Matadero Creek Renaturalization

Conceptual Alternative Analysis

Prepared for:

CITY OF PALO ALTO

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wra ENVIRONMENTAL CONSULTANTS

Table of Contents

Figures

Tables

Appendices

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List of Acronyms

Acronym	*Full Name*
bgs	Below Ground Surface
CAD	Computer Assisted Drafting
CEQA	California Environmental Quality Act
cfs	Cubic Feet per Second
VW	Santa Clara Valley Water District
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GIS	Geographic Information System
HEC-RAS	Hydraulic Engineering Center – River Analysis System
LiDAR	Light Detection and Ranging
n	Manning's Roughness Coefficient
NVCAP	North Ventura Coordinated Area Plan
TCE	Trichloroethylene
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WSEL	Water Surface Elevation
yr	Year

Glossary

Term	*Definition*
Annual Exceedance Probability	The annual exceedance probability is the percent chance of an occurrence each year.
Bankfull Discharge or Bankfull Streamflow	A simplified understanding of bankfull flow is that it is the streamflow at which water begins to overtop the streambanks and start to spread out beyond the active channel. It can also be expressed relative to the return period for a peak flow (e.g., the 2-year event).
Discharge	Discharge (also called 'streamflow') is the quantity of water flow passing through channel at a location and expressed as a rate in terms of volume per unit time (i.e., cubic feet per second).
Flood Conveyance	Flood conveyance refers to the maximum magnitude of streamflow (discharge) that a channel can hold without overtopping its banks.
Flood Performance	The system's reaction to the flood; the capability of the system to accommodate a particular flood event and/or the full range of flood events
Freeboard	"Freeboard" is a means to express a factor of safety relative to flood water elevations by compensating for the unknowns and uncertainties with predicting flood heights. The freeboard is a vertical distance (e.g., 1 to 3 feet) between the flood water elevation and natural or built features like channel banks, levee crests or bridge soffits.
Geomorphic Bankfull	Geomorphic bankfull refers to either the physical field indicators of the bankfull discharge, or the streamflow when those indicators are just inundated. It may differ from the discharge reaching the top of bank or the effective discharge.
Incised Channel	An incised stream has experienced erosion and has a lowered channel bed elevation relative to adjoining topography, such that overbanking occurs less frequently than would be expected for the present hydrology.

Low Water Crossing	A road/trail/bridge crossing a creek that is often 'at grade' meaning the crossing is at an elevation similar to the channel (not high above it) and can be easily crossed during typical low flow, but not used during high flows/floods.
Planform Geometry	The planform geometry of a stream refers to the overall layout and shape of the channel as viewed from overhead (i.e., map view); It may have one or more active channels and each of the channels may have a range of curvature (sinuosity) and width.
Recurrence Interval or Return Period	The recurrence interval or return period is the estimated average number of years between events (e.g., floods, fires, earthquakes) of a certain magnitude.
Rock Vanes	Rock vanes have many variations, but are generally rock structures that extend from out from one bank of a channel into the flow and typically have a vertical slope and plan orientation to help direct high flow water towards the middle of the channel.
Rock Weir	Rock weirs have many variations, but are generally rock structures that cross from one bank of a channel to the opposite bank and may have various vertical and plan view shapes to achieve different functions.
Roughness	Roughness is a measure of the amount of frictional resistance water experiences when flowing over land surfaces (i.e., soil, rocks, vegetation or built features) and in channels (e.g., stream bed and bank materials). It is expressed in engineering calculations using the Manning's n value.
Soffit	The soffit is the lower surface of an arch and/or the underside (bottom) surface of a bridge.

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Executive Summary

The project reach of Matadero Creek within the City of Palo Alto (City) between Park Boulevard and northeast of El Camino Real is a simple U-shaped concrete-lined flood control channel with limited co-benefits to the community or ecosystem in terms of aesthetics, recreation opportunities, or habitat. The City is considering possible renaturalization of a portion of Matadero Creek that would aim to enhance recreational, environmental and public safety benefits. The purpose of this analysis was to develop a range of conceptual design approaches and evaluate their performance and feasibility by applying initial screening related to hydrology, hydraulics, and geomorphology relative to the existing and project objectives. Each of the action alternatives introduce corridor enhancements such as more natural creek channel geometry, earthen channel bed materials and native vegetation, along with expanded public access and landscaping, while providing for maintenance access.

All five concept designs offer opportunities to improve habitat, aesthetics and recreation within the Matadero Creek corridor relative to existing conditions. Hydraulic modeling and initial preliminary cost estimates informed the assessment and comparison between five options. Small scale approaches such as Concepts 1 and 2 are less feasible, since the local increased roughness from proposed vegetation along with the existing bridges configurations would hydraulically increase flooding upstream in areas where mitigation would be challenging. Approaches that would treat longer reaches of the creek and replace Lambert Avenue bridge (Concepts 1A, 2A and 3) avoid potential adverse flood water elevation changes upstream of El Camino Real. They would all be hydraulically feasible.

The five Matadero Creek naturalization options will be presented at public hearings to the Planning and Transportation Commission and City Council in conjunction with the North Ventura Coordinated Area Plan (NVCAP) draft plans. The City Council will ultimately decide which naturalization option should move forward. When staff begins the implementation process to fully design and construct the creek naturalization project, it will be subject to a thorough design review and California Environmental Quality Act (CEQA) review process, which includes opportunities for the public to participate.

1 Introduction

The City of Palo Alto (City) tasked WRA, Inc. to evaluate the potential for converting a portion of the existing concrete flood control channel of Matadero Creek into a more natural amenity for the benefit of the public and the environment and prepare conceptual design options. This report summarizes the planning and analysis supporting conceptual channel designs for the renaturalization of a portion of Matadero Creek in the City as part of the planning process for the NVCAP. A range of options were explored from a no-action alternative to full renaturalization of the channel corridor.

The purpose of this effort was to create a range of designs reflecting the interests of the community within the overall constraints of the urban setting. Design of the channel considered the natural processes of hydrology, hydraulics, geomorphology, and riparian vegetation establishment, while addressing necessary public service and safety functions and aesthetics. At a conceptual level of detail, the design process does not provide comprehensive engineering feasibility analysis or environmental evaluation, which will occur during more future planning and design phases. The scope of this analysis included:

- Development of conceptual plan and section views of the creek channel
- Evaluation of hydraulics under existing and proposed conditions
- Quantification of material quantities
- Estimation of probable costs

2 Renaturalization Objectives

The overall goals of the project are to reconstruct the Matadero Creek channel for enhanced recreational, environmental and public safety benefits, creating riparian ecosystem habitat, and re-establishing geomorphic channel function. These goals are consistent with the environmental vision of the City of Palo Alto Comprehensive Plan 2030 “to manage natural resources that sustain the environment and protect creeks” (City of Palo Alto, 2017). The objectives considered during conceptual alternatives design reflect the various stakeholder priorities, as expressed below:

- Enhance recreational and public park space in the North Ventura Coordinated Area Plan
- Promote community vitality through increased accessibility for bicyclists and pedestrians
- Provide flexibility for compatibility with potential adjacent land uses
- Re-establish riparian ecosystem habitat and geomorphic function

3 Constraints

The Matadero Creek corridor within the study area is highly constrained by urban development and infrastructure. Road and rail crossings limit the opportunities for widening the channel, both within and downstream of the study area. The existing channel has two 90 degree bends directly downstream of the study area, before passing under the Caltrain railroad and Alma Street bridges. Matadero Creek’s primary function is to safely convey floodwaters, and maintenance of the flood control channel is performed by Santa Clara Valley Water District (Valley Water). Beyond the 60-foot wide Valley Water maintenance easement, adjacent parcels are all private property between Lambert Avenue and Park Boulevard. Upstream of El Camino Real, the Valley Water easement is very narrow (roughly 25 feet wide) overlain on several private parcels, limiting options for flood management in that reach.

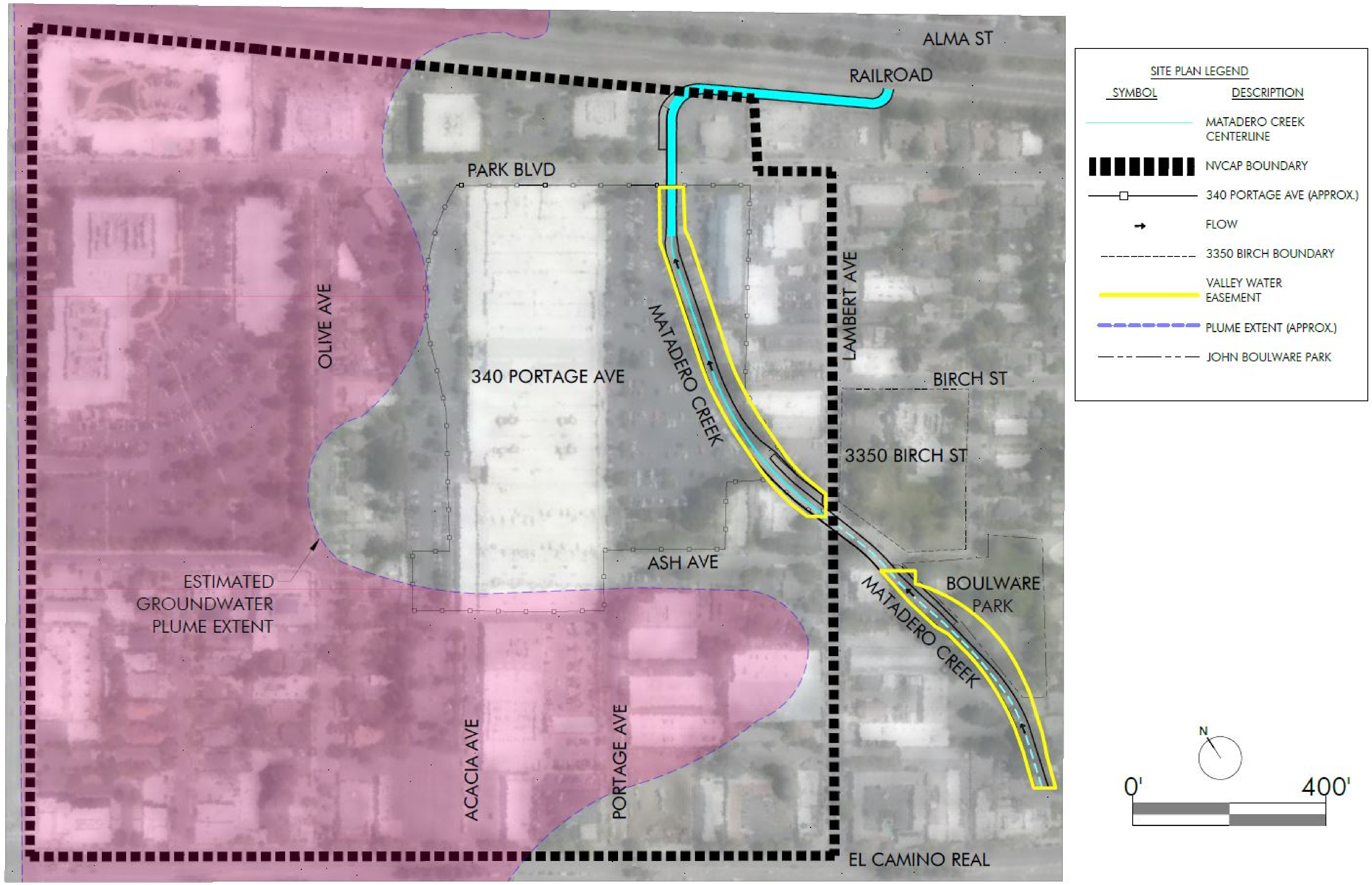

Figure 1. Overview of the Matadero Creek renaturalization study area

4 Site Assessment

Site data provided by Valley Water and the City in formats suitable for geographic information system (GIS) and computer assisted drafting (CAD) included the following:

- As-built drawings
- Parcel maps
- Rights-of-way
- Valley Water easement boundary
- Roadways, street centerlines and sidewalks
- Building footprints
- FEMA flood zones
- Topography (dated September 2018)

Valley Water also provided several relevant engineering studies, including:

- Matadero & Barron Creeks Remediation Project – Final Engineering Report (Schaaf & Wheeler, 2002)
- Matadero & Barron Creeks Structural Investigation Report (SCWVD , 2001)
- Matadero & Barron Creeks Geotechnical Investigation Report (Schaaf & Wheeler, 2001)
- Phase I Environmental Site Assessment and Soil and Groundwater Quality Screening (Schaaf & Wheeler , 1999)

WRA reviewed the Federal Emergency Management Agency (FEMA) Flood Insurance Study for Matadero Creek (FEMA, 2014), and the HEC-2 hydraulic model of Matadero Creek developed for FEMA by Schaaf and Wheeler (Schaaf & Wheeler, 2002) for the National Flood Insurance Program developed by Schaaf and Wheeler in HEC-2 format.

The CAD and GIS files provided by Valley Water and the City were assembled into a base map using AutoCAD Civil 3D. A field reconnaissance of the site was performed by WRA and City staff on October 25, 2019. Site photos from the field visit are provided in Appendix D. Typical conditions of the existing U-shaped concrete channel are shown in Figure 2 and described further in the following sections.

Figure 2. Existing Conditions in Matadero Creek, looking downstream along 340 Portage Avenue, toward Park Boulevard.

4.1 Existing Conditions Summary

The existing Matadero Creek channel was constructed by Valley Water in 1994. Two Valley Water maintenance vehicle access ramps, protected by locked chain-link fences, are located on both sides of Lambert Avenue. The channel is lined with reinforced concrete, with weep holes allowing for seepage from shallow groundwater. The existing channel is 25 feet wide and 12 feet deep. A small low-flow channel about five feet wide and 1.3 feet deep is inset along the center of the concrete channel through most of the project area.

A small amount of flow, less than 1 cfs, was observed during the field reconnaissance. Algal blooms were observed. The concrete lining prevents the establishment of native riparian vegetation, but non-native climbing ivy vegetation was observed on portions of the concrete retaining walls of the channel. Under existing conditions, the channel appears to provide very little aquatic habitat, no riparian habitat, no recreational values, and arguably very little aesthetic value.

4.2 Groundwater Contamination Plume

Groundwater in the vicinity of Matadero Creek has been shown to contain trichloroethylene (TCE) and other volatile organic compounds (VOCs). The estimated extent of the TCE contamination plume (at first encountered groundwater, around 15 to 30 feet below ground surface (bgs)) as of June 2019 is shown in Figure 1 (Stantec, 2020). The concept design alternatives have considered the available public information documenting the presence and status of this groundwater contamination plume. Once a concept has been chosen, further analysis of any consequences and proper mitigation to avoid adverse interaction with the plume during construction or over the life of the project would be conducted.

5 Hydrology

According to the USGS, the Matadero Creek watershed drainage area upstream of Lambert Avenue is 7.25 square miles. Other available hydrologic data available for this study include a FEMA Flood Insurance Study (FIS) (FEMA, 2014), and the engineering report for Matadero and Barron Creeks (Schaaf & Wheeler, 2002). The hydrology of the Matadero Creek watershed upstream of the study area is somewhat complicated by infrastructure engineered to manage stormwater with a system of bypasses that transfer water between subbasins.

The Matadero Creek watershed has a flow regime typical of streams in the San Francisco Bay area, which experiences a Mediterranean climate. Streamflow generally increases during the cool wet winters and decreases over the mild dry summers. Nearly all stormwater runoff occurs between the months of September and May. The creek may dry completely for short periods during summer months or longer periods in drought years. Typical winter months include high flows after rainfall events, and the potential for significant flood peaks in response to large, regional rainfall-runoff events.

