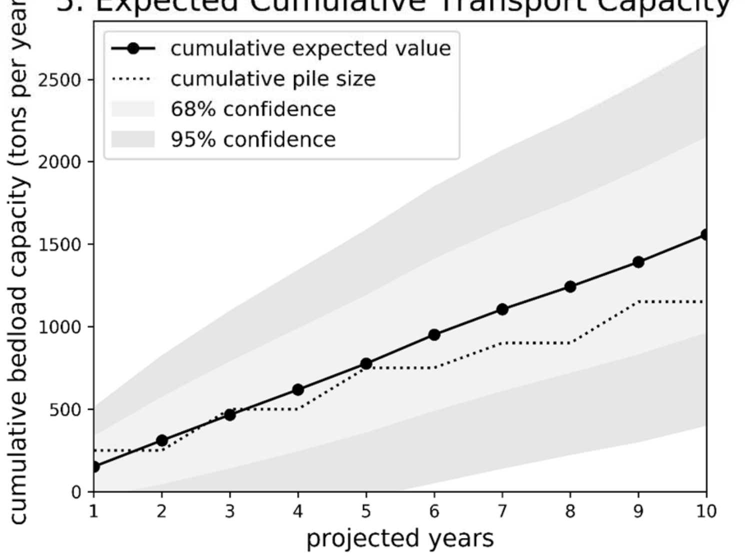
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	NA
2011 – wet	467
2012 – dry	39
2013 – dry	118
2014 – dry	0
2015 – average	14
2016 - average	191
2017 - wet	NA

[1]Flow record from 1999 – 2016
[2]See flood risk discussion on page 5
[3] Sampled only from years at least 95% complete

Recommended Gradation	
Grain Size Class	**Proposed Percentage**
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	15 – 20%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	25 – 30%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	40 – 45%
Boulders *(> 265 mm, >10 in)*	5-10%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data
Flow record used is a combination of the SCVWD gage Uvas Creek at Luchessa Avenue from 1999 to 2016; 2017 data is not available. Data is not calibrated below 200 cfs, but still reported. This brief record is also partially incomplete, with data missing from June 2001 – October 2010, and from October 2014 to the end of the record, only partial data is available for December 2014 and February 2015. The gage is located approximately 1.7 miles downstream, where the watershed increases by approximately 3%; the flow record was reduced by 3% accordingly. Additional hydrologic evaluations should be pursued during design refinement.

Effective Discharge
The largest proportion of bedload is estimated to be transported at approximately 200 cfs which is approximately equal to bankfull flow. The 100-year flow at Santa Teresa Boulevard is 17,000 cfs. The flow of record is approximately 7,300 cfs in February, 2,000. Flows shown in plots 1-4 are effective discharge, the second-most effective discharges (50 cfs), and the peak flow of record. Grab sample from UC4-3 existing gravel bar included in plot 4, compared to grain size distribution (GSD) of bedload at each flow.

Gravel Gradation and Injection Plan
Gravel introduced at UC4-3 will have benefits for downstream section of the reach, which was historically mined for gravels. Introduction of new sediments at regular intervals will give longer-term benefits for sediment supply downstream.

Steady State/Episodic Cycles
Uvas reservoir upstream of the project site tends to attenuate flow fluctuations. Sediment trapping by the reservoir also significantly impacts the pulses of sediment associated with episodic events, however there are significant un-dammed tributaries which may introduce pulses of sediment. The system is adjusting from a braided to single thread channel, which we largely attribute to changes in vegetation as a result of more consistent base flow releases from Uvas Dam, and reduction in sediment load. However, there is significant opportunity for the channel to migrate cause considerable episodic sediment discharge. Post-project monitoring should carefully consider episodic events. We recommend detailed monitoring during the initial 5-10 year phase to help bracket potential augmentation quantities.

Lifetime Expectancy
This gradation was specifically selected to be transported downstream into the mid-channel pool reach that is depleted of sediment. To maintain consistent sediment supply, the expected injection amount is 200 tons every 2 years. Because UC4-3 is steeper, the design gradation selected is coarser than at UC4-5. Based on expected cumulative transport (plot 5), the injection pile may be depleted year after year. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion, but may also mobilize sediment stored in the banks. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

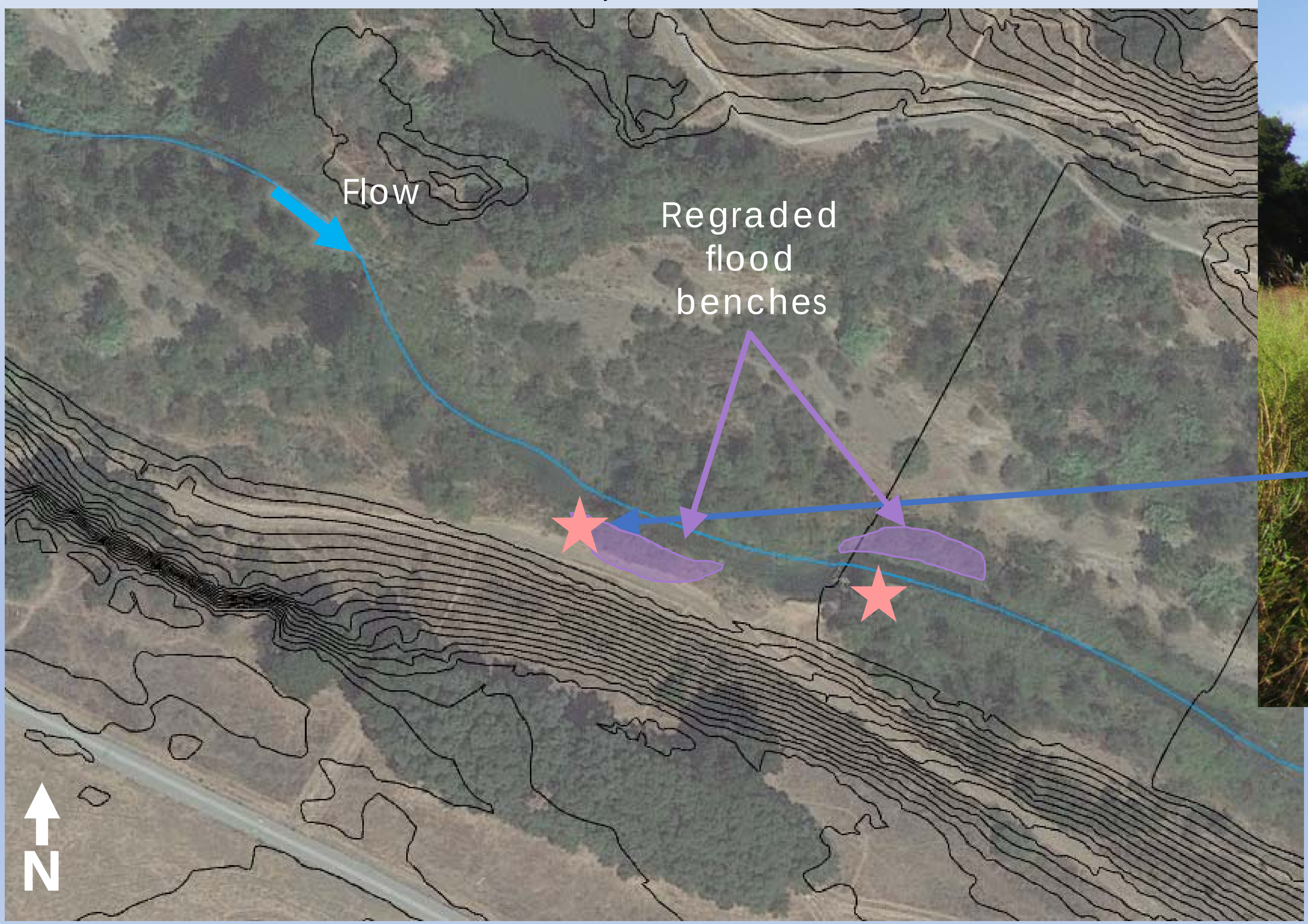
Uvas Creek 4-3, Project 1: Gravel

Santa Clara Valley Water District

Description
Here we propose placing small injection piles at two locations (stars pictured below). The first is on the right bank at the head of an existing riffle. The second is on an existing sand and gravel bar on the right bank and downstream of an existing wood and boulder feature. Construction of a flood bench on the either bank can be designed to accommodate flood capacity with the newly added gravel injection piles.

Stability Recommendations
Cobbles and boulders should be added to the gradation. We expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events. LWD augmentation downstream will help retain gravels in the upstream riffle.

Note: Contours are combined 2006 SCVWD with district survey data



View of right bank, looking upstream, February 2018.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Uvas Creek 4-3, Project 2: Wood

Santa Clara Valley Water District

Description

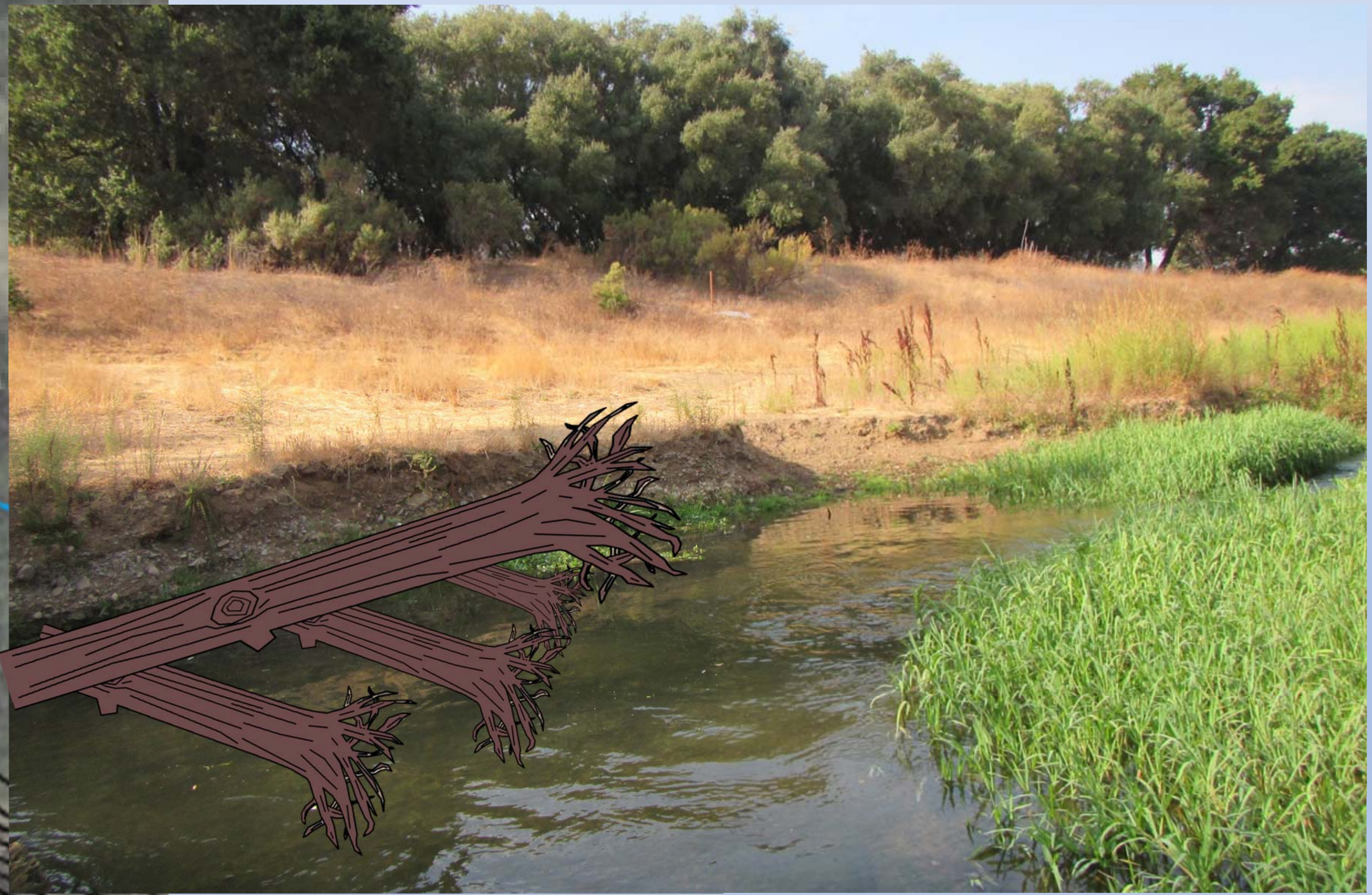
The intended function of wood at this site is three-fold. First, wood placed at the positions pictured below may help trap sediments on the right bank downstream of the injection pile, potentially providing high-flow refuge. Second, the wood pieces as positioned will likely develop scour downstream deepening the shallow pool and providing channel complexity even with additional sediment supplied from upstream. Placement of wood should consider logs and boulders already in place just downstream.

Stability Recommendations

The wood should be anchored into the right bank, either driven in or buried under excavated sediments. The right bank may need to be regraded to accommodate flood capacity.

Existing wood and boulder feature, Looking downstream, October, 2017

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Right bank, looking upstream, October 2017.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Uvas Creek 4-3

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increase spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection piles shrink, sediment transported downstream	Channel morphology or injection pile surveys, gravel tracer surveys
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Potential Flood Risks
Regulatory floodway. All designs must accommodate the 100-year base flood flows without raising water surfaces. This is achievable through bank modifications, or by altering channel "roughness". In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints

- Additional work is required to meet flood regulations.
- The channel is likely to shift or relocate during significant flows. We consider this reach to be highly episodic relative to other reaches.

Anticipated Geomorphic and Engineering Next Steps

- Design Basis Report to refine objectives and success criteria
- Detailed plans and specifications development
- Detailed flood analysis and CLOMR, if necessary
- Sediment procurement
- Wood procurement
- Mercury testing of existing sediments, which are likely to be mobilized.

Access and Staging
Access and staging both would need to be arranged with the City of Gilroy, but creek side trails provide ready access via Miller Avenue and City of Gilroy park facilities.

Adjacent to existing incised low-flow channel is a vegetated floodplain approximately 300 feet wide

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Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Santa Clara Valley Water District

Uvas Creek 4-5

Location
Downstream of Santa Teresa Boulevard, upstream of Eliot School.

Existing Conditions

- The Uvas Reservoir effectively traps all coarse sediment supplied from the upper watershed, however a large portion of the watershed is un-dammed.
- Reach transitions from a broad, formerly braiding plain to a persistent "narrows" reach just upstream of Miller Avenue, that has been mapped as such since the 1930s. It is likely the Miller Avenue crossing location was selected because of the persistent "narrows"
- Gravel mining occurred just upstream of the proposed injection side, and large in channel quarry ponds persisted through the 1980s when it eventually filled. Channel is still likely recovering from this historic "episode".
- The system is adjusting from a braided to single thread channel, which we largely attribute to changes in vegetation as a result of more consistent base flow releases from Uvas Dam. However, there is significant opportunity for the channel to migrate upstream of UC4-5 and cause significant episodic sediment discharge.
- Silts and sands smother many riffles.
- Project site is in a regulatory floodway that is contained within levees. No increase in base flood (100-year) water surface elevation is allowed.
- Reach is run-riffle-pool sequence at the top, transitioning to a deep "narrows" where a long mid-channel pool extends nearly 2000 feet.
- CEM stage IV. Incision has occurred, but not as severe as many other program streams. Widening and channel migration is expected, and may interrupt project implementation.

Problem
Gravels are smothered and fast water feeding habitat is limited. Limited LWD recruitment due to relatively young age of riparian corridor. Miller Avenue backwaters a long mid-channel pool through a historic "narrows".

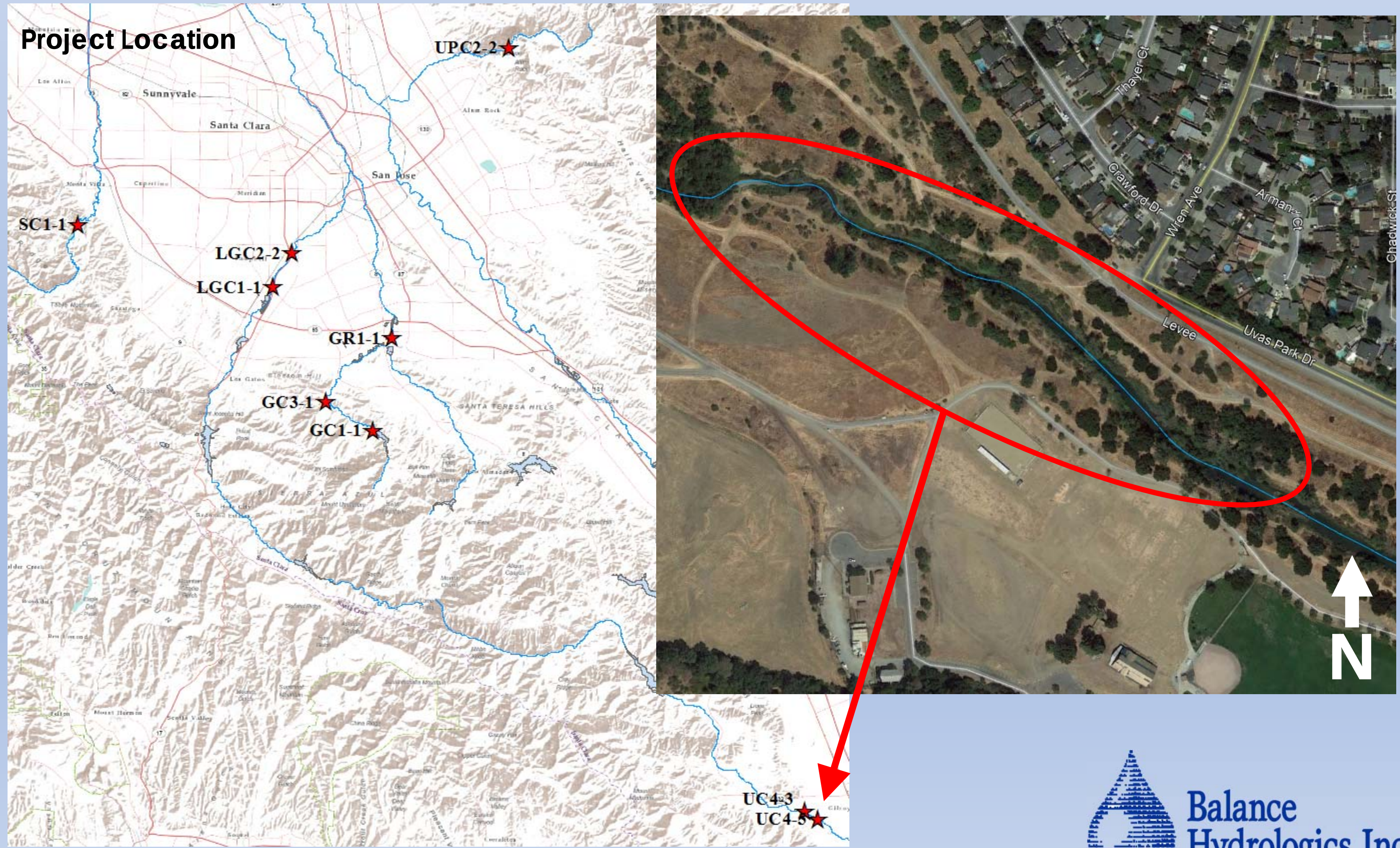
Project Approach
Two projects are proposed at this site:

1. A gravel injection pile just downstream of historic gravel quarry location.
2. Wood placement will be focused on creating cover in long mid-channel pools.