Flows in Matadero Creek are diverted into an underground bypass at Bol Park, and return to the main stem of Matadero Creek just downstream of El Camino Real, upstream of the study area. Flows are manually diverted from Barron Creek to Matadero Creek during large stormwater runoff events, to prevent Barron Creek from being flooded (Schaaf & Wheeler, 2002).

The United States Geological Survey (USGS) operated a gage on Matadero Creek near Lambert Avenue intermittently from Water Year 1953 to 2003 (USGS Gage #11166000). This long flow record provides a valuable resource for understanding the hydrology of the site, but it does not include flow diversions into Matadero Creek from Barron Creek for nearly all years that it was active. This limits its usefulness for estimating low frequency, higher flood flow design events. However, the gage provides a good estimate of more frequent events, like the 1.5-year recurrence interval peak flow, which is frequently used as an analog to represent the geomorphic bankfull discharge for stream restoration design.

Peak flow rates from the period of record at the USGS gage were used to estimate recurrence interval and annual exceedance probability of frequent flow events. Peak flows were ranked from largest to smallest. Recurrence interval, T, was calculated by dividing the rank of the flow, m, by the quantity 1 plus the total number of years, $n = 63$. Annual exceedance probability, P, was calculated by finding the inverse of the recurrence interval, $1/T$. Flow magnitudes calculated in this manner for the 1.5- , 2.0- and 10-year events for renaturalization of Matadero Creek are summarized in Table 1.

Schaaf and Wheeler’s engineering analysis to support Valley Water’s redesign of Matadero Creek in 2002 took into consideration the effect of the Barron Creek bypass on design flow magnitudes (Schaaf & Wheeler, 2002). Their estimate of the 100-year peak flow is listed in Table 1 and applied in this analysis of design alternatives. The 2002 study estimated that the 100-year flow is significantly larger than reported in the FEMA FIS. The FEMA study used regional regression equations to estimate the 100-year flood, not taking into account the diversion at Barron Creek.

Table 1. Peak flow magnitudes downstream of El Camino Real

Recurrence Interval (yr.)	Annual Exceedance Probability (%)	Flow Rate (cfs)	Source
1.5	67%	300	Peak Flow Data Analysis
2	50%	400	Peak Flow Data Analysis
10	10%	900	Peak Flow Data Analysis
100	1%	2,700	(Schaaf & Wheeler, 2002)

Neither the FEMA FIS nor Schaaf and Wheeler study reported flow changes in Matadero Creek due to the presence of the Matadero bypass, also known as the Stanford Channel (Valley Water, 1993). However, examination of HEC-2 hydraulic model input data provided by Schaaf and Wheeler reveals that roughly half of the flow from Matadero Creek enters the bypass at Bol Park, and re-enters the mainstem just downstream of El Camino Real. Our design evaluation incorporates hydrology inputs that reflect the bypass discharge amount and location.

The 100-yr peak flow in the main stem of Matadero Creek, upstream of El Camino Real, is 1,100 cfs (Schaaf & Wheeler, 2002). This relatively low flow in the main stem of Matadero Creek upstream from El Camino Real has implications for the hydraulics discussed below and in Appendix A. Increased water surface elevations at the outlet of the El Camino Real culvert are expected to result in backwater upstream of the culvert.

6 Hydraulics

Hydraulic modeling was performed for Matadero Creek using HEC-RAS, a one-dimensional (1D) model developed by the US Army Corps of Engineers. The model was developed from an earlier version from FEMA, programmed using HEC-2, a pre-cursor to HEC-RAS, using as-built channel and bridge geometry. The model cross sections and bridge information was imported into HEC-RAS and georeferenced. The model extends from the headwaters of Matadero Creek, above Bol Park, to the Palo Alto Flood Basin in San Francisco Bay. The model was used to evaluate the flood capacity of the existing channel, and quantify and compare the concept alternatives' effects on water surface elevations, velocity and shear stress.

Flood damage reduction channels like Matadero Creek are required by FEMA and Valley Water to provide a certain amount of freeboard during the design flow, typically the 100-year flow event. Freeboard accounts for uncertainty in the 100-year flow rate and the estimated water surface elevation, due to issues such as debris wracking on bridges, sedimentation, and in-channel vegetation. Freeboard is usually expressed in feet above the design flood elevation. Contemporary FEMA requirements stipulate that floodwalls shall have at least 1 foot of freeboard above the base flood elevation (100-year event). Valley Water requires 3.5 feet freeboard along floodwalls and levees, and 4 feet within 100 feet of bridges.

The 100-year flood event was modeled using the existing geometry of Matadero Creek, and the five proposed scenarios, using the 1D HEC-RAS model. A Manning's roughness value of 0.015 was used to represent the concrete lined channel, consistent with the values used in the FEMA model. Roughness was increased to 0.018 in the vicinity of the 90 degree channel bends downstream of Park Boulevard and upstream of the railroad crossing.

The model indicates that the existing channel will not likely contain the 100-year event *with adequate freeboard* relative to the conservative criteria of Valley Water and FEMA. The existing 100-year water surface elevations likely exceed the elevations of the bridge soffits in the study area, including Alma Street, Park Boulevard, Lambert Avenue and El Camino Real. Channel bank elevations are expected to be overtopped at multiple locations between El Camino Real and Park Boulevard. Documentation of hydraulics analytical methods and results is provided in Appendix A.

7 Stakeholder Input

The five Matadero Creek naturalization options will be presented at public hearings to the Planning and Transportation Commission and City Council in conjunction with the NVCAP draft plans. The City Council will ultimately decide which naturalization option should move forward. When staff begins the implementation process to fully design and construct the creek naturalization project, it will be subject to a thorough design review and CEQA review process, which includes opportunities for the public to participate.

7.1 Valley Water

Information provided by Valley Water in spring of 2019 (Arroyo, 2019) state that any changes to the Matadero Creek flood protection facility must not:

- Increase Valley Water's maintenance costs
- Reduce maintenance access
- Reduce the level of flood protection currently provided by the channel
- Create channel instability

Additionally, Valley Water has stated that any proposal must:

- Include a net benefit to Valley Water
- Include the reservation of lands in Valley Water fee title for Valley Water's use in fulfilling future mitigation planting requirements for its stream maintenance program
- Provide sufficient additional right-of-way to Valley Water to operate and maintain the modified facility, including all areas required to contain the same level of flood protection currently afforded
- Include regulatory permitting
- Provide appropriate mitigation that does not include use of Valley Water right-of-way for mitigation planting
- Provide a geomorphically stable channel, not increasing erosion or sediment deposition

7.2 NVCAP Working Group

The NVCAP Working Group included a diverse group of 14 citizens led by the City of Palo of Alto, including residents, property owners, members of the Architectural Review Board, Parks and Recreation Commission and the Planning & Transportation Commission. WRA attended meetings from October 2019 to December 2019 and assisted with identification of problems, opportunities, objectives and constraints related to the project, as summarized below in Table 2.

Community members were generally enthusiastic about the prospect of renaturalizing a portion of Matadero Creek, expressing a dedication to beautifying the area, improving the natural environment, creating habitat for aquatic and riparian species, and providing additional recreational opportunities. The primary concerns raised related to public safety (flooding and drowning during stormwater runoff events), feasibility, cost, maintenance, and the groundwater plume.

Table 2. Problems, opportunities, objectives and constraints identified during working group meetings

Problems	• Poor Habitat • Poor Aesthetics • No Recreational Access • No Geomorphic Function
Opportunities	• Site Redevelopment • 340 Portage • 3350 Birch • Boulware Park
Objectives	• Create Riparian Habitat • Beautify the Creek Corridor • Provide Mitigation Planting • Provide Public Access
Constraints	• Channel stability • Cost (Design, Construction, Maintenance and Monitoring) • Property Ownership • Flood Conveyance • Public Safety • Groundwater Plume • Maintenance Access

7.3 Sobrato

The Sobrato Organization is the primary property owner within the NVCAP, including the 340 Portage parcel (formerly Fry's Electronics). Discussions with their representatives have highlighted community needs for additional housing and retail space, as well as balancing economic benefits of redevelopment of the area against environmental benefits. In particular, it was noted the community must consider the opportunity costs of setting aside acreage for open space, recreation and habitat in exchange for loss of additional affordable housing.

8 Reference Projects

Efforts to renaturalize urban creeks similar to Matadero Creek are on-going and have been successfully implemented elsewhere in California and within the Valley Water service area. The challenges faced and outcomes observed provide useful context for planning and design of a project in the City of Palo Alto.

8.1 Valley Water Example Projects

8.1.1 Hale Creek

Hale Creek is similar in size to Matadero Creek, and is currently a trapezoidal concrete channel, with little apparent habitat or aesthetic value. A typical section is presented in Figure 3. Valley Water has prepared 90% plans for renaturalization of a 650 ft long reach of Hale Creek near Los Altos (Valley Water, 2018). The design includes: demolition of the existing concrete channel; installation of new, set-back vertical concrete walls; replacement of the concrete channel bed with an earthen bottom including an inset bankfull channel; and, riparian plantings on the adjacent surface. The proposed channel would occupy the entire width of the Valley Water right-of-way.

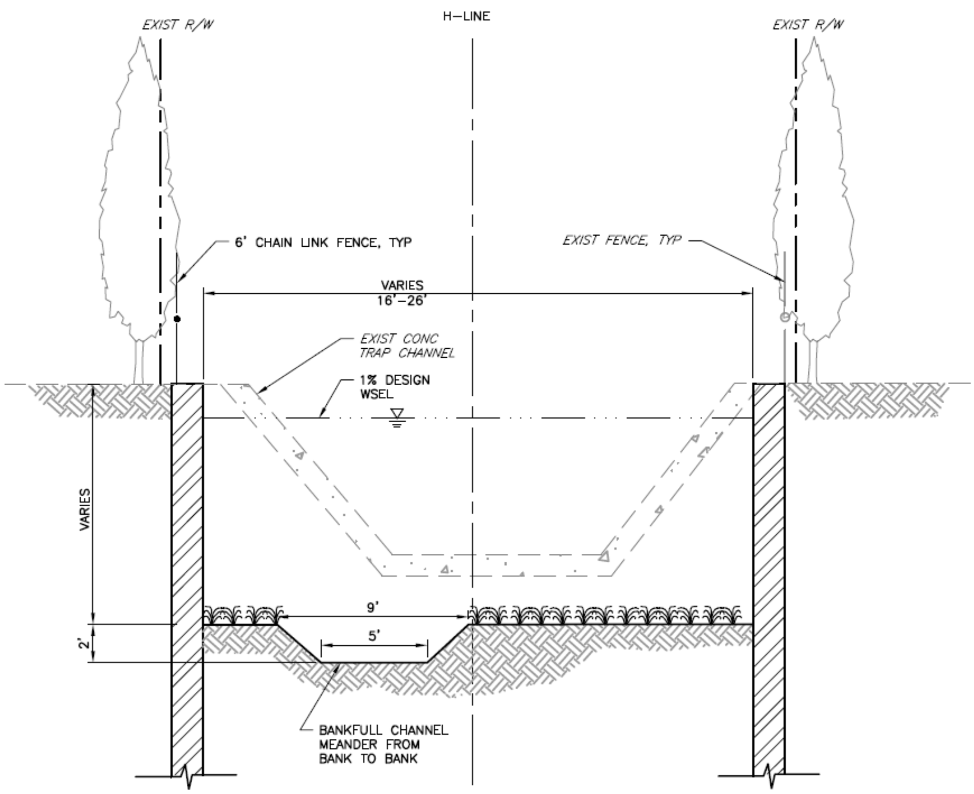

Figure 3. Section view comparing 90% design of Hale Creek to existing conditions

8.1.2 Permanente Creek

Permanente Creek has an existing narrow U-shaped concrete channel (Figure 4). Valley Water has prepared a description, conceptual renderings and section views of a proposed riparian restoration and public trail extension project between Highway 101 and Middlefield Road in Mountain View, CA. The existing U-shaped concrete channel would be removed and replaced by a new concrete bank would be built at ½:1 side slope east of the channel (Figure 4). An earthen bankfull channel (sized to convey the 1.5-yr flow of 180 cfs) and a vegetated floodplain and vegetated bank would be created on the west side of the channel. A 12-foot wide path for pedestrian and maintenance access would be built on the concrete bank side of the channel, along with a safety fence Figure 4. A rock riffle invert stabilization structure would be built at every 0.5 foot rise along the channel bottom. The expected maintenance would include weed and graffiti control for the trail and concrete bank, bank repair for the natural bank as needed over time, and vegetation maintenance.

Figure 4. Comparison of existing conditions (upper) with a conceptual rendering (lower) of an enhanced Permanente Creek between Highway 101 and Middlefield Road in Mountain View, CA

8.2 San Luis Obispo Creek

San Luis Obispo Creek in downtown San Luis Obispo, CA, is an example of a successfully implemented project with similar constraints to Matadero Creek. The creek is highly constrained by infrastructure and private property, and concrete channels provide channel stability and flood conveyance upstream and downstream of the restored reach. Prior to restoration, the earthen channel banks were unstable, with little riparian vegetation and habitat value (Figure 5). Considerable amounts of riparian vegetation were lost due to bank erosion, which contributed fine sediment to the flow and degraded water quality.

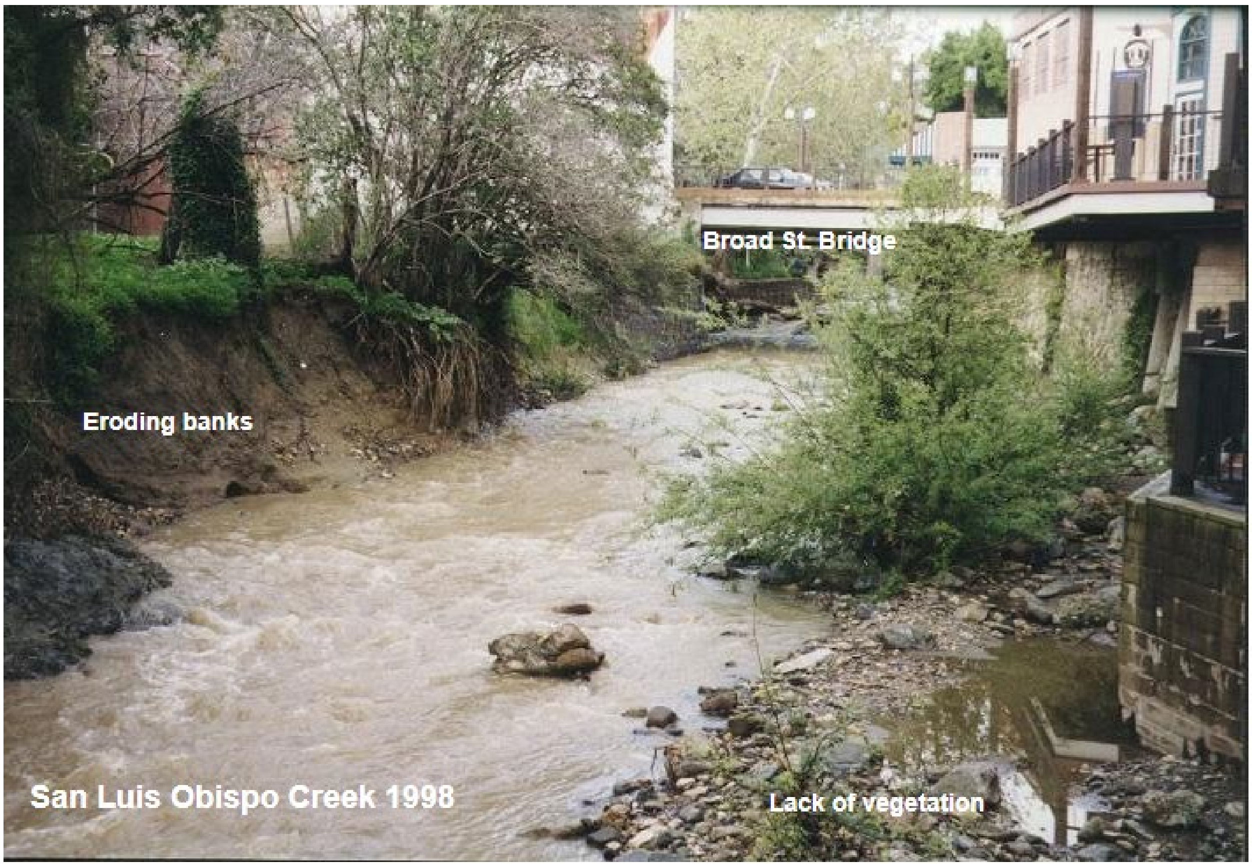

Figure 5. San Luis Obispo Creek, prior to restoration, 1998 (photo by Don Funk)

The renaturalization project goals for San Luis Obispo Creek, home to native Central California Coast Steelhead trout (*Oncorhynchus mykiss*), included stabilizing the channel and banks, providing recreational access, creating aquatic and riparian habitat, and improving aesthetics. The project involved the construction of a series of rock vanes and rock weirs constructed from boulders, as well as extensive landscaping and installation of pedestrian trails and picnic areas. The project was implemented during the summer low flow to reduce potential impacts on aquatic organisms. Example photos of the finished project are presented in Figure 6 and Figure 7.