Start of 2000-foot mid-channel pool, February 2018

* Measured on Oct 17, 2017

Uvas Creek 4-5 Site Parameters	
Upstream (impounded) watershed area	*70 mi^2 (16 mi^2)*
Channel roughness	*0.05*
Channel slope	*0.22%*
*Field temperature**	*16.0°C*
*Turbidity**	*3.7 ntu*
*Embeddedness**	*45%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*10/65/25/10/0 (%)*



Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase spawning habitat; improve cover	Uvas Reservoir, historic gravel mining, Miller Avenue crossing, flood mitigation incentivizes channel simplification	Add instream wood; establish repeat gravel augmentation injection site

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

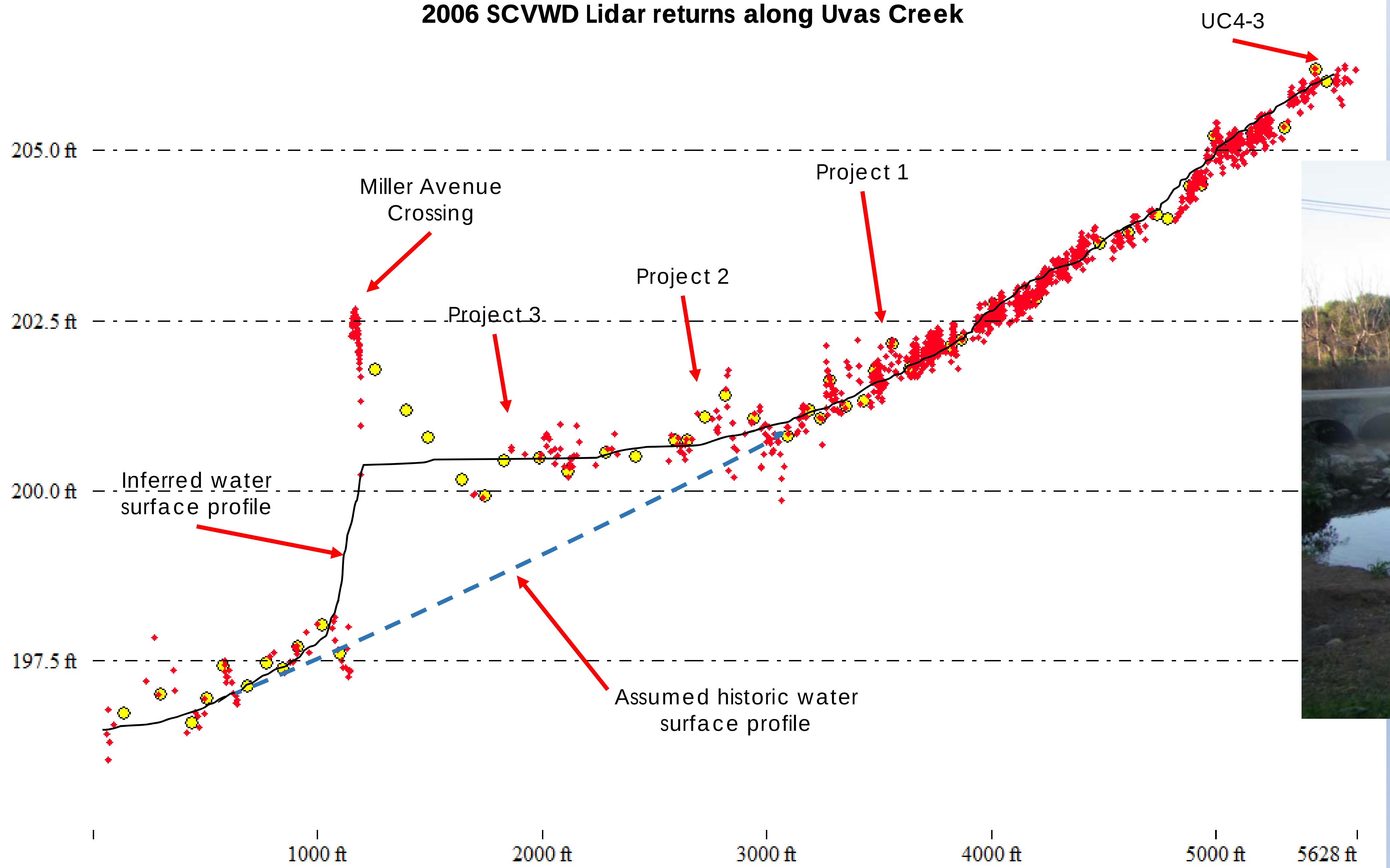
Uvas Creek 4-5, Miller Avenue

Santa Clara Valley Water District

The Uvas Creek crossing at Miller Avenue appears to have backwatered Uvas creek for approximately 2,000 feet upstream. The resulting water surface elevations have increased, creating a long mid-channel pool. In addition, the Miller Creek crossing is a repeated source of flooding problems on Uvas Creek. Therefore, significantly greater restored habitat functions and values are likely should the District choose to pursue addressing the flood capacity issues at the Miller Creek crossing alongside restoration activities in this reach of Uvas Creek. The following projects assume Miller Avenue will stay in place, if crossing alterations are made, these plans should be refined.

The Uvas Creek channel profile is depicted below using the 2006 SCVWD Lidar dataset, and because most Lidar lasers do not penetrate water, returns likely represent the water surface elevation or the channel banks. The red dots are elevations of lidar returns in an area around the drawn profile. The yellow dots are interpolation points and should be ignored between Project 3 and the Miller Avenue crossing. The black line shows the inferred water surface channel profile.

A study by Vendetti et al., 2014[1] shows that downstream backwater conditions may act to plunge the high-velocity core into pool bottoms increasing erosion when conventional understanding would infer a velocity reduction at a pool. The backwater effects from Miller Avenue crossing may contribute to the continued erosion of pools. Future investigations should include a continuous bed profile (thalweg) survey.



Miller Avenue crossing, looking upstream, February 2018

[1] Venditti, J. G., Rennie, C. D., Monhof, J., Bradley, R. W., Little M., Church, M., Flow in bedrock canyons, 2014, Nature, vol 513, 9p.

Balance Hydrologics, Inc.

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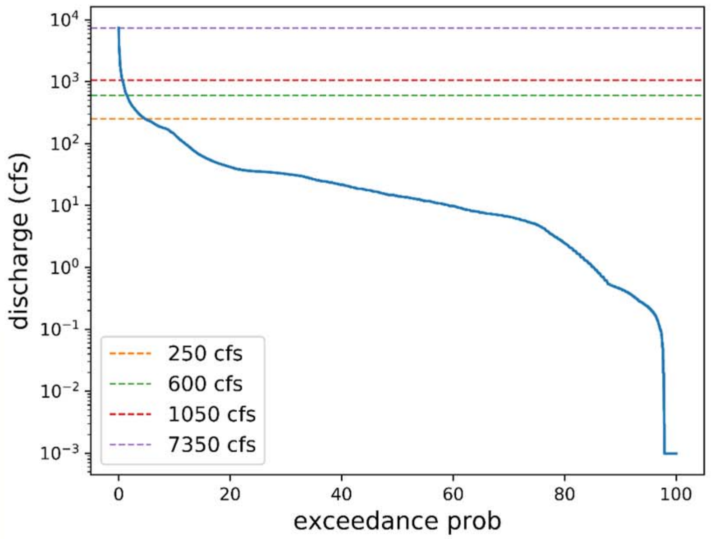
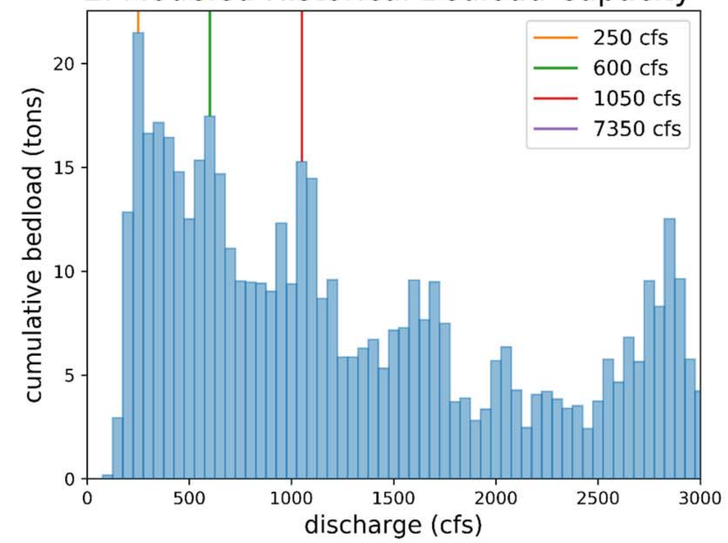
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Uvas Creek 4-5: Sediment Transport