Figure 6. San Luis Obispo Creek Pedestrian Bridge

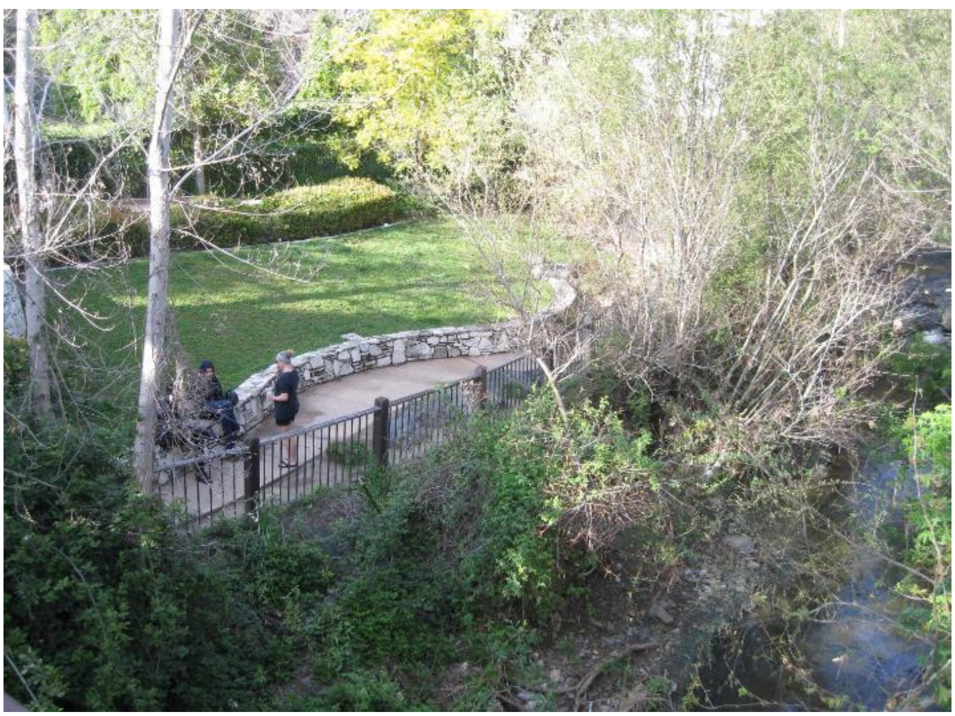

Figure 7. San Luis Obispo Creek Pedestrian Trail

9 Concept Design Summaries

Five alternative concepts have been prepared for the Matadero Creek project reach. All of the concepts include demolition and removal of the existing U-shaped concrete channel, installation of an earthen channel bottom, riparian plantings, access for recreation and maintenance, and floodwalls to mitigate flood risk. The replacement concrete walls will include plantable cellular concrete retaining walls. These allow for planting with native herbaceous flowering plants preferred by pollinators, and may be less vulnerable to graffiti. An example of a plantable concrete retaining wall is presented in Figure 8.

Figure 8. Example of plantable concrete retaining wall structure in San Diego, California (Soil Retention, 2020)

All concepts would establish a geomorphic bankfull channel as an inset channel within the overall flood channel bottom. The geomorphic bankfull channel would be sized to convey flows expected to occur often (i.e., on a regular, nearly annual frequency). The bankfull flow would be somewhat less than the 1.5-year peak flow of 300 cfs (Table 1). Flows larger than this magnitude would begin to inundate the adjacent earthen surface across the flood channel bottom to the plantable concrete walls. The specific channel size and shape, and the centerline alignment (i.e., planform) will be developed further as engineering and design progresses. At a conceptual level of design, the geomorphic channel is roughly sized to have a 25 ft bottom width and be about 3 feet deep.

All concepts would install step-like structures in the channel bed constructed from boulders (i.e., rock vanes or rock weirs) to provide vertical stability for the channel. They would occur at intervals along the channel length throughout the project reach. The specific dimensions, spacing, and rock sizing for these features would be determined at a later stage of engineering and design, but approximate locations are depicted on the concept plans.

The primary features, benefits, cost, and potential issues for each of the five concepts are described in the following section. Assessment of the flood performance of each concept is summarized below, with additional details available in Appendix A.

9.1 Concept 1 – Enhanced Easement Corridor

Concept 1 would expand the channel corridor width to the boundaries of the existing Valley Water easement, which is 60 feet wide from Park Boulevard to Lambert Avenue. This would double the channel width relative to the existing 30-foot wide concrete channel. A section view of Concept 1 is presented in Figure 9. A plan view of Concept 1 is presented in Figure 10.

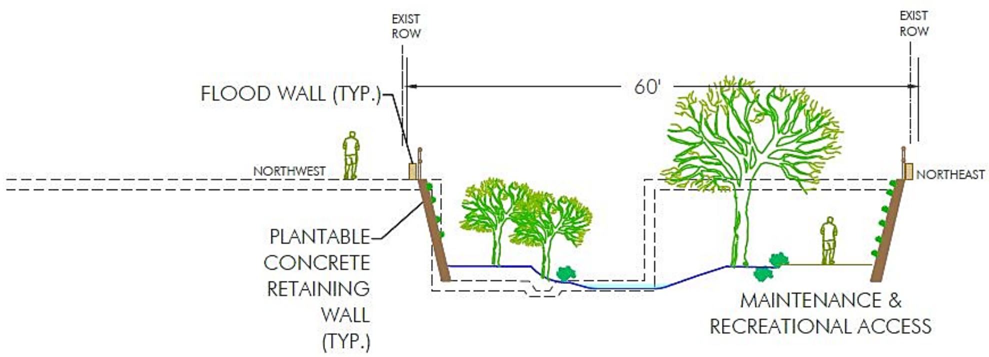

Figure 9. Section View of Concept 1 and Concept 1A

Hydraulic modeling indicates that Concept 1 would increase water surface elevations along the project reach and upstream of El Camino Real by as much as one foot. Increases in water surface elevation could be mitigated between El Camino Real and Park Boulevard by floodwalls (see Figure 10). However, the narrow Valley Water easement and private parcels upstream of El Camino Real likely makes structural flood risk mitigation measures in that section infeasible. *Concept 1 is likely infeasible from a hydraulics perspective.*

9.2 Concept 1A – Enhanced Easement Corridor + Boulware Park Integration

Concept 1A would use the same section geometry as Concept 1 (Figure 9), but would extend further upstream as shown in Figure 11 to allow integration of portions of the City-owned 3350 Birch Avenue and Boulware Park properties. It includes replacing Lambert Avenue bridge with a longer span to better accommodate the wider channel (60 feet).

Hydraulic modeling indicates that Concept 1A would increase water surface elevations in some portions of the project reach by as much as one foot, but *decrease* water surface elevations upstream of El Camino Real by roughly 0.5 feet. Increases in water surface elevation may be mitigated between El Camino Real and Park Boulevard by floodwalls (see Figure 11), and no adverse effect would occur further upstream. *Concept 1A appears to be feasible from a hydraulics perspective.*

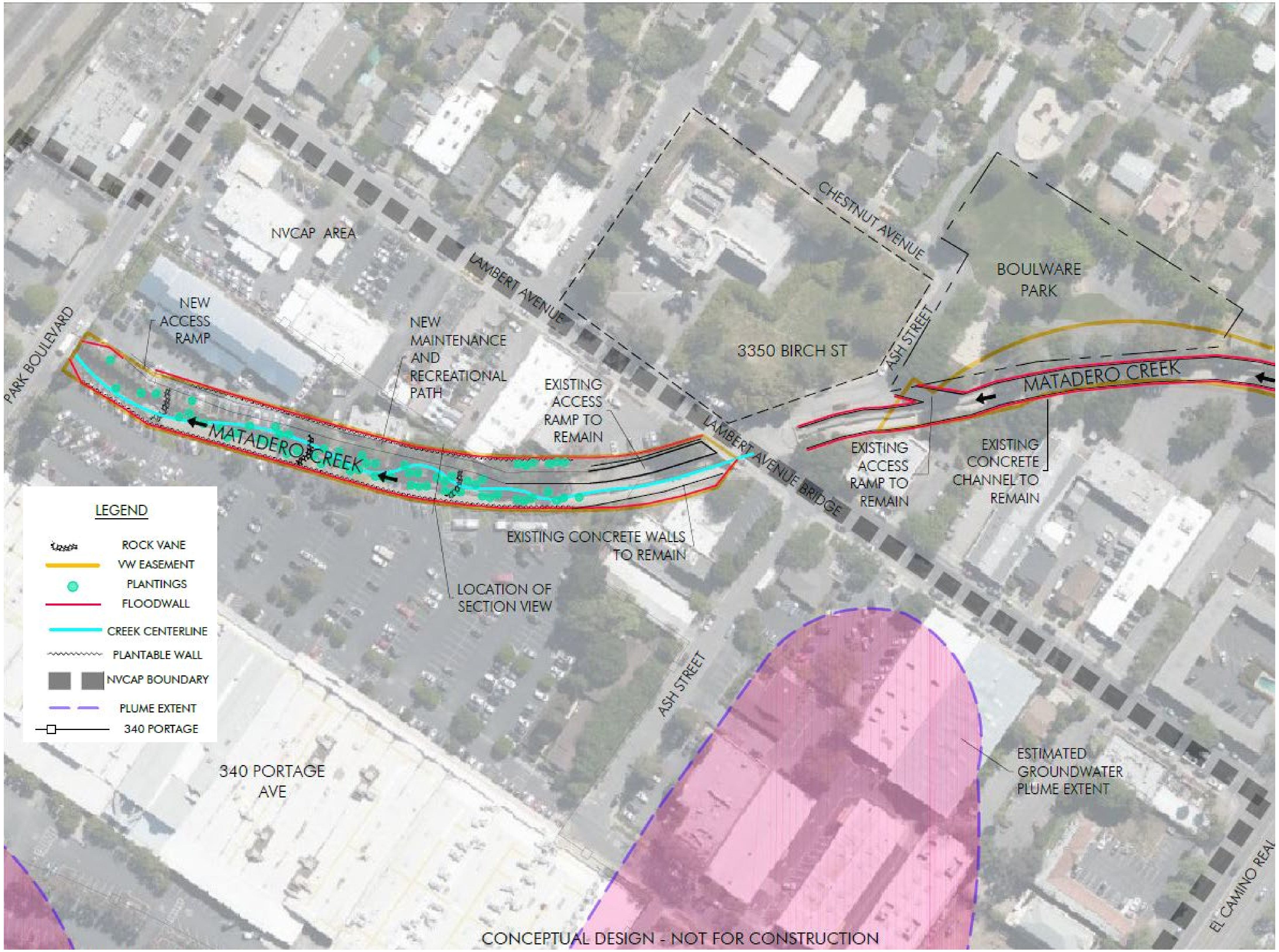

Figure 10. Plan View of Concept 1

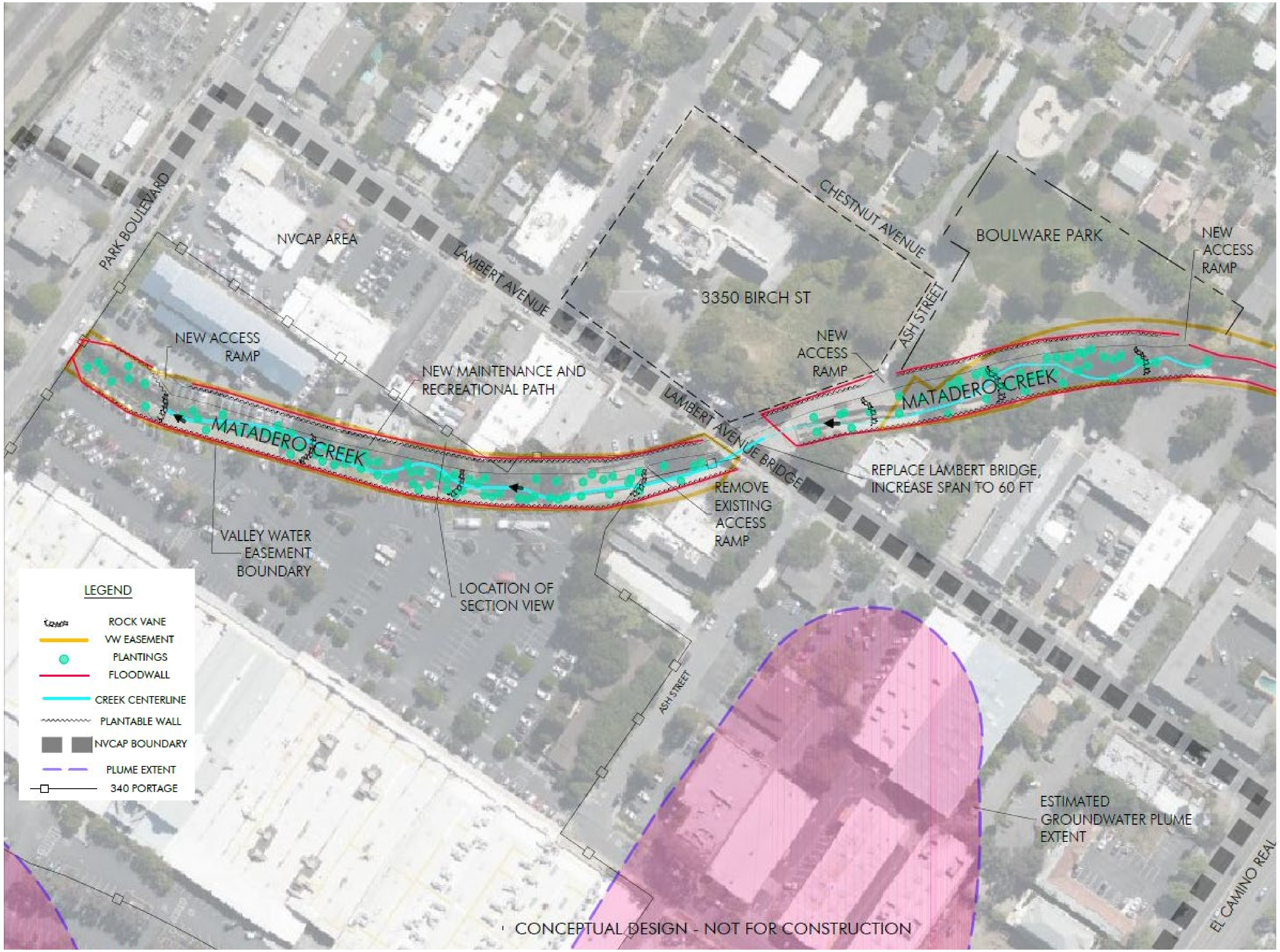

Figure 11. Plan view of Concept 1A

9.3 Concept 2 – Widened Corridor with Bank Angle Reduction

Concept 2 would emulate the aforementioned example of San Luis Obispo Creek. The left bank would be laid back at a 3:1 angle throughout much of the reach between Lambert Avenue and Park Boulevard, to a maximum corridor top width of 85 feet (Figure 12). The area available for riparian plantings, creative landscape architecture design and recreation access would be increased along the modified left bank slope as well as across the channel bottom within the existing right-of-way. A plan view of Concept 2 is presented in Figure 13.