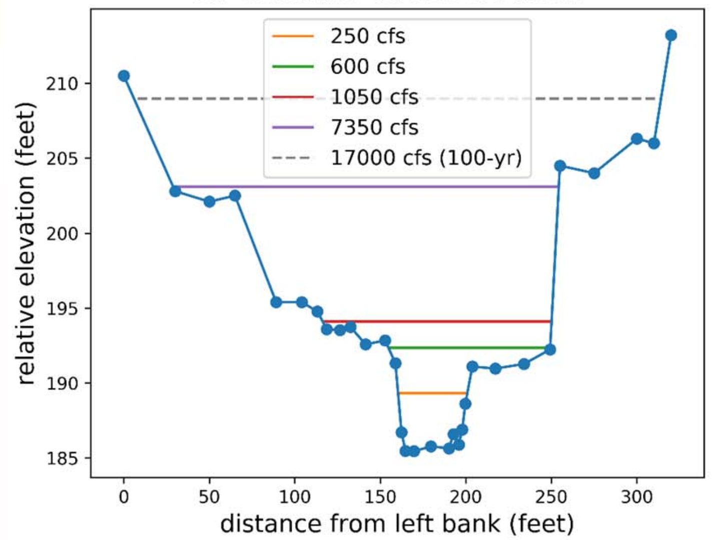
1. Flow-Duration Curve[1]



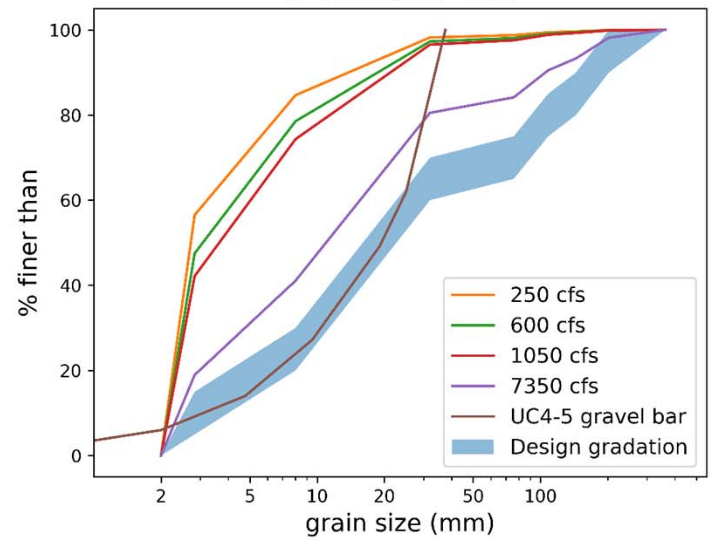
2. Modeled Historical Bedload Capacity[1]



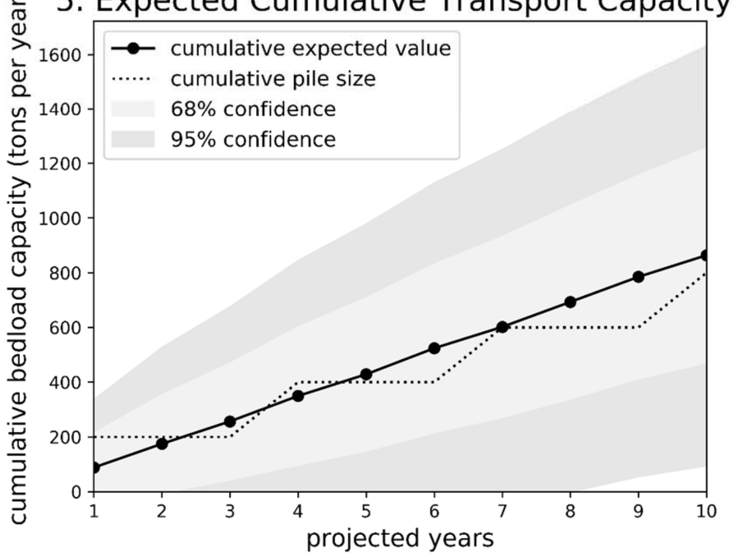
3. Channel Cross-Section[2]



4. Bedload GSD



5. Expected Cumulative Transport Capacity[3]



6. Bedload Capacity

Water Year	(tons/year)
2010 - wet	NA
2011 – wet	302
2012 – dry	4
2013 – dry	40
2014 – dry	0
2015 – average	1
2016 - average	131
2017 - wet	NA

[1]Flow record from 1999 – 2016
[2]See discussion of flood risk on page 7
[3]Sampled only from years at least 95% complete

Recommended Gradation

Grain Size Class	Proposed Percentage
Small Gravels *(2 – 16 mm, 0.08 – 0.63 in.)*	25 – 30%
Large Gravels *(16 – 64 mm, 0.63 – 2.5 in)*	35 - 40%
Cobbles *(64 – 256 mm, 2.5 – 10 in)*	25 – 30%
Boulders *(> 265 mm, >10 in)*	0 – 5%

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Hydrologic Data

Flow record used is a combination of the SCVWD gage Uvas Creek at Luchessa Avenue from 1999 to 2016; 2017 data is not available. Data is not calibrated below 200 cfs, but still reported. This brief record is also partially incomplete, with data missing from June 2001 – October 2010, and from October 2014 to the end of the record, only partial data is available for December 2014 and February 2015. The gage is located approximately 1.3 miles downstream, where the watershed increases by approximately 2%; the flow record was reduced by 2% accordingly. Additional hydrologic evaluations should be pursued during design refinement.

Effective Discharge

The largest proportion of bedload is estimated to be transported at approximately 250 cfs; the 100-year flow at Santa Teresa Boulevard is 17,000 cfs. The flow of record is approximately 7380 cfs in February, 2000. Flows shown in plots 1-4 are effective discharge, the second- and third-most effective discharges (600 and 1050 cfs), and the peak flow of record.

Gravel Gradation and Injection Plan

Gravel introduced at project 1 will have benefits for downstream section of the reach. With sufficient sediment supply, deep pools may fill and gravel bars may form. Continued gravel injection at project 1 will likely have lasting benefits for the reach.

Steady State/Episodic Cycles

Uvas reservoir upstream of the project site tends to attenuate flow fluctuations. Sediment trapping by the reservoir also significantly impacts the pulses of sediment associated with episodic events, however there are significant un-dammed tributaries which may introduce pulses of sediment. The system is adjusting from a braided to single thread channel, which we largely attribute to changes in vegetation as a result of more consistent base flow releases from Uvas Dam. However, there is significant opportunity for the channel to migrate upstream of UC4-5 and cause significant episodic sediment discharge. Post-project monitoring should carefully consider episodics. There are significant sediment sources and sinks, thus evaluating the existing sediment yields is challenging. We recommend detailed monitoring during the initial 5-10 year phase to help bracket potential augmentation quantities.

Lifetime Expectancy

This gradation was specifically selected to be transported downstream into the mid-channel pool reach that is depleted of sediment. The design gradation is relatively fine because this reach has a shallow slope compared with other channels. To maintain consistent sediment supply, the expected injection amount is 200 tons every 2 years. Averaged over the long-term, sediment transport is expected to vary year-to-year (see table 6). Years with aberrantly high runoff may lead to more rapid depletion. Injection site should be actively monitored.

NOT FOR CONSTRUCTION

 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Uvas Creek 4-5, Project 1: Gravel Injection Pile

Santa Clara Valley Water District

Description

This project recommends a gravel injection pile co-located with an existing gravel bar. The injection gradation will be selected to promote transport downstream with the goal of filling in portions of the downstream mid-channel pool and to slow channel incision. Just upstream of this site was a historical gravel mining pool, which has depleted sediment supply compared with UC4-3. To accommodate flood capacity, a flood bench should be carved out of the left bank.

Stability Recommendations

Cobbles and boulders should be added to the gradation. Though we expect transport of gravel-sized material at moderate flows, and transport of nearly the entire gradation at large recurrence interval events, existing gravel bar implies flow patterns that preferentially deposit gravels here, which may retain sediment supply at injection site over a longer period. LWD augmentation downstream at the ramp will help retain gravels in the reach.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

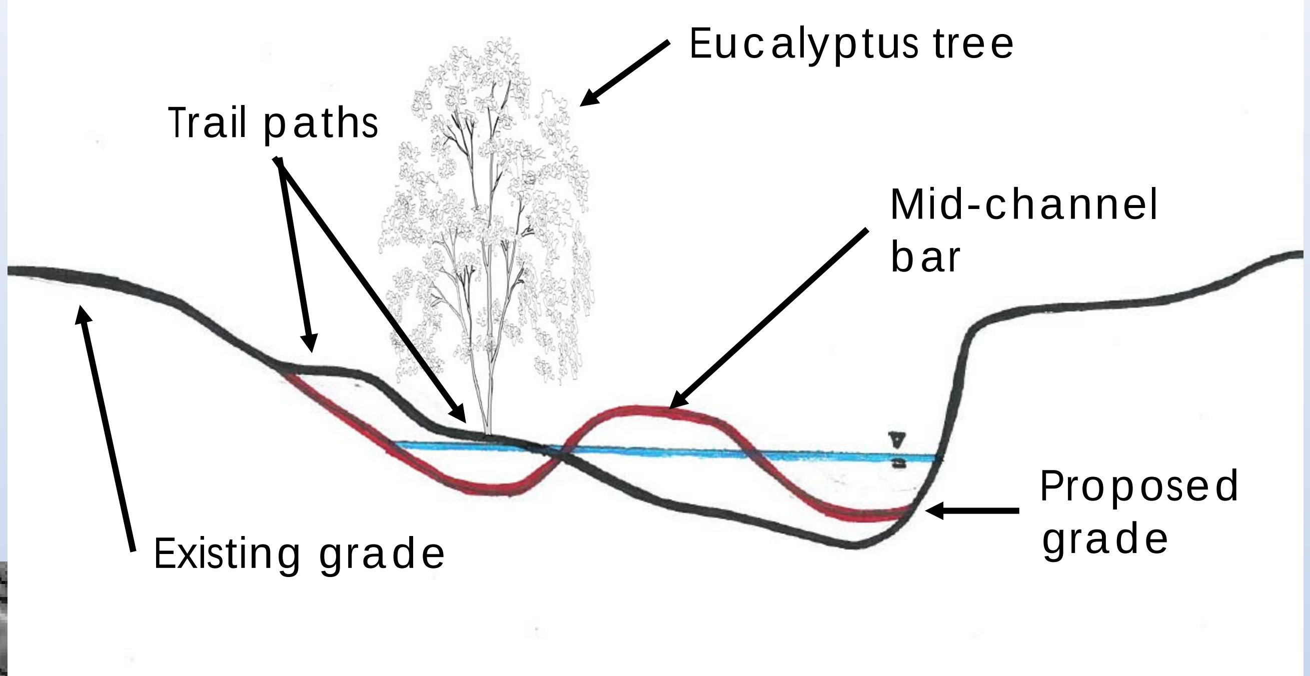
Balance Hydrologics, Inc.