Hydraulic modeling indicates that Concept 2 would increase water surface elevations along the project reach and upstream of El Camino Real by as much as one foot. Increases in water surface elevation could be mitigated between El Camino Real and Park Boulevard by floodwalls (see Figure 13). However, the narrow Valley Water easement and private parcels upstream of El Camino Real likely makes structural flood risk mitigation measures infeasible. *Concept 2 is likely infeasible from a hydraulics perspective.*

9.4 Concept 2A – Widened Corridor with Bank Angle Reduction + Boulware Park Integration

Concept 2A would use the same section geometry as Concept 2 (Figure 12), but would extent further upstream as shown in Figure 14 to allow integration of portions of the City-owned 335 Birch Avenue and Boulware Park properties. It includes replacing Lambert Avenue bridge with a longer span to better accommodate the increased channel width (i.e., 85 feet). Concept 2A would provide additional amenities to Boulware Park and facilitate a pedestrian corridor extending from Boulware Park to Park Boulevard.

Hydraulic modeling indicates that Concept 2A would increase water surface elevations in some portions of the project reach by as much as one foot, but *decrease* water surface elevations upstream of El Camino Real by roughly 0.5 feet. Increases in water surface elevation between El Camino Real and Park Boulevard may be mitigated by floodwalls (see Figure 14), and no adverse effect would occur further upstream. *Concept 2A appears to be feasible from a hydraulics perspective.*

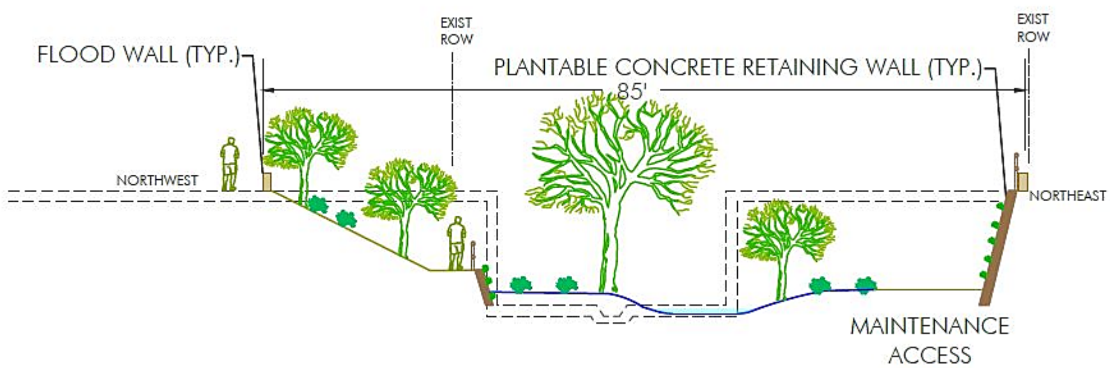

Figure 12. Section View of Concept 2 and Concept 2A

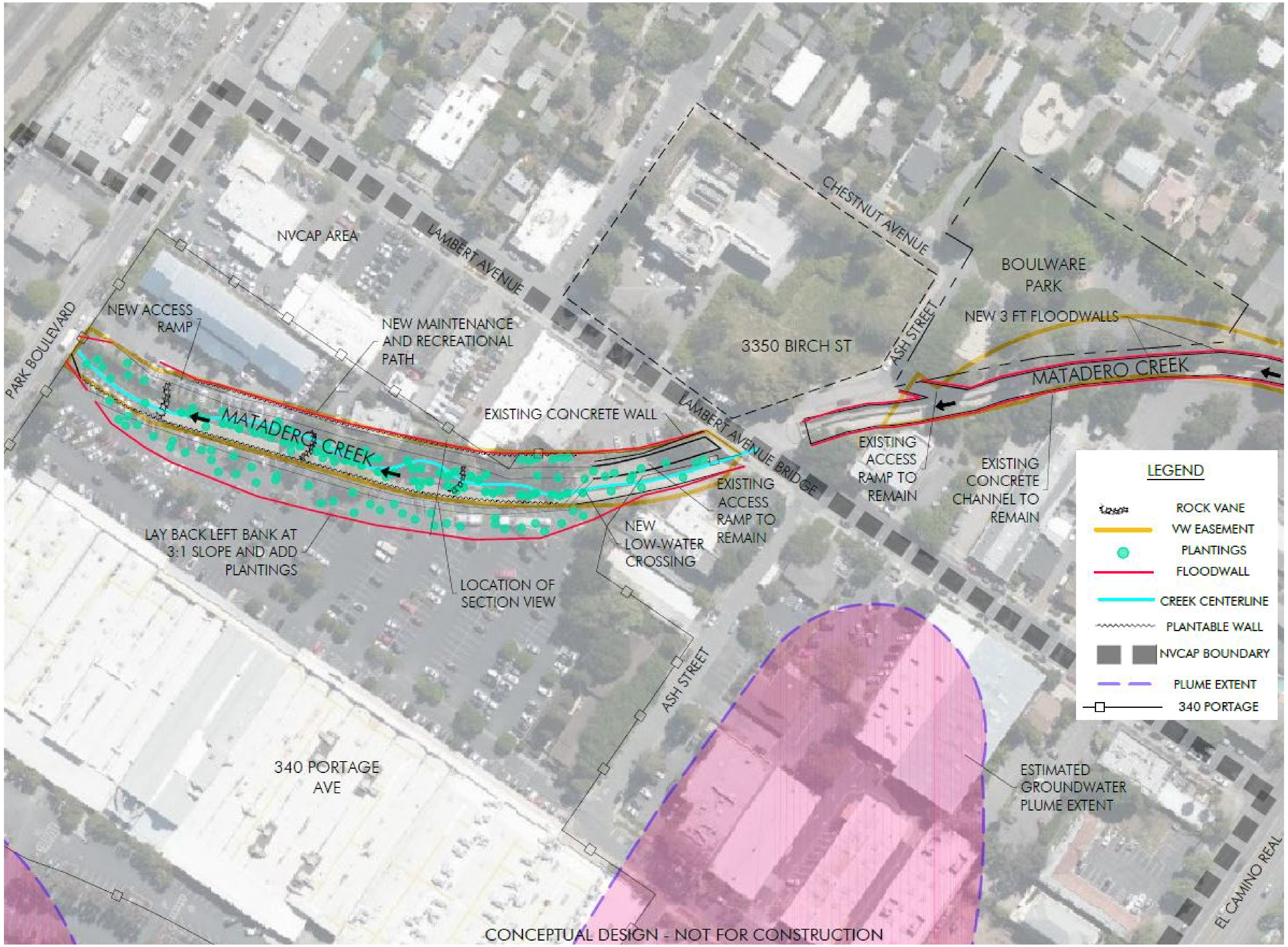

Figure 13. Plan View of Concept 2

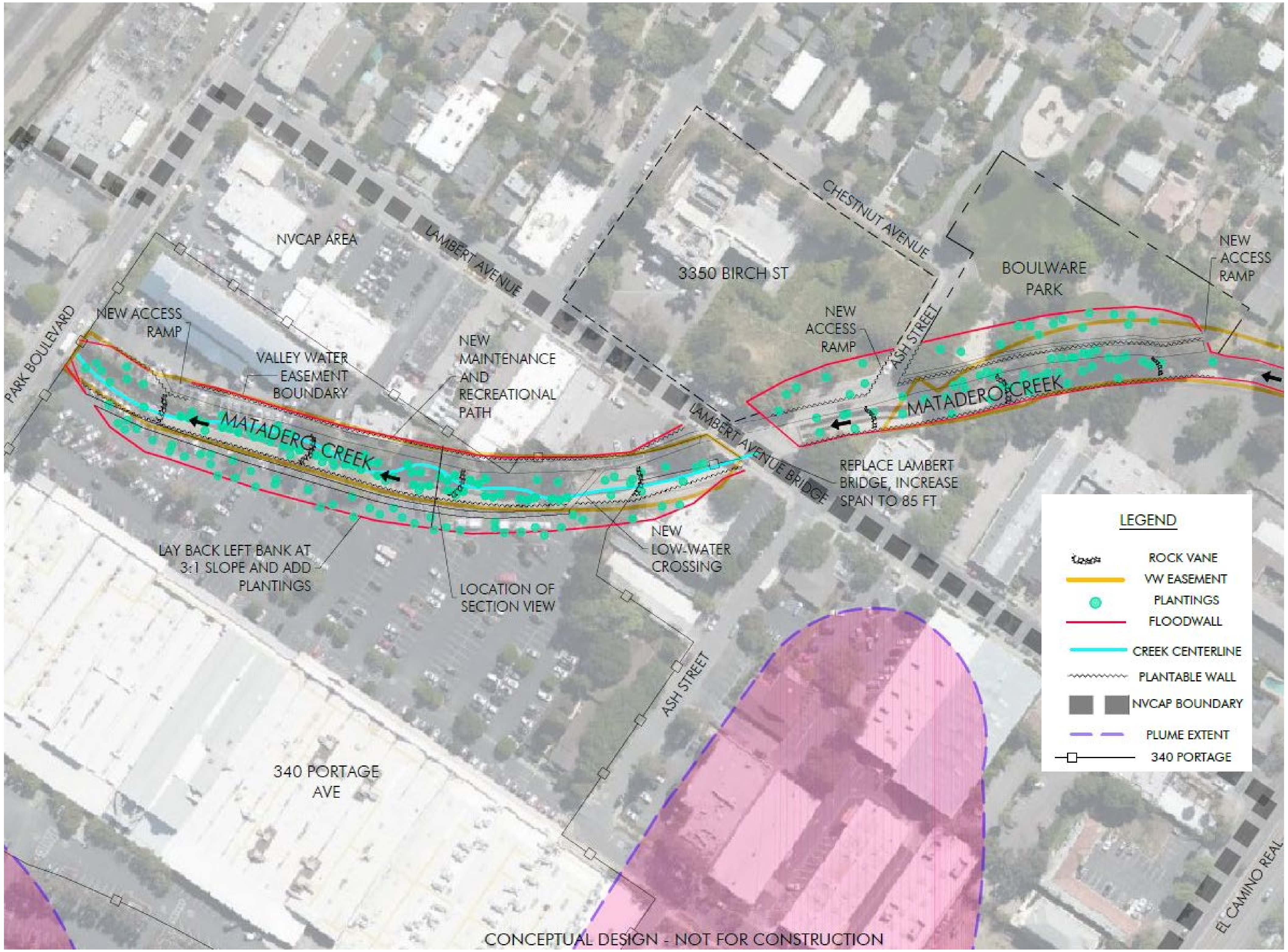

Figure 14. Plan view of Concept 2A

9.5 Concept 3 – Maximum Renaturalization

Concept 3 would seek to maximize the width allowed for the Matadero Creek ecosystem. The corridor would be widened to a top width of roughly 100 feet (Figure 15). The area available for riparian plantings, creative landscape architecture design and recreation access would be increased along the margin of the low elevation channel bottom adjacent to the inset geomorphic channel. Concept 3 extends upstream as far as Concepts 1A and 2A (Figure 16). It includes replacing Lambert Avenue bridge, with the longest proposed span (100 feet), to accommodate the wider corridor. As with Concepts 1A and 2A, pedestrian recreational path would extend from Boulware Park to Park Boulevard, passing under the longer Lambert Avenue bridge span.

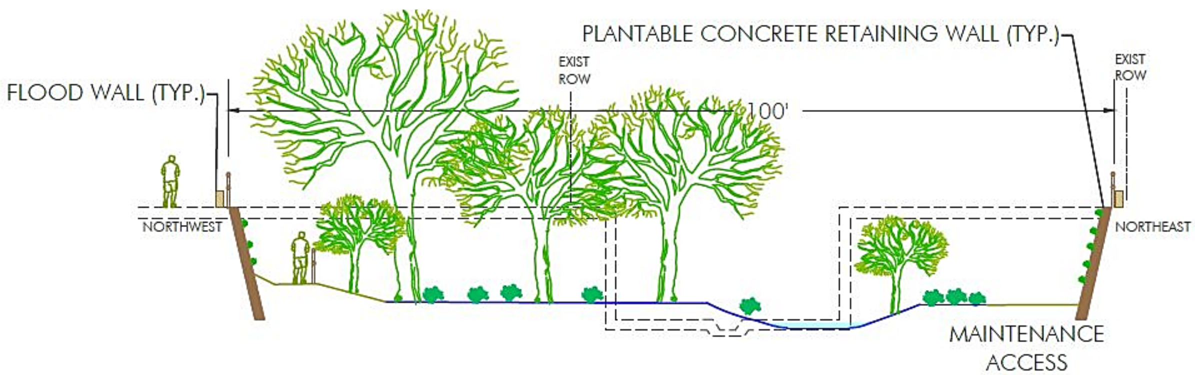

Figure 15. Section view of Concept 3

Hydraulic modeling indicates that Concept 3 would increase water surface elevations in some portions of the project reach by as much as one foot, but *decrease* water surface elevations upstream of El Camino Real by more than 0.5 feet and *decrease* water surface elevations in some areas between Lambert Avenue and the El Camino Real by around 0.5 feet. Increases in water surface elevation between Lambert Avenue and Park Boulevard may be mitigated by floodwalls, and no adverse effect would occur further upstream. *Concept 3 appears to be feasible from a hydraulics perspective.*

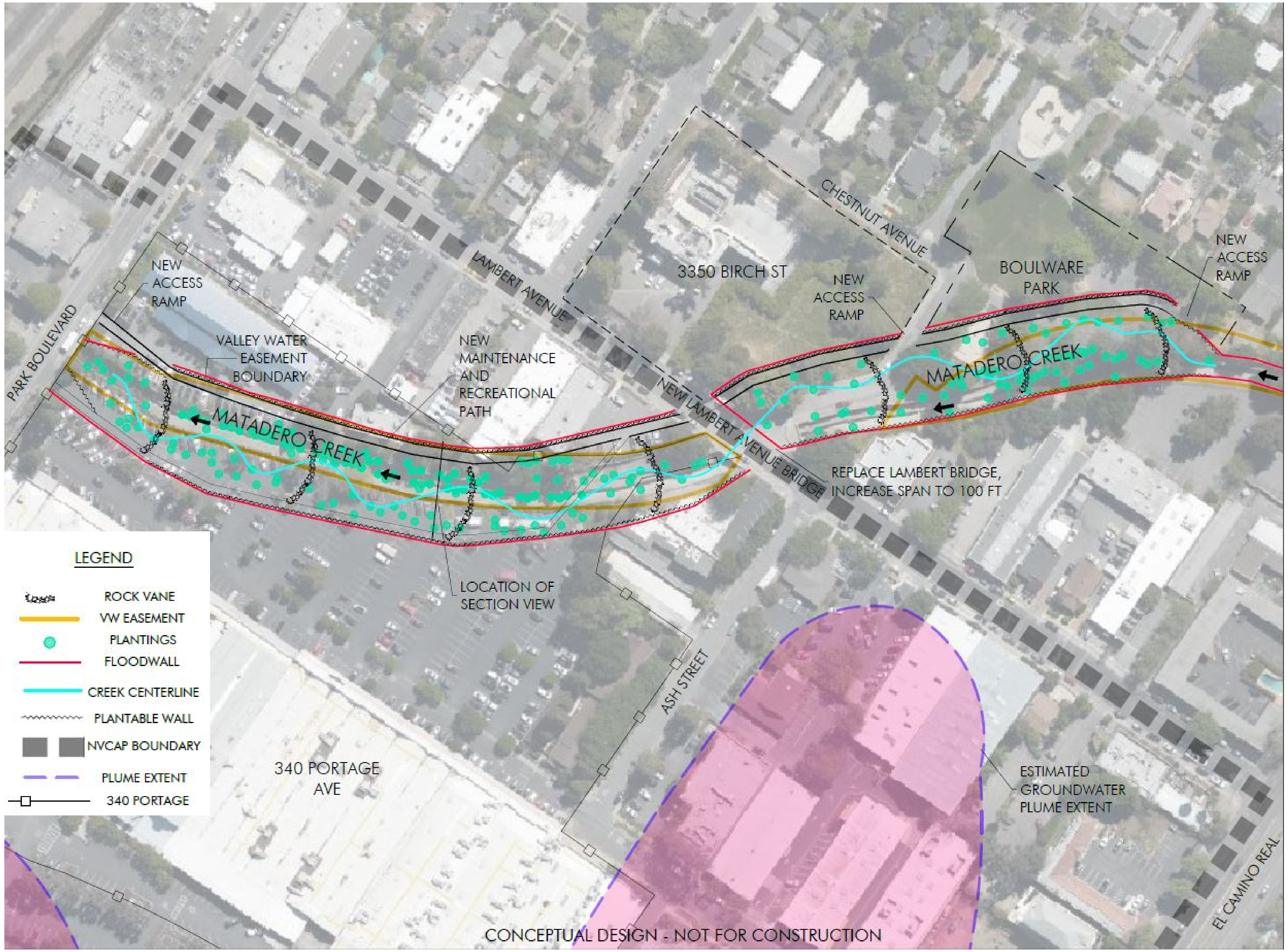

Figure 16. Plan view of Concept 3

10 Material Quantities

The quantities of various materials required for implementation of the conceptual designs were estimated, including, but not limited to: real estate acquisition, demolition, earthwork, retaining walls, access paths and ramps, floodwalls, and bridges. Volumes, areas, and linear feet of project features were estimated using the concept design drawings, developed in AutoCAD Civil 3D. This concept-level accounting of material quantities provides the basis for initial planning-level budgetary cost estimates.

11 Cost Estimates

Cost estimates were developed for each of the five concept designs by applying RSMEANS construction cost estimating software's database of unit costs and professional judgment based on recent civil engineering projects in the San Francisco Bay Area (Table 3). Material quantities for all anticipated elements of each of the five designs were multiplied by unit costs, including normal overhead and profit to arrive at costs for each aspect of the design and total costs for the project. Multipliers were further added to the raw totals to account for design (20%), permitting (10%), construction management (10%), and contingencies (25%). Real estate acquisition costs were added separately based on the recently assessed value of the 340 Portage Avenue parcel per acre. The 12.53 ac property was assessed at $41,614,954 in June 2019 (County of Santa Clara, 2020), resulting in a unit cost of roughly $4M/ac, including a markup of 20% for overhead and profit. A complete breakdown of costs is provided in Appendix B.

While all of the costs are preliminary as is typical for a conceptual level of design, the real estate costs may have the largest degree of uncertainty. Demand for real estate in commercial areas of Palo Alto is extremely high, and the market value may exceed the assessed value and/or be subject to more rapid change than unit costs in some of the other cost categories.

Table 3. Budgetary cost summary based on conceptual designs

Design Alternative	Construction Cost	Total Cost
Concept 1	$2,000,000	$3,000,000
Concept 1A	$5,000,000	$8,000,000
Concept 2	$2,000,000	$5,000,000
Concept 2A	$6,000,000	$11,000,000
Concept 3	$8,000,000	$16,000,000

12 Conclusion

All five concept designs offer opportunities to improve habitat, aesthetics and recreation within the Matadero Creek corridor relative to existing conditions. The concepts have varied ability to also address the flood conveyance capacity needs, meet freeboard standards, and provide for required maintenance. Small scale approaches such as Concepts 1 and 2 are less feasible, since the local increased roughness from proposed vegetation along with the existing bridges configurations would hydraulically increase flooding upstream in areas where mitigation would be challenging. Approaches that would treat longer reaches of the creek also replace the bridge at Lambert Avenue with a longer span to match the wider channel corridor. The concepts that replace Lambert Avenue bridge (Concepts 1A, 2A and 3) avoid potential adverse flood water elevation changes upstream of El Camino Real and would all be hydraulically feasible. Water surfaces between Park Avenue and Lambert Avenue would be similar for these three designs. The water surfaces between Lambert Avenue and El Camino Real would differ slightly for each of these three concepts, decreasing as the replacement bridge span lengthens.

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APPENDIX A – HYDRAULIC MODELING

Matadero Creek Renaturalization

Hydraulic Modeling

Prepared for:

CITY OF PALO ALTO

Prepared by:

WRA ENVIRONMENTAL CONSULTANTS

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Contents

Tables

Figures

INTRODUCTION

Conceptual designs for renaturalization of Matadero Creek in Palo Alto, CA, were evaluated in terms of hydraulic performance to determine their feasibility. The existing U-shaped concrete channel, while providing little in the way of habitat natural stream function, is highly efficient for stormwater conveyance. Renaturalization would increase the roughness of the channel, as well as create expansion and contraction losses, increasing water surface elevations. These increases may be mitigated with channel widening and construction of floodwalls, where feasible. Five conceptual designs were evaluated, and compared to the existing conditions.

A summary of the concept designs is presented in Table 1.

Table 1. Concept design dimension summary

Name	Top Width (ft)	Replace Lambert Bridge?	Side Slope	Project Length (ft)
Existing	25	No	Vertical	N/A
1	60	No	Vertical	800
1A	60	Yes	Vertical	1,300
2	85	No	3:1	800
2A	85	Yes	3:1	1,300
3	100	Yes	Vertical	1,300

HYDROLOGY

The Matadero Creek watershed has a flow regime typical of streams in the San Francisco Bay area, which experiences a Mediterranean climate, with cool wet winters and relatively mild summers. Nearly all stormwater runoff occurs between the months of September and May. The creek may dry completely during summer months, and also experience significant flooding in the winter months in response to large, regional rainfall-runoff events.

The hydrology of the Matadero Creek watershed upstream of the study area is somewhat complicated due to a system of bypasses and interbasin transfers. Flows in Matadero Creek are diverted into an underground bypass at Bol Park, and return to the mainstem of Matadero Creek just downstream of El Camino Real, upstream of the study area. Flows are manually diverted from Barron Creek to Matadero Creek during large stormwater runoff events, to prevent Barron Creek from being flooded (Schaaf & Wheeler, 2002).

The United States Geological Survey operated a gage on Matadero Creek near Lambert Avenue intermittently from Water Year 1953 to 2003 (USGS Gage #11166000). This long flow record provided a valuable resource for understanding the hydrology of the site, but as it did not include flow diversions into Matadero Creek from Barron Creek for nearly all years that it was active, it is likely not an appropriate data set for estimating design flood flows. However, the gage likely provides a good estimate of more frequent events, like the 1.5-year recurrence interval flood, which is frequently used as an analog for the geomorphic bankfull discharge in stream restoration design.

According to the USGS, the Matadero Creek watershed drainage area is 7.25 square miles at Lambert Avenue. This parameter is useful in applying regional equations for determining suitable geometry of the renaturalized channel. Other available hydrologic data available for this study included a FEMA Flood Insurance Study (FIS) (FEMA, 2014), and the engineering report for Matadero and Barron Creeks (Schaaf & Wheeler, 2002).

Peak flow rates from the period of record at the USGS gage were used to estimate recurrence interval and annual exceedance probability of frequent flow events. Peak flows were ranked from largest to smallest. Recurrence interval, *T*, was calculated by dividing the rank of the flow, *m*, by the quantity 1 plus the total number of years, *n* = 63. Annual exceedance probability, P, was calculated by finding the inverse of the recurrence interval, 1/*T*. Flow magnitudes recommended for use in renaturalization of Matadero Creek are summarized in Table 2. Peak flow magnitudes are summarized in Table 2.

Table 2. Peak flow magnitudes in Matadero Creek, downstream of El Camino Real

Recurrence Interval (yr)	Annual Exceedance Probability (%)	Flow Rate (cfs)	Source
1.5	67%	300	Peak Flow Data Analysis
2	50%	400	Peak Flow Data Analysis
10	10%	900	Peak Flow Data Analysis
100	1%	2,700	(Schaaf & Wheeler, 2002)

An engineering analysis to support Valley Water's redesign of Matadero Creek in 2002 took into consideration the effect of the Barron Creek bypass on design flow magnitudes (Schaaf & Wheeler, 2002). The study determined that the 100-year flow is significantly larger than reported in the FEMA FIS, which used regional regression equations to estimate the 100-year flood, not taking into account the diversion at Barron Creek. Neither the FEMA FIS nor Schaaf and Wheeler study reported flow changes in Matadero Creek due to the presence of the Matadero bypass, also known as the Stanford Channel (Valley Water, 1993). However, examination of HEC-2 hydraulic model input data provided by Schaaf and Wheeler revealed that roughly half of the flow (1,600cfs) from Matadero Creek enters the bypass at Bol Park, and re-enters the mainstem just downstream of El Camino Real. Based on the HEC-2 model from Schaaf and Wheeler, the 100-yr peak flow in the mainstem of Matadero Creek, upstream of El Camino Real, is 1,100 cfs. This relatively low flow in the mainstem of Matadero Creek upstream from El Camino Real has significant implications for the hydraulics of the project concepts. , as increased water surface elevations at the outlet of the El Camino Real culvert are expected to result in backwater upstream of the culvert.

HYDRAULICS

Hydraulic modeling was performed for Matadero Creek using HEC-RAS, a one-dimensional model developed by the US Army Corps of Engineers. The model was developed from an earlier version from FEMA, programmed using HEC-2, a pre-cursor to HEC-RAS, using as-built channel and bridge geometry. The model cross sections and bridge information was imported into HEC-RAS and georeferenced.

Figure 1. Plan view of model geometry

The model extended from the headwaters of Matadero Creek, above Bol Park, to the Palo Alto Flood Basin, in San Francisco Bay. The model was used to evaluate the flood capacity of the existing channel, and quantify the effects of renaturalization on water surface elevations, velocity and shear stress.

Flood damage reduction channels like Matadero Creek are required by FEMA and Valley Water to provide a certain amount of freeboard above the design flow, typically the 100-year flow event.

Freeboard accounts for uncertainty in the 100-year flow rate, as well as the resulting water surface elevation, due to issues such as debris wracking on bridges, sedimentation, and in-channel vegetation. Freeboard is usually expressed in feet above the design flood elevation. Contemporary FEMA requirements stipulate that floodwalls shall have at least 1 foot of freeboard above the base flood elevation (100-year event). *Valley Water requires freeboard of 3.5 feet for floodwalls and levees, and 4 feet within 100 feet of bridges.* Valley Water provides additional details where the design water surface is below natural ground. One foot of freeboard for constructed, non-natural channels is acceptable where large amounts of vegetation are not anticipated in the channel. Valley Water also provides details concerning bridges. New bridges shall maintain the same freeboard as the existing or proposed channel either upstream of downstream, whichever is greater. Where an existing bridge or culvert can convey the design flow under pressure, it must be structurally sound and must be able to resist the resultant lateral and uplift forces (Valley Water, 2006). FEMA guidelines do not provide details for freeboard when the design water surface is below the natural bank (Schaaf & Wheeler, 2002).

The 100-year flood event was modeled using the existing geometry of Matadero Creek, and the five proposed scenarios, using the 1-dimensional HEC-RAS model. A Manning's roughness value of 0.015 was used to represent the concrete lined channel, consistent with the values used in the FEMA model. Roughness was increased to 0.018 in the vicinity of the 90 degree channel bends downstream of Park Boulevard and upstream of the railroad crossing. Roughness for proposed conditions in the channel reflect the presence of extensive plantings, maintained regularly through mowing, pruning and limbing-up of trees. Roughness values are summarized in Table 3.

Table 3. Manning's roughness values

Condition	Roughness Value
Existing Concrete Channel	0.015
Existing Channel Bends	0.018
Proposed Channel	0.060

A plot of water surface elevations under existing conditions is presented in Figure 2. The model showed that the existing channel does not likely contain the 100-year event with adequate freeboard. One foot of freeboard is not maintained between the bridges under existing conditions. The 100-year flow will likely result in water surface elevations exceeding the elevations of the existing bridge soffits in the study area, including Alma St., Park Blvd, Lambert Ave. and El Camino Real. Channel bank elevations are expected to be overtopped at multiple locations between El Camino Real and Park Blvd under existing conditions.

A comparison between water surface elevations for existing conditions and Concept 1 is presented in Figure 2. Concept 1 would increase backwater by about 1.5 ft due to increased roughness and the backwater effects of Lambert Bridge. This increase in backwater would be transmitted upstream of El Camino Real, beyond the existing Valley Water flood damage reduction project on Matadero Creek. While floodwalls could likely be built within the existing project area, the reach upstream of El Camino Real has private property along it. Construction of a flood risk mitigation project there would be difficult and expensive. Increasing flood risk in that reach by increasing backwater from the 100-yr event would require mitigation for that increase in risk. Therefore, Concept 1 is likely not feasible.

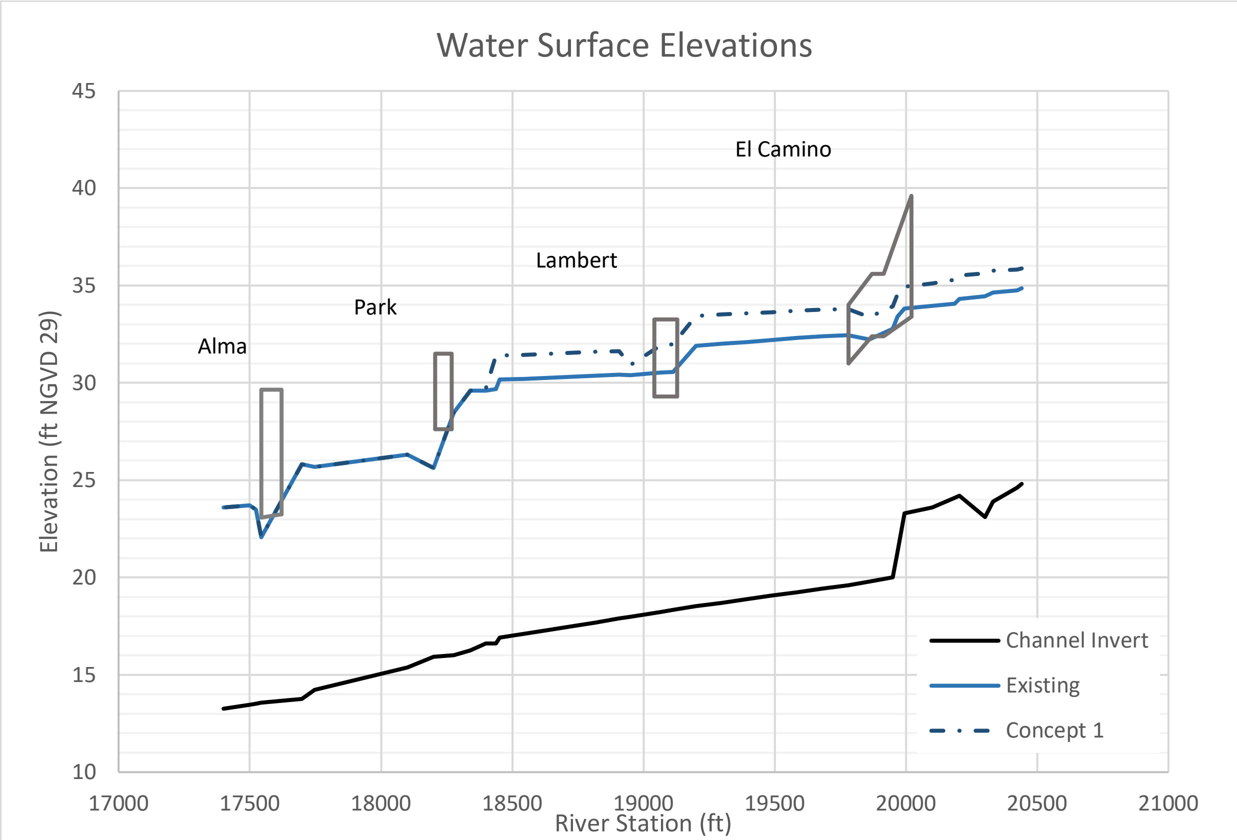


Figure 2. Water surface profiles of existing conditions and Concept 1

A comparison between water surface elevations for existing conditions and Concept 1A is presented in Figure 3. Water surface elevation profile for existing channel and Concept 1A. The backwater profile increases relative to existing conditions upstream of Park Blvd., and stays higher than existing conditions until near the upstream end of the project area. The channel expansion, and replacement of Lambert Bridge allow backwater effects to be confined to the Valley Water project area. Increased water surface elevations could likely be mitigated by floodwalls for Concept 1A.