Uvas Creek 4-5, Project 2: Gravel Bar Construction

Santa Clara Valley Water District

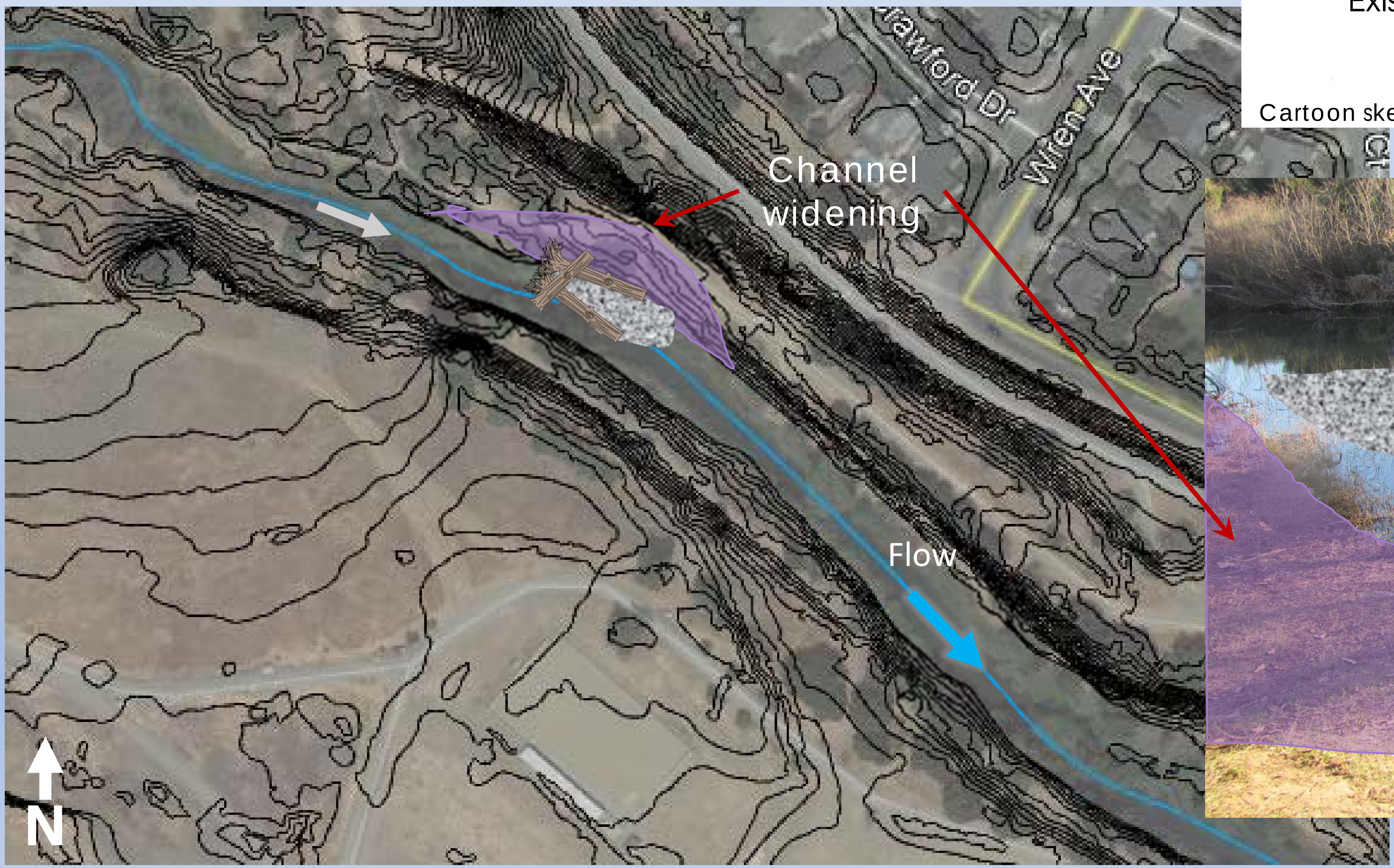
Description
A large eucalyptus tree is located on the left bank of the Uvas Creek approximately 800 feet downstream of project 1, a series of terraces have formed on the left bank. For Project 2 we propose constructing a mid-channel bar with an engineered log jam positioned at the upstream face for gravel stability. This reach of Uvas is in a regulatory floodway, and so to accommodate the flood capacity, the non-native eucalyptus tree should be removed and the channel banks re-graded to widen the channel. The project may also include native plantings.

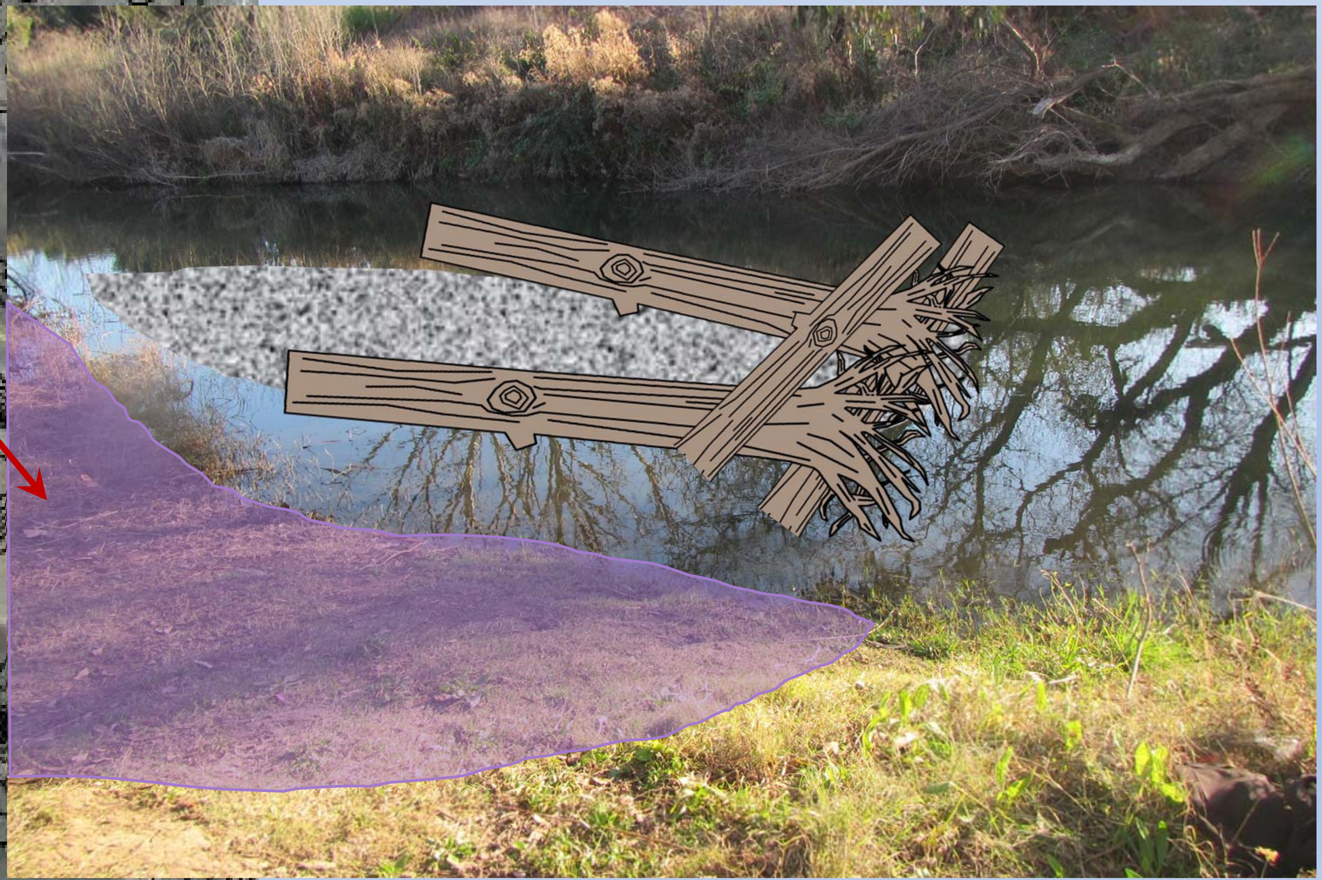
Stability Recommendations
The engineered log jam should be designed to retain of gravels. We anticipate that large boulder ballast is appropriate that this site. Duckbills and cables may also be effective, depending on the channel bed subsurface.



Cartoon sketch of channel cross-section with existing and proposed grade

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented





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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

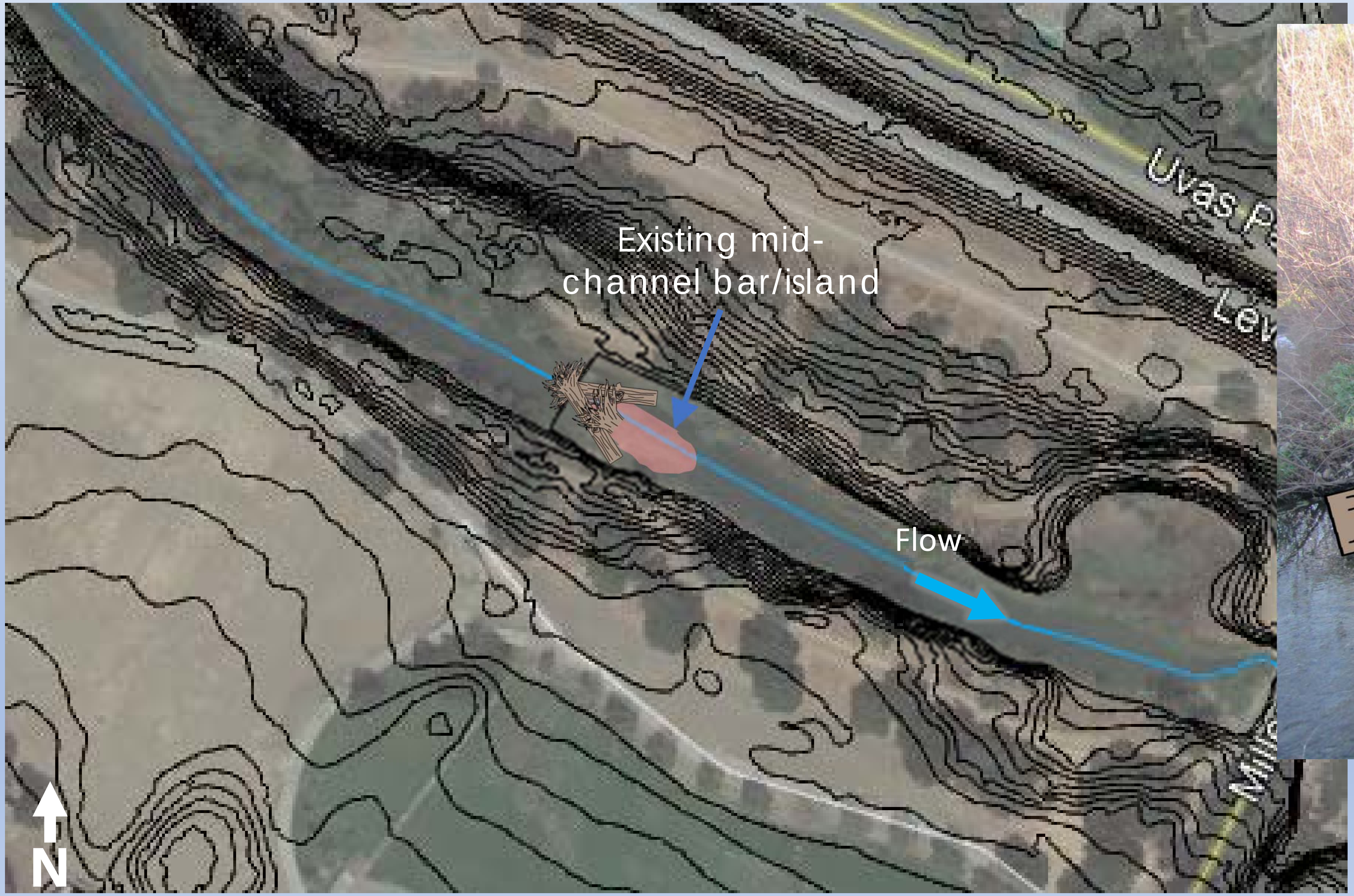
Uvas Creek 4-5, Project 3: Wood

Santa Clara Valley Water District

Description
There is an existing mid-channel bar located approximately 550 feet upstream from the Miller Avenue crossing. The mid-channel bar is currently colonized with young willows, and has split flow so that small riffles have formed on either side of the bar. This project is intended to introduce wood to stabilize the existing bar feature and to provide cover. An engineered log jam could be used to bolster the front of the gravel bar and trapping gravels as they are transported from upstream. Excavations to improve flood capacity may not be required here, because wood may be occupy ineffective flow areas. If further evaluation suggests otherwise, flood bench excavation may be required to meet flood requirements.

Stability Recommendations
The channel banks are largely fine clays, silts, and sands, and may be suitable for driving logs to anchor the jam. We recommend anchoring the ELJ with a one or more rootwads or logs driven into the bed of the channel. Cabling logs together, or boulder ballasting may be appropriate supplemental stabilizing measures.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.



Looking downstream from the left bank at existing mid-channel bar, February 2018.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Uvas Creek 4-5

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: Gravel	Increased fast water feeding and spawning habitat	Bed surface gradation more similar to spawning gravels in riffles and pool tails	Channel bed gradation surveys
	Increase sediment mobility and availability	Injection pile is mobilized as predicted	Physical surveys of injection piles
Project 2: Wood	Increase cover and channel complexity	Topographic variation around placed wood	Channel bed surveys
		Logs are secure	Field evaluation of stability, re-photography

Long mid-channel pools are not present downstream of Miller Avenue crossing: Here se see a series of pools and gravel bars. We hypothesize that gravels that enter the narrows do not reside there for long, and instead are deposited downstream of Miller Avenue.

Potential Flood Risks
Regulatory floodway. All designs must accommodate the 100-year base flood flows without raising water surfaces. This is achievable through bank modifications, or by altering channel "roughness". In the event that transported sediment exacerbate flooding downstream, further evaluation, and potentially maintenance may need to occur.

Constraints
- Miller Avenue Crossing is severely limiting the habitat potential for this reach.
- Additional work is required to meet flood regulations.

Anticipated Geomorphic and Engineering Next Steps
- Design Basis Report to refine objectives and success criteria
- Coordination with agencies regarding Miller Avenue crossing
- Detailed plans and specifications development
- Detailed flood analysis
- Sediment procurement
- Wood procurement

Access and Staging
Access and staging both would need to be arranged with the City of Gilroy, but creek side trails provide ready access via Miller Avenue and City of Gilroy park facilities.

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 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Balance Hydrologics, Inc.

Upper Penitencia 2-2

Location
Upper Penitencia Creek in Alum Rock Park upstream of the Youth Science Institute.

Existing Conditions
- With Cherry Flat Dam in the upper watershed as the only barrier to sediment supply, Upper Penitencia Creek is relatively unimpaired with respect to gravel supply; considerable sediment is sourced from tributary watersheds and from the steep canyon-like banks. Ample boulder supply has formed bedrock- and boulder-steps interspersed with runs and pools.
- Historical use of the Alum Park area included recreational mineral springs. Grouted cobble walls and weirs built for this purpose have created a small passage barrier. AT UPC 2-2, the weir has created a deep plunge pool just upstream of a bedrock and boulder step.
- The limit of anadromy is approx. 0.8 miles upstream on Upper Penitencia Creek and 1.87 miles upstream on Arroyo Aguague. Naturally-formed channel waterfalls formed the passage barrier.
- CEM stage 1, although grouted cobble walls have prevented floodplain erosion on the left bank in this reach.

Problem
While adequate sediment supply is available in this reach, a constructed weir imposes a fish passage barrier which has been identified by CDFW, with a base flow jump height of 2.8 feet, limiting access to undeveloped upstream habitat. Just downstream of the weir is a steep bedrock and boulder step section, which appears stable. Elevation of the first bedrock step appears to set pool elevation.

Project Approach
One project is proposed at this site:

1. Roughened channel of step pool channel design with LWD placement is designed to raise water surface elevations in the existing pools to reduce jump height over the concrete and stone weir, improving fish passage.

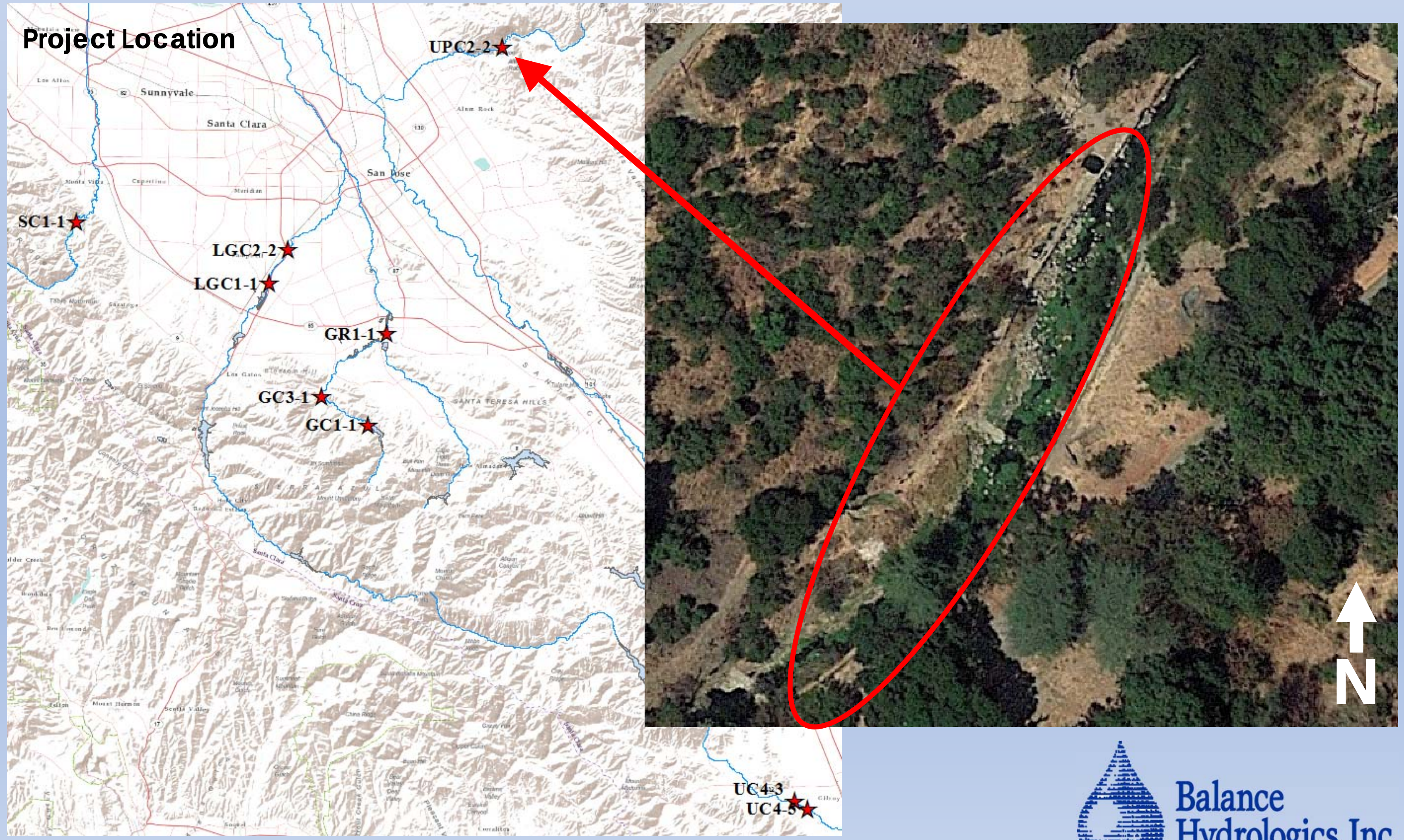
Goals	Causes of Downcutting Or Habitat Deterioration	Objectives to Achieve Goal
Increase pool water-surface elevation to reduce fish passage barrier	Constructed weir and elevation of downstream bedrock and boulder step	Add instream wood to reduce jump height