A comparison between water surface elevations for existing conditions and Concept 2 is presented in Figure 4. As with Concept 1, backwater effects of the proposed project extend upstream of El Camino Real, likely making it unfeasible.

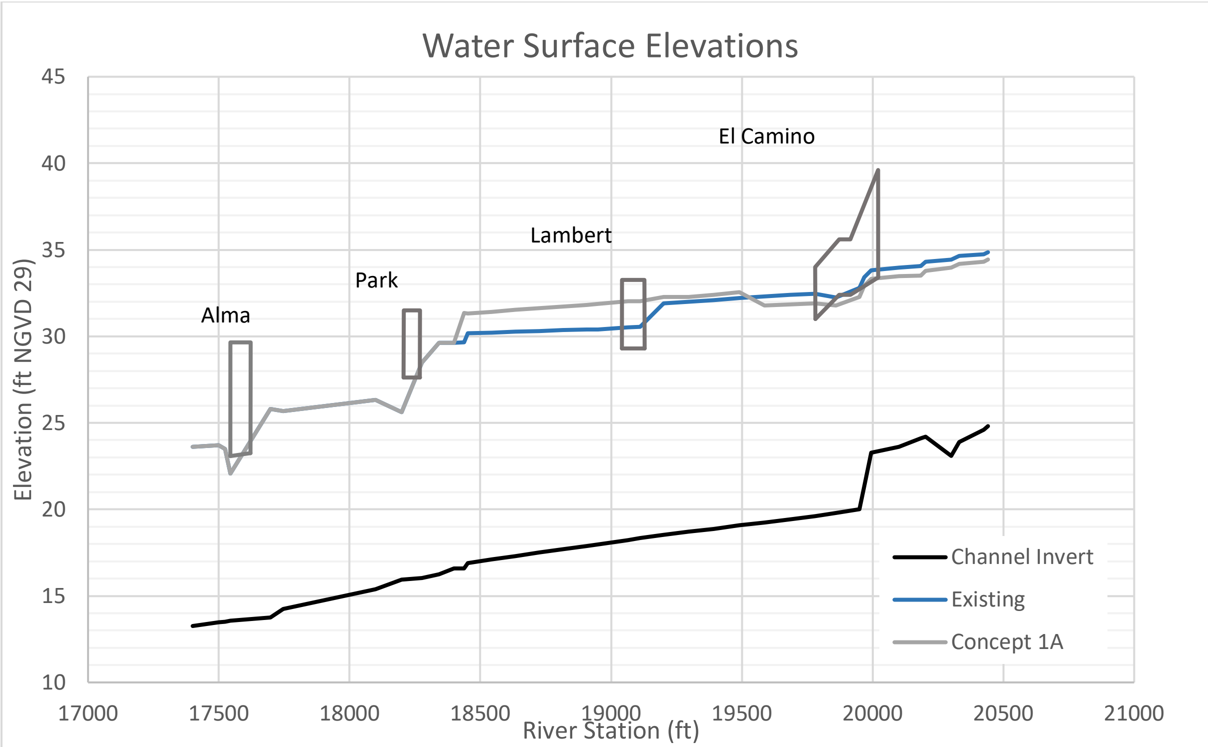


Figure 3. Water surface elevation profile for existing channel and Concept 1A

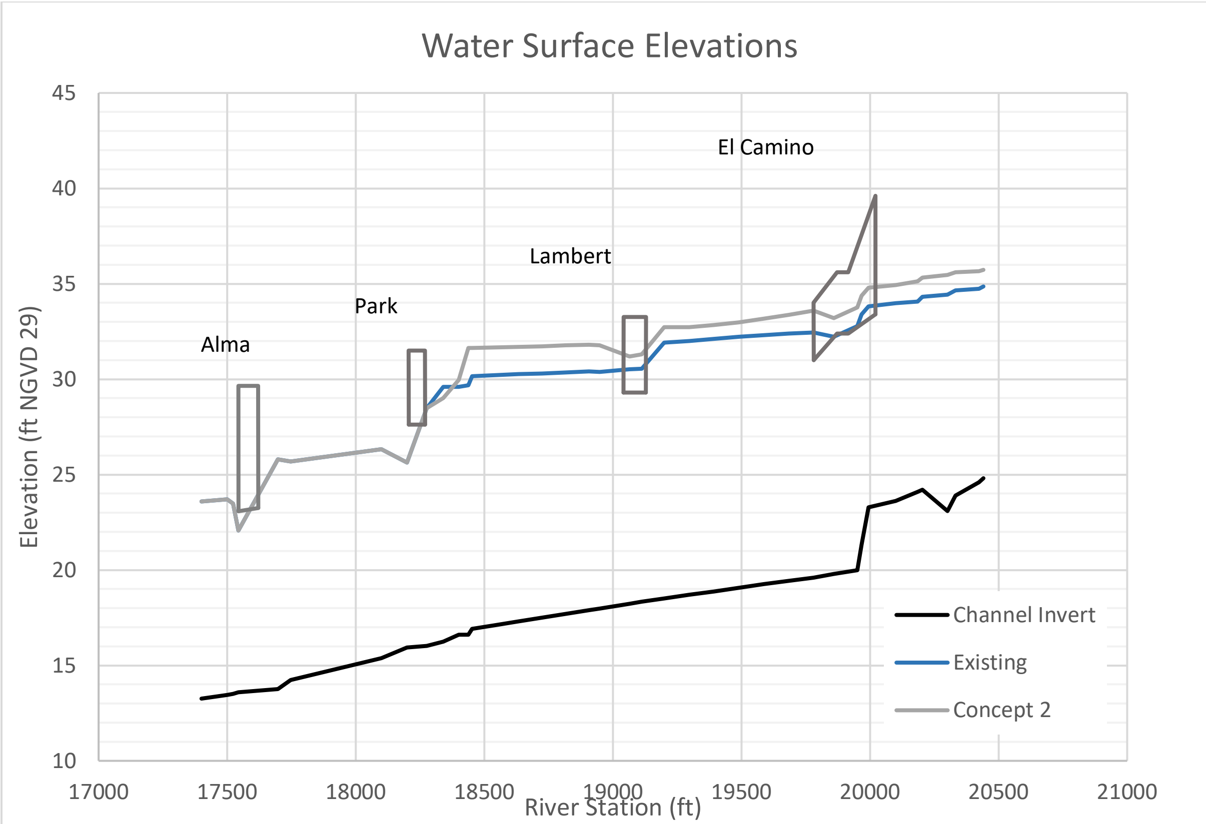


Figure 4. Water surface elevation profile for existing channel and Concept 2

A comparison between water surface elevations for existing conditions and Concept 2A is presented in Figure 5. As with Concept 1A, backwater effects of the proposed project appear to be confined to an area where the flood risk could be mitigated with floodwalls. Finally, a comparison between water surface elevations for existing conditions and Concept 3 is presented in Figure 6. Concept 3 would likely decrease backwater upstream of El Camino Real for a distance of approximately 1,000 ft.

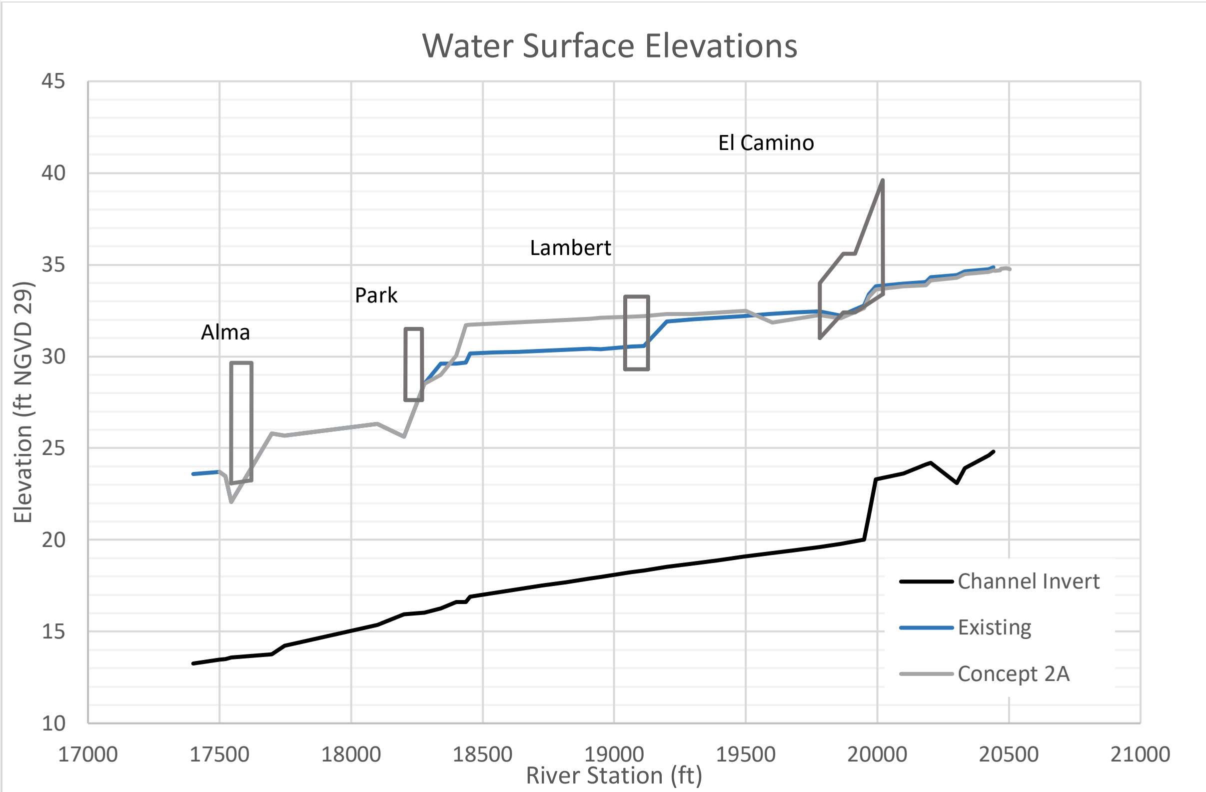


Figure 5. Water surface elevation profile for existing channel and Concept 2A

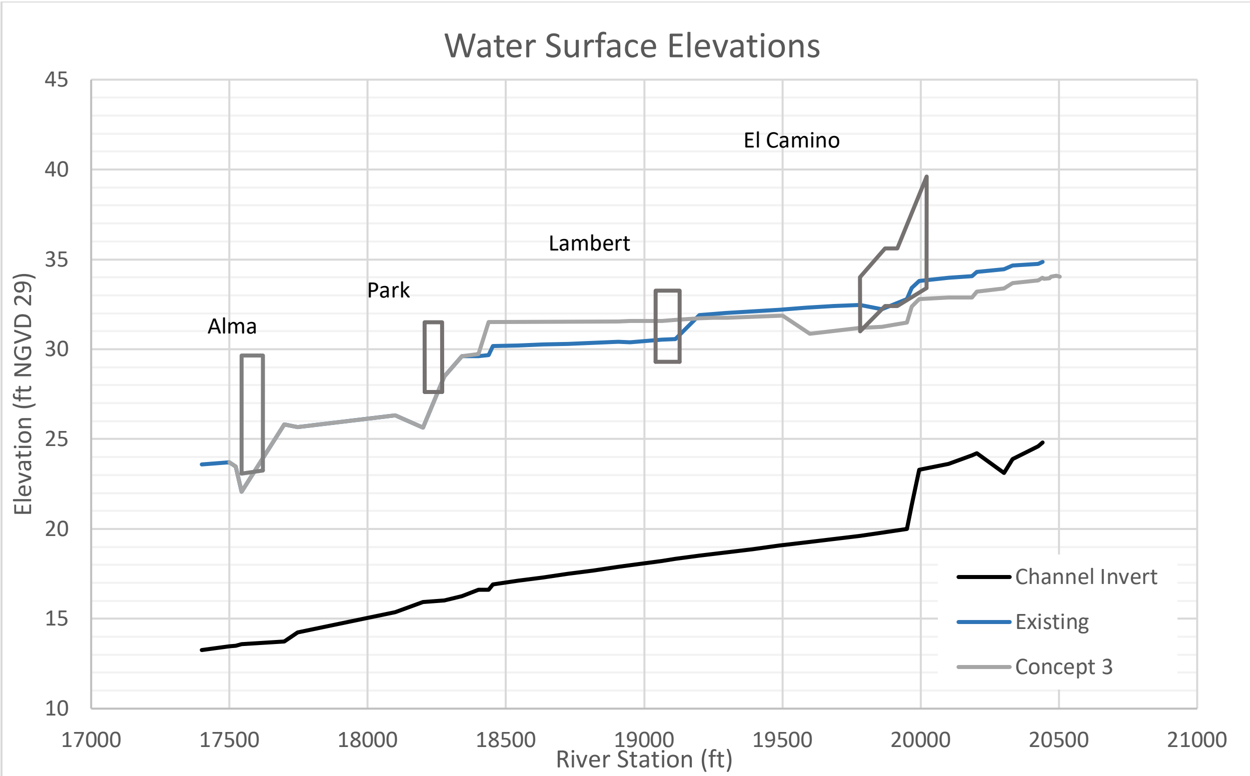


Figure 6. Water surface elevation profile for existing channel and Concept 3

The effects of the project on sediment transport were evaluated by comparing the with-project shear stress to existing conditions both within the project area, and upstream. Shear stress is the primary parameter used to evaluate sediment transport capacity. It can vary considerable within a reach and throughout the watershed. If a reach of interest has significantly lower shear stress than upstream reaches, that can be indicator that deposition is likely to occur in that reach. Conversely, if a reach of interest has significantly higher shear stress than upstream sediment supply reaches, that can be an indicator that the channel is likely to incise. Frequent events like the 1.5-year event are used for this evaluation because these frequent events tend to move the most sediment over time and are often considered to be the channel-forming discharge.

Comparisons of shear stress for existing and proposed conditions are presented in Figure 7 through Figure 11. Proposed shear stress values within the project area are circled in red. Shear stress values appear to be consistently lower for Concept 1 than existing conditions, and lower than the supply reach, indicating potential for sedimentation. The other proposed concepts are not expected to significantly impact sediment transport capacity relative to existing conditions.