Passage barrier, October 2017.

Santa Clara Valley Water District

* Measured on Oct 17, 2017

Upper Penitencia 2-2 Site Parameters	
Upstream (impounded) watershed area	*19 mi^2 (2.4 mi^2)*
Channel roughness	*0.06*
Channel slope	*3.6%*
*Field temperature**	*13.7°C*
*Turbidity**	*ND*
*Embeddedness**	*35%*
*Existing est. silt/sand/gravel/ cobble/boulder**	*5/10/30/25/25/5 (%)*



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Balance Hydrologics, Inc.

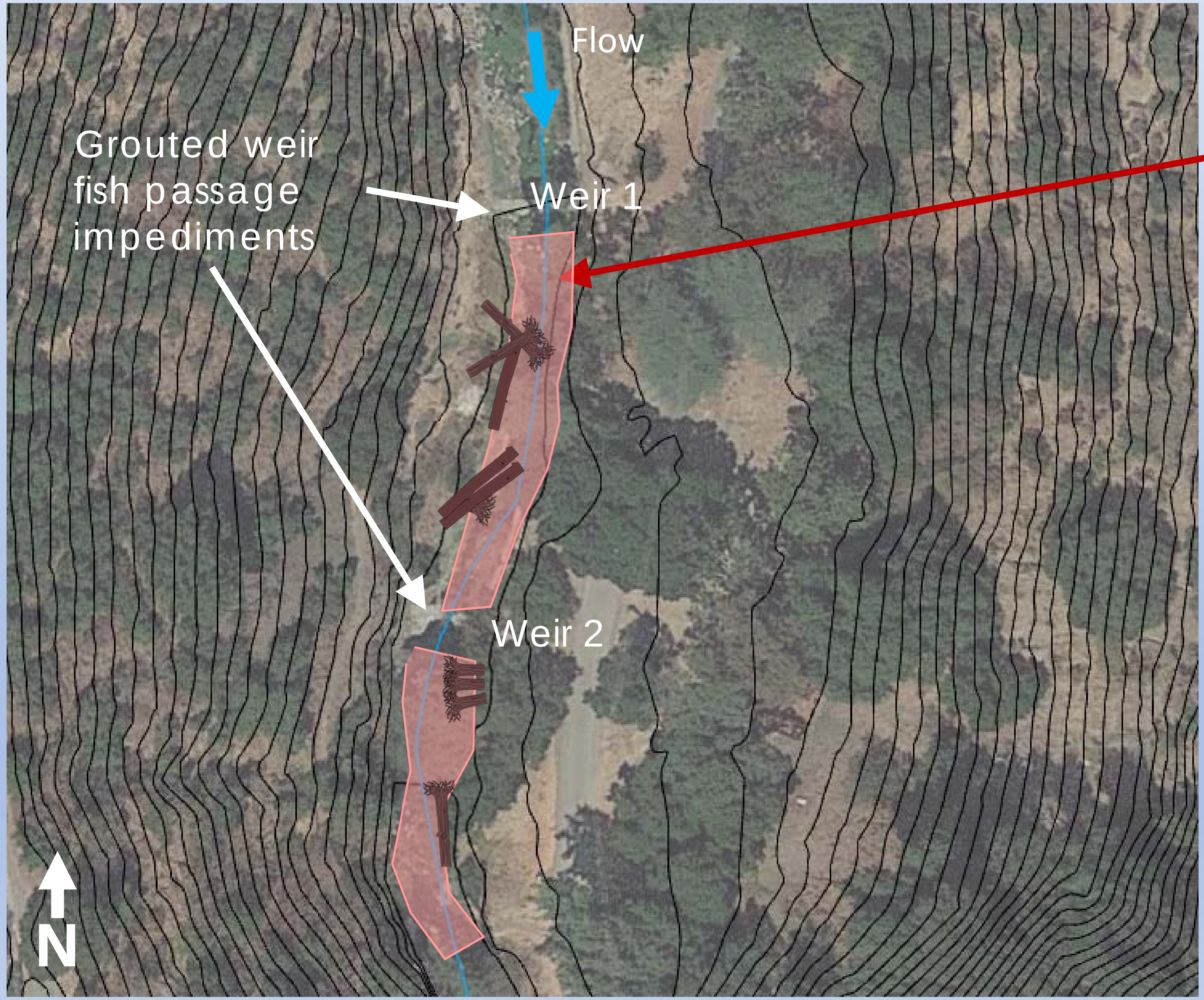
 Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

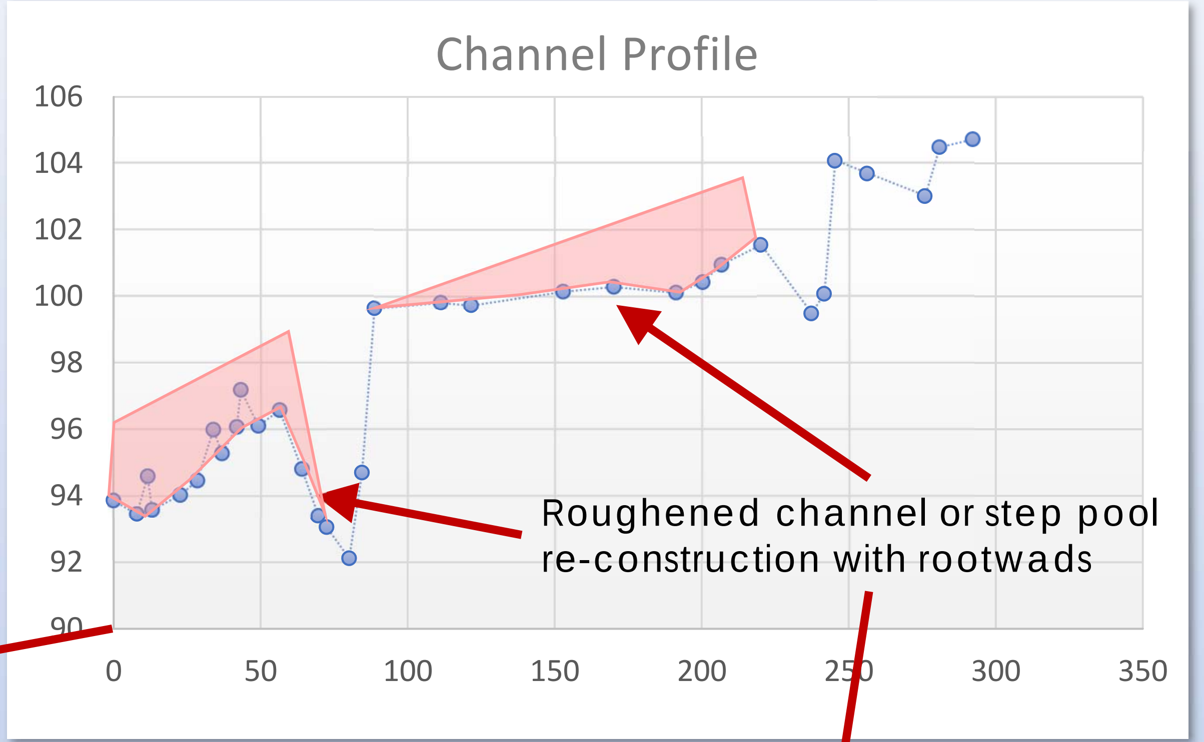
Upper Penitencia, Project 1: Wood

Description
LWD augmentation projects at UPC2-2 should be accomplished as part of channel grade adjustment and stabilization to create LWD refugia and enhance fish passage to upstream reaches on Upper Pentencia Creek. This may take the form a roughened channel or step pool creation project will primarily serve as a way to increase water-surface elevations in the pool downstream of the grouted-cobble weirs, reducing the jump height of the fish passage barrier at low flow.

Stability Recommendations
Exposed bedrock and historic grouted cobble and boulder walls may pose a challenge for anchoring logs, thus placing rootwads and logs in conjunction with placed boulders is recommended.