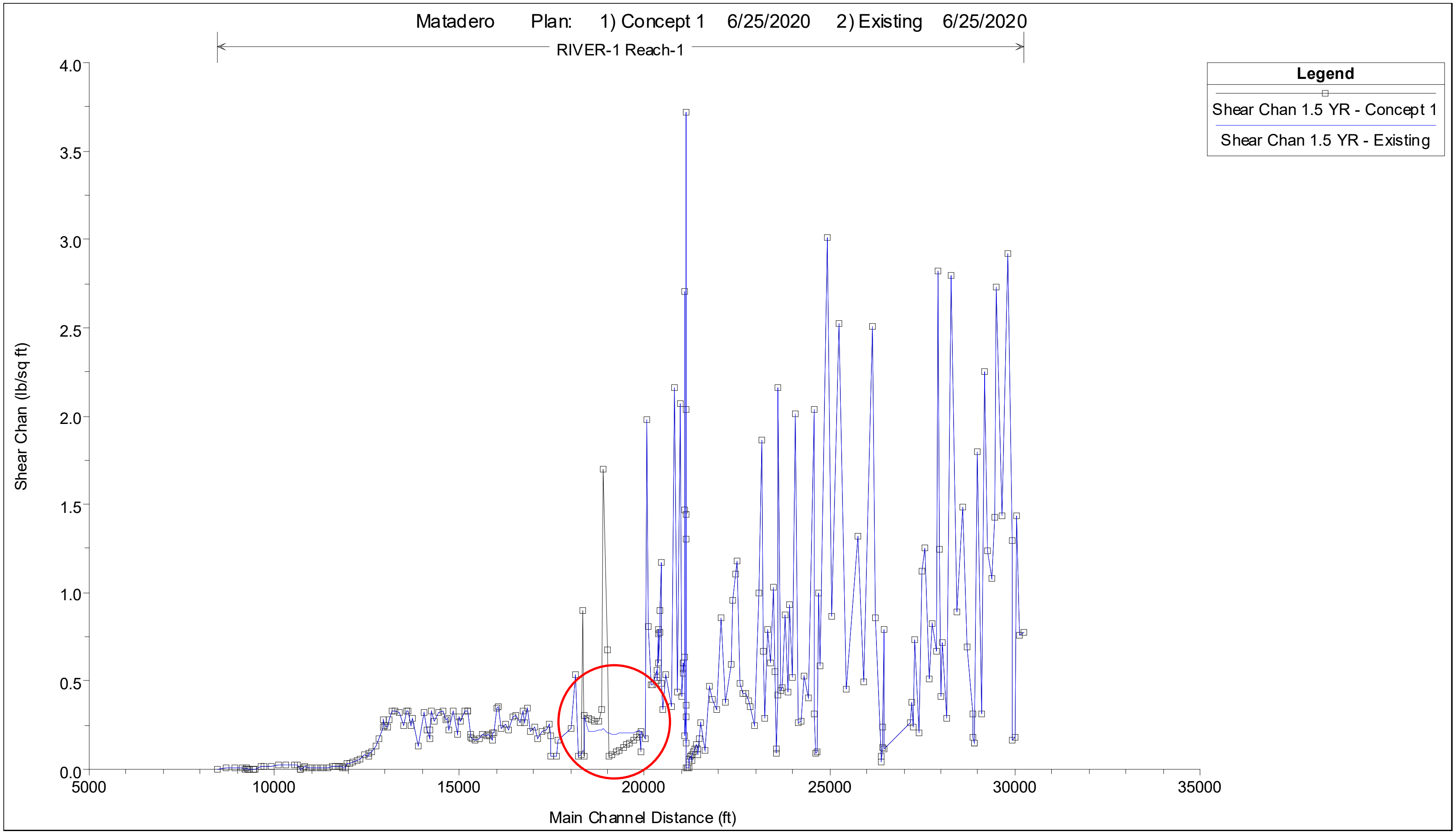


Figure 7. Comparison of channel shear stress (lb/ft^2) for a 1.5-yr recurrence interval event for existing conditions and Concept 1. Project area circled in red.

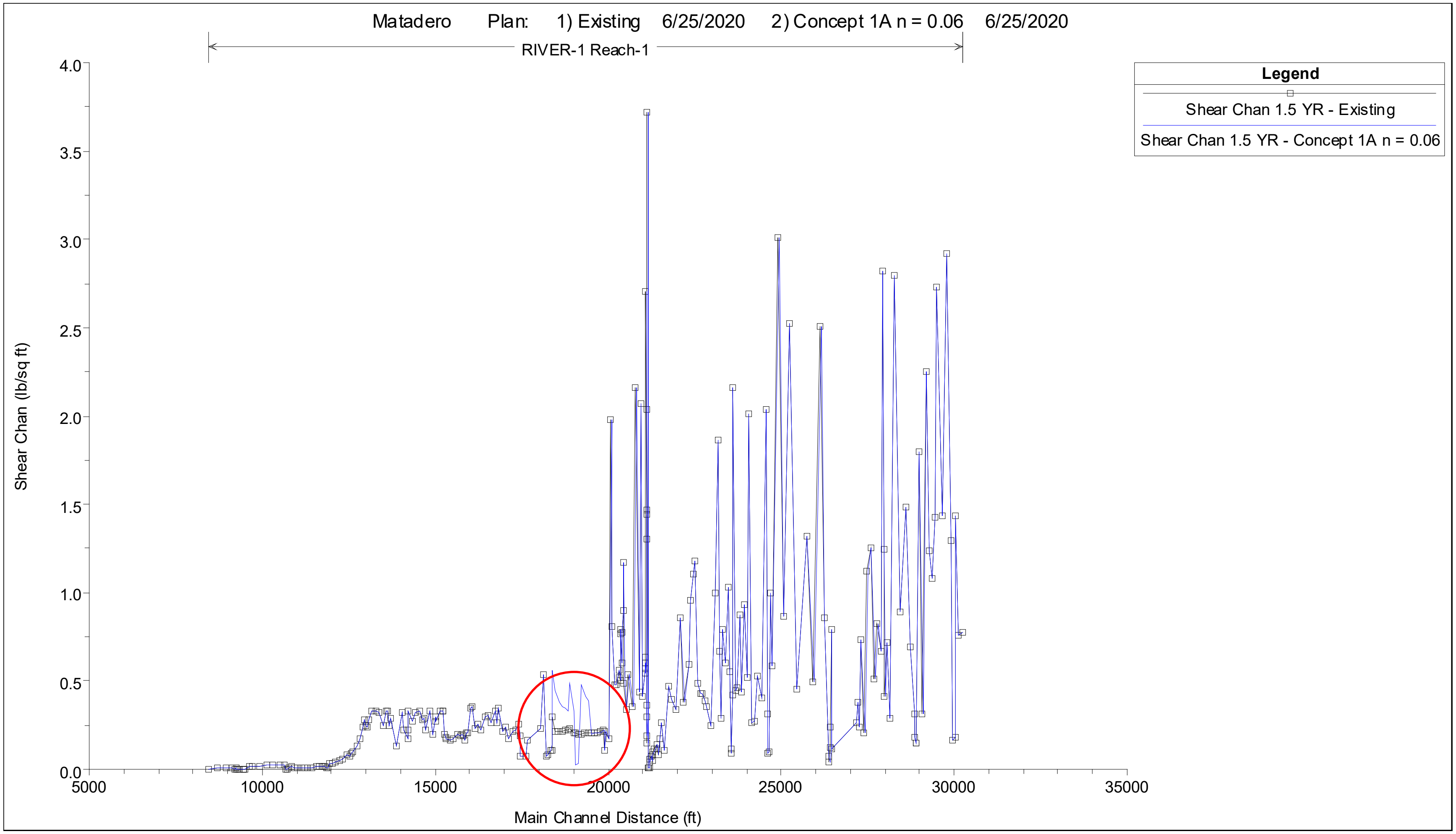


Figure 8. Comparison of channel shear stress (lb/ft^2) for a 1.5-yr recurrence interval event for existing conditions and Concept 1A. Project area circled in red.

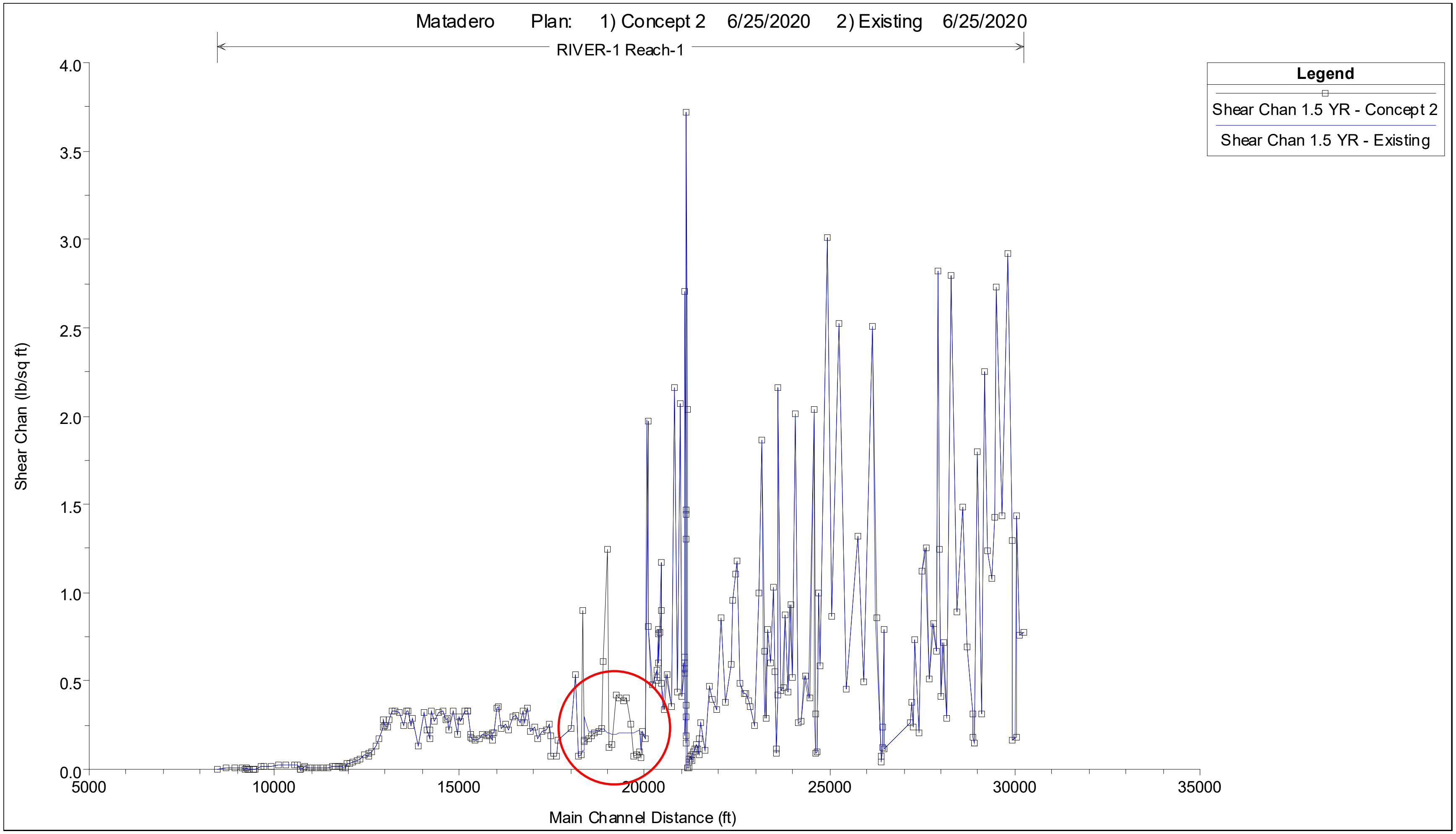


Figure 9. Comparison of channel shear stress (lb/ft^2) for a 1.5-yr recurrence interval event for existing conditions and Concept 2. Project area circled in red.

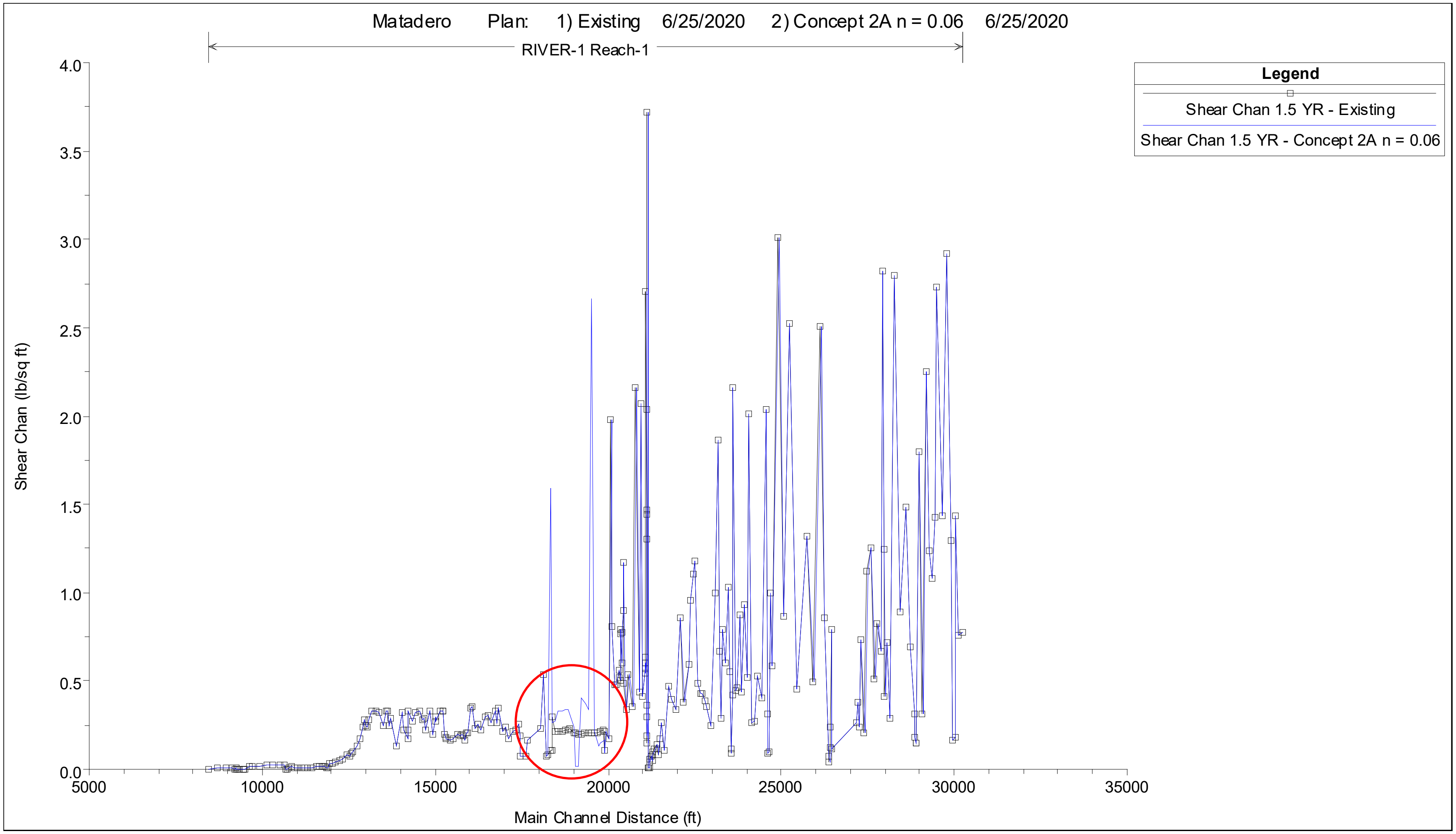


Figure 10. Comparison of channel shear stress (lb/ft²) for a 1.5-yr recurrence interval event for existing conditions and Concept 2A. Project area circled in red.