Note: Base contours are from SCVWD 2006. Low-flow areas of the channel are not well represented.





View from weir, looking downstream, October 2017.

NOT FOR CONSTRUCTION

Please see the Countywide Gravel and LWD Augmentation Program Report, 2018 for further explanation of conceptual designs

Santa Clara Valley Water District

Balance Hydrologics, Inc.

Upper Penitencia 2-2

Santa Clara Valley Water District

Project	Proposed Project Benefits	Success Criteria	Monitoring Recommendation
Project 1: LWD Augmentation	Improve fish passage	Base flow jump height reduced to below 0.5 feet	Base flow barrier surveys
	Additional habitat refuge	LWD in place for 5 years	Re-photography

Potential Flood Risks
The FEMA SFHA 100-year floodplain is not mapped in Alum Rock Park. Water year 2017 high-water marks indicate that flows did not overtop existing grouted cobble walls. Wood placement is designed to locally increase water-surface elevation. Flood risks will need to be defined, and if necessary, potential flood risk can be modeled and presented to stakeholders, including the City of San Jose.

Constraints
- Significant material will need to be imported to construct roughened channel
- Project execution will require coordination with City of San Jose.
- It is our understanding that some, but not all, of the grouted walls are historically significant (LSA, 2008), thus alterations to grouted cobble walls may be prohibited.

Anticipated Geomorphic and Engineering Next Steps
- Design Basis Report to refine feasibility, objectives and success criteria
- Implement log stability calculations and develop stabilization approach
- Detailed plans and specifications development
- Detailed flood analysis, if deemed necessary
- Potential coordination with City of San Jose
- Wood and boulder sourcing

Access and Staging
Access roads are excellent through the park, but will need to be coordinated with the City of San Jose. Grouted cobble walls may make channel access difficult with large equipment. Work could potentially be completed with long-arm equipment. Staging is excellent and is available on either side of the trail and adjacent to the project. Project site has restroom facilities and running water.

Weir 1. Looking upstream at upstream passage barrier, October 2017.

Downstream of Weir 2. Looking downstream, October 2017. Proposed project would extend through this reach and would shore up the foundation of the pictured grouted wall

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APPENDIX F

Relative Wood Decay Rates by Type for Select Native and Non-native Species

TABLE 2

Grouping of Test Woods for Above Ground Decay Resistance and Service Life in a Climate such as that of Wisconsin[a]

Most resistant (≥20 years)	*Resistant (14–19 years)*	*Moderately resistant (8–13 years)*	*Nonresistant (≤7 years)*
Douglas-fir, heartwood	Douglas-fir, sapwood	Western hemlock, sapwood	None
Western white pine, heartwood	Englemann spruce, sapwood	Lodgepole pine, sapwood	
Redwood, heartwood	Englemann spruce, heartwood	Southern yellow pine, sapwood	
Redwood, sapwood	Eucalyptus sp., sapwood	Red pine, sapwood	
Eucalyptus sp., heartwood	Sugar maple, interior	Western red cedar, sapwood	
Red oak, sapwood	Yellow birch, interior	Red alder, sapwood	
Red oak, heartwood	Balsam poplar, sapwood	Basswood, sapwood	
White oak, heartwood		Basswood, heartwood	
White oak, sapwood			
Lodgepole pine, heartwood		Sweetgum, sapwood	
Ponderosa pine, heartwood			
Western red cedar, heartwood			

[a]Based on years to failure of cross-brace joints in Madison, Wisconsin.

T. L. Highley

Source: Comparative Durability of Untreated Wood in Use Above Ground, T.L. Highley, 1995

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Table 2 **Above ground decay resistance estimates for common wood types native and exotic to the United States from Highley (1995). Absolute age estimates should be ignored a) because experimental site was located in Wisconsin, and b) experiment evaluated above ground lifespan.**

Table 14–1. Grouping of some domestic and imported woods according to average heartwood decay resistance[a]

Very resistant	Resistant	Moderately resistant	Slightly or nonresistant
Domestic			
Black locust	Baldcypress, old growth	Baldcypress, young growth	Alder, red
Mulberry, red	Catalpa	Cherry, black	Ashes
Osage-orange	Cedar	Douglas-fir	Aspens
Yew, Pacific	Atlantic white	Honey locust	Beech
	Eastern redcedar	Larch, western	Birches
	Incense	Pine, eastern white, old growth	Buckeye
	Northern white	Pine, longleaf, old growth	Butternut
	Port-Orford	Pine, slash, old growth	Cottonwood
	Western redcedar	Redwood, young growth	Elms
	Yellow	Tamarack	Basswood
	Chestnut		Firs, true
	Cypress, Arizona		Hackberry
	Junipers		Hemlocks
	Mesquite		Hickories
	Oaks, white[b]		Magnolia
	Redwood, old growth		Maples
	Sassafras		Pines (other than those listed)[b]
	Walnut, black		Spruces
			Sweetgum
			Sycamore
			Tanoak
			Willows
			Yellow-poplar
Imported			
Angelique	Aftotmosia (Kokrodua)	Andiroba	Balsa
Azobe	Apamate (Roble)	Avodire	Banak
Balata	Balau[b]	Benge	Cativo
Goncalo alves	Courbaril	Bubinga	Ceiba
Greenheart	Determa	Ehie	Hura
Ipe (lapacho)	Iroko	Ekop	Jelutong
Jarrah	Kapur	Keruing[b]	Limba
Lignumvitae	Karri	Mahogany, African	Meranti, light red[b]
Purpleheart	Kempas	Meranti, dark red[b]	Meranti, yellow[b]
Teak, old growth	Mahogany, American	Mersawa[b]	Meranti, white[b]
	Manni	Sapele	Obeche
	Spanish-cedar	Teak, young growth	Okoume
	Sucupira	Tornillo	Parana pine
	Wallaba		Ramin
			Sande
			Sepitir
			Seraya, white

[a]Decay resistance may be less for members placed in contact with the ground and/or used in warm, humid climates. Substantial variability in decay resistance is encountered with most species, and limited durability data were available for some species listed. Use caution when using naturally durable woods in structurally critical or ground-contact applications.
[b]More than one species included, some of which may vary in resistance from that indicated.

Source: Wood Handbook: Wood as an Engineering Material, Centennial Edition,USDA, 2010

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Table 14-1 **Relative decay resistance estimates for common wood types native and exotic to the United States from Bergman and others (2010).**

APPENDIX G

Potential Success Criteria, Monitoring Approach and Adaptive Management Actions

Appendix G: Potential success criteria, monitoring approach and adaptive management actions

Gravel augmentation

	Potential success criteria	Monitoring method		Potential thresholds for adaptive management	Potential adaptive action if success criteria are not met
Habitat	Improved/increased spawning and/or habitat	Evaluate intervening hydrologic events, identify episodic (e.g. landslides, large floods) events which may influence monitoring observations	• Grainsize evaluations · Embeddedness evaluations · Geomorphic facies mapping · Cross-section and long profile surveys	· No reduction in embeddedness compared to baseline · No net increase in riffle length, number, width compared to baseline	· Add gravel · Change augmentation approach · Add more coarse material, or LWD to increase sediment storage
	Minimize negative impacts to existing habitat types		· Cross-section long profile surveys at and downstream of site · Geomorphic mapping up and downstream of site through sensitive habitat types identified pre-project · Critical Riffle methodologies (CDFW) · Onsite hydrologic data collection	· Existing habitat is threatened by project actions, e.g. riffles become backwatered or pools are persistently filled even though hydrologic data suggest sufficient flushing flows · Aggraded sediment becomes a seasonal of perennial passage impediment	· Strategically add or remove LWD · Halt or slow augmentation · Remove aggraded sediment
Logistic	Gravel moved during events expected to transport gradation		· Physical surveys of pile or created feature and analysis of hydrology · Tracer studies	Observed transport is considerably less than expected	· Revise gradation · Change placement method/location
	No increased flood risk downstream		· Evaluations conducted in keeping with Stream Maintenance Program Management Guidelines (MGs)	Monitoring suggests flood capacity is reduced, and detailed evaluation of antecedent conditions suggests augmentation is the cause	· Remove sediment and reevaluate injection site · Reduce volume of injected coarse sediment · Coarsen gradation and/or add more LWD to site to arrest and store more sediment

Large woody debris augmentation

	Potential success criteria	Monitoring method		Potential thresholds for adaptive management	Potential adaptive action if success criteria are not met
Habitat	Deeper pools	Evaluate intervening hydrologic events, identify episodic (e.g. landslides, large floods) events which may influence monitoring observations	· Cross-section and long profile surveys and evaluations	Pools are not deeper than baseline	· Add more LWD or change configuration. Potentially remove or relocate pieces of wood.
	Retention of coarse sediments		· Cross-section and long profile surveys and evaluations	Scour compared to baseline	· Add more LWD or change configuration
	Improved cover		· Visual observations, habitat and geomorphic mapping · Detailed surveys coupled with 2D hydrodynamic modeling to evaluate Habitat Suitability Indices (HSI)	· Geomorphic mapping demonstrates no improvement in cover · HSI analyses demonstrate that cover is not improved over baseline	· Add more LWD or change configuration
	Retain organic matter		· Quantify particulate organic matter	Less organic matter accumulation compared to baseline	· Add more LWD or change configuration
Logistic	LWD is secure and stable		· Re-photography · Physical inspection of LWD, or LWD structure	Cabling and ballast is inadequate to secure wood or wood is not stable	· Supplemental ballast or revise stabilizing approach

<u>Notes</u>

1. A post-project "as-built" monitoring survey to serve as the baseline condition against which future conditions are evaluated