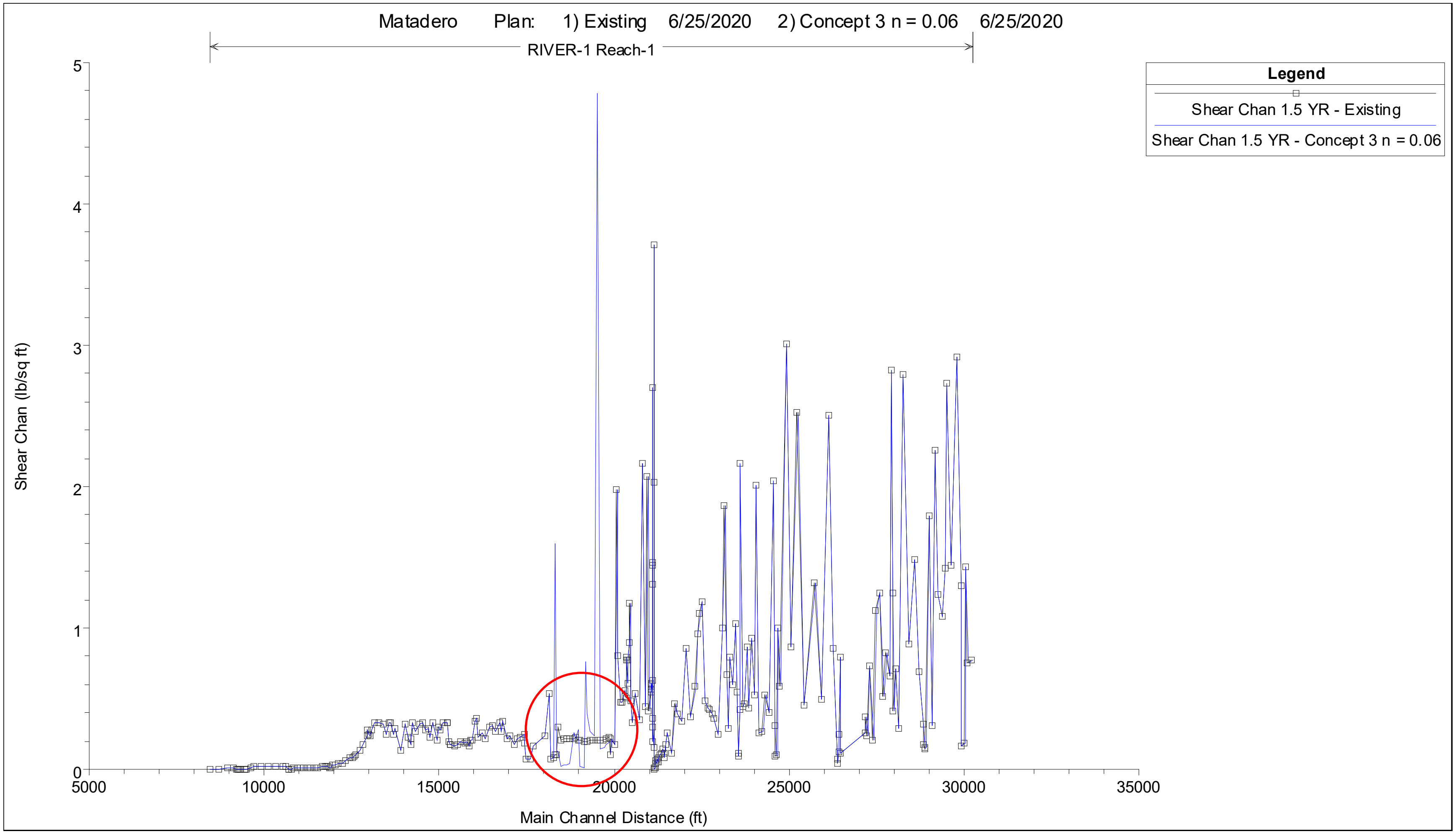


Figure 11. Comparison of channel shear stress (lb/ft²) for a 1.5-yr recurrence interval event for existing conditions and Concept 3. Project area circled in red.

CONCLUSION

The hydraulic evaluation of Matadero Creek identified several key issues related to renaturalization of the urbanized concrete channel. First, the existing channel does not contain the 100-year event with the amount of freeboard required by Valley Water and the Federal Emergency Management Agency. Second, Concepts 1 and 2 will likely increase water surface elevations upstream of El Camino Real reducing their feasibility from a flood risk management perspective. However, Concepts 1A, 2A and 3, which all include replacing Lambert Bridge with a longer span, would need floodwalls to mitigate the effects of increasing backwater. However, these measures would be required only within the project reach, particularly between Park Blvd. and Lambert Ave. Sediment management issues are expected to be locally substantial for Concept 1 due to backwater at Park Blvd., but neither sediment deposition nor channel incision are not expected to be problematic for any of the other concepts.

APPENDIX B – COST ESTIMATE

Concept 1							
A. Demolition							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
A1	024113175050	Removal of Pavement and curb (Asphalt)	1667	SY	$ 7.98	$ 10.79	$ 17,983.33
A2	024113601755	Fencing Demo, Chain link, 6' high	250	LF	$ 2.76	$ 3.96	$ 990.00
A3	024113175400	Concrete pavement 7"-24" thick plain	1094	CY	$ 101.22	$ 137.44	$ 150,359.36
A4	312316130900	Excavating Soil	7293	BCY	$ 7.95	$ 10.53	$ 76,798.80
A5	312323203312	Hauling and Disposal Asphalt	456	LCY	$ 9.18	$ 11.53	$ 5,255.76
A6	312323203312	Hauling and Disposal Concrete	1641	LCY	$ 9.18	$ 11.53	$ 18,920.73
A7	312323203312	Hauling and Disposal Soil + Rock	9190	LCY	$ 9.18	$ 11.53	$ 105,956.09
A8	24113980200	Remove sod, edging, planters and tree guying	20	MSF	$ 51.62	$ 75.38	$ 1,507.60
						Subtotal	**$ 377,772**

B. Site Preparation							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
B1	N/A	Misc. Removal	1	LS	$ 5,000.00	$ 6,000.00	$ 6,000.00
B2	15626500610	Temorary Fencing	1000	LF	$ 5.05	$ 6.77	$ 6,770.00
B3	N/A	SWPPP Preparation	1	LS	$ 15,000.00	$ 18,000.00	$ 18,000.00
B4	312514160200	Erosion Control Blanket	5000	SY	$ 1.73	$ 2.09	$ 10,450.00
B5	15433400980	Dust Control	5	MO	$ 393.85	$ 433.24	$ 2,166.20
B6	31251416100	Silt Fence	1000	LF	$ 1.45	$ 1.95	$ 1,950.00
B7	312514160705	Straw Wattles	1000	LF	$ 4.54	$ 5.44	$ 5,440.00
		Street sweeping/vacuuming	30	day	$ 1,000.00	$ 1,200.00	$ 36,000.00
B8	N/A	Stream Seperation System	1	LS	$ 15,000.00	$ 18,000.00	$ 18,000.00
B9	15433701300	Dewatering Pump (Submersible) 6"	2	MO	$ 2,455.50	$ 2,701.05	$ 5,402.10
B10	15433701200	Dewatering Pump (Submersible) 4"	2	MO	$ 2,983.80	$ 3,282.18	$ 6,564.36
						Subtotal	**$ 116,743**

Concept 1							
C. Construction							
Item Number	RSMeans Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
C1	N/A	Plantable Concrete Retaining Wall	15072	SF	$ 25.00	$ 30.00	$ 452,160.00
C2	321216140020	Access Road (Asphaltic Concrete)	6650	SF	$ 2.94	$ 3.37	$ 22,410.50
C3	32610100100	Pedestrian Trail (Cement Concrete)	35	SY	$ 13.76	$ 16.61	$ 584.43
C4	5521350210	Handrail	10	LF	$ 376.00	$ 422.95	$ 4,229.50
C6	313713100300	Channel Bed Gravel/Cobble	2263	TON	$ 23.69	$ 26.61	$ 60,206.01
C7	31113450500	Flood Wall, Footing	2845	LF	$ 6.59	$ 9.41	$ 26,771.45
C8	31113855120	Flood Wall, Wall	8535	SF	$ 39.54	$ 72.23	$ 616,440.38
						Subtotal	**$ 1,182,802**

D. Planting and Seeding							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
D1	TBD	Trees and Shrubs - 1 Gallon, incl. plant/mulch/amendments/installation	60	EA	$ 20.00	$ 24.00	$ 1,440.00
D2	TBD	Trees and Shrubs - 5 Gallon, incl. plant/mulch/fertilizer/installation	10	EA	$ 90.00	$ 108.00	$ 1,080.00
D3	TBD	Trees and Shrubs - 15 Gallon, incl. plant/mulch/fertilizer/installation	40	EA	$ 250.00	$ 300.00	$ 12,000.00
D4	TBD	Hydroseed	0.689	AC	$ 3,500.00	$ 4,200.00	$ 2,892.56
D5	TBD	Planting Maintenance and Guarantee Period - 120 days	1	LS	$ -	$ -	$ -
						Subtotal	**$ 17,413**

E. Irrigation							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
E1	TBD	Irrigation System - Temporary Drip	110	EA	$ 50.00	$ 60.00	$ 6,600.00
E2	TBD	Irrigation Maintenance and Guarantee Period - 120 days	1	LS	$ -		$ 660.00
						Subtotal	**$ 7,260**

TOTAL	**$ 1,701,989**
Real Estate	**$ -**
Design (20%)	**$ 340,398**
Permitting (10%)	**$ 170,199**
Management (10%)	**$ 170,199**
Contingency (25%)	**$ 425,497**
GRAND TOTAL	**$ 2,808,282**

Concept 1A							
A. Demolition							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
A1	024113175050	Removal of Pavement and curb	6066	SY	$ 7.98	$ 10.79	$ 65,447.34
A2	024113601755	Fencing Demo, Chain link, 6' high	600	LF	$ 2.76	$ 3.96	$ 2,376.00
A3	024113175400	Concrete pavement 7"-24" thick plain	1706	CY	$ 101.22	$ 137.44	$ 234,442.10
A4	312316130900	Excavating Soil	12800	BCY	$ 7.95	$ 10.53	$ 134,784.00
A5	312323203312	Hauling and Disposal Asphalt	1517	LCY	$ 9.18	$ 11.53	$ 17,485.25
A6	312323203312	Hauling and Disposal Concrete	2559	LCY	$ 9.18	$ 11.53	$ 29,501.43
A7	312323203312	Hauling and Disposal Soil + Rock	16128	LCY	$ 9.18	$ 11.53	$ 185,955.84
A8	24113980200	Remove sod, edging, planters and tree guying	27.5	MSF	$ 79.40	$ 116.64	$ 3,207.60
						Subtotal	**$ 673,200**

B. Site Preparation							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
B1	N/A	Misc. Removal	1	LS	$ 5,000.00	$ 6,000.00	$ 6,000.00
B2	15626500610	Temorary Fencing	1000	LF	$ 5.05	$ 6.77	$ 6,770.00
B3	N/A	SWPPP Preparation and Implementation	1	LS	$ 30,000.00	$ 36,000.00	$ 36,000.00
B4	312514160200	Erosion Control Blanket	5000	SY	$ 1.73	$ 2.09	$ 10,450.00
B5	N/A	Dust Control	5	MO	$ 393.85	$ 433.24	$ 2,166.20
B6	31251416100	Silt Fence	1000	LF	$ 1.45	$ 1.95	$ 1,950.00
B7	312514160705	Straw Wattles	1000	LF	$ 4.54	$ 5.44	$ 5,440.00
B8	15433701300	Dewatering Pump (Submersible) 6"	2	MO	$ 2,456.00	$ 2,701.05	$ 5,402.10
B9	15433701200	Dewatering Pump (Submersible) 4"	2	MO	$ 2,984.00	$ 3,282.18	$ 6,564.36
						Subtotal	**$ 80,743**

Concept 1A							
C. Construction							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
C1A	N/A	Plantable Concrete Retaining Wall	45632	SF	$ 25.00	$ 30.00	$ 1,368,960
C2	321216140020	Access Road (Asphatic Concrete)	12670	SF	$ 2.94	$ 3.37	$ 42,698
C3	32610100100	Pedestrian Tail (Cement Concrete)	573	SY	$ 13.76	$ 16.61	$ 9,523
C4	5521350210	Handrail	20	LF	$ 376.00	$ 422.95	$ 8,459
C6	313713100300	Channel Bed Gravel/Cobble	4489	TON	$ 23.69	$ 26.61	$ 119,461
C7	31113450500	Flood Wall, Footing	2845	LF	$ 6.59	$ 9.41	$ 26,771
C8	31113855120	Flood Wall, Wall	8535	SF	$ 39.54	$ 72.23	$ 616,440
						Subtotal	**$ 2,192,312**

D. Planting and Seeding							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
D1	TBD	Trees and Shrubs - 1 Gallon, incl. plant/mulch/amendments/installation	60	EA	$ 20.00	$ 24.00	$ 1,440.00
D2	TBD	Trees and Shrubs - 5 Gallon, incl. plant/mulch/fertilizer/installation	10	EA	$ 90.00	$ 108.00	$ 1,080.00
D3	TBD	Trees and Shrubs - 15 Gallon, incl. plant/mulch/fertilizer/installation	40	EA	$ 250.00	$ 300.00	$ 12,000.00
D4	TBD	Hydroseed	1.500	AC	$ 3,500.00	$ 4,200.00	$ 6,300.00
D5	TBD	Planting Maintenance and Guarantee Period - 120 days	1	LS	$ -		$ -
						Subtotal	**$ 20,820**

E. Irrigation							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
E1	TBD	Irrigation System - Temporary Drip	110	EA	$ 50.00	$ 60.00	$ 6,600.00
E2	TBD	Irrigation Maintenance and Guarantee Period - 120 days	1	LS	$ -		$ -
						Subtotal	**$ 6,600**

Concept 1A							
F. Additional Costs							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
F1	N/A	Real Estate Costs lower	0.00	AC	$ 3,321,225.38	$ 3,985,470.45	$ -
F2	N/A	Lambert Bridge	3600	SF	$ 500.00	$ 600.00	$ 2,160,000.00
						Subtotal	**$ 2,160,000**

TOTAL	**$ 5,133,675**
Real Estate	**$ -**
Design (20%)	**$ 1,026,735**
Permitting (10%)	**$ 513,367**
Management (10%)	**$ 513,367**
Contingency (25%)	**$ 1,283,419**
GRAND TOTAL	**$ 8,470,563**

Concept 2

A. Demolition

Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
A1	024113175050	Removal of Pavement and curb	3343	SY	$ 7.98	$ 10.79	$ 36,068.57
A2	024113601755	Fencing Demo, Chain link, 6' high	500	LF	$ 2.76	$ 3.96	$ 1,980.00
A3	024113175400	Concrete pavement 7"-24" thick plain	608	CY	$ 101.22	$ 137.44	$ 83,532.98
A4	312316130900	Excavating Soil	11345	BCY	$ 7.95	$ 10.53	$119,464.80
A5	312323203312	Hauling and Disposal Asphalt	836	LCY	$ 9.18	$ 11.53	$ 9,635.56
A6	312323203312	Hauling and Disposal Concrete	911.666667	LCY	$ 9.18	$ 11.53	$ 10,511.52
A7	312323203312	Hauling and Disposal Soil + Rock	14294.9333	LCY	$ 9.18	$ 11.53	$164,820.58
A8	24113980200	Remove sod, edging, planters and tree guying	27.5	MSF	$ 79.40	$ 116.64	$ 3,207.60
						Subtotal	**$ 429,222**

B. Site Preparation

Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
B1	N/A	Misc. Removal	1	LS	$ 5,000	$ 6,000.00	$ 6,000.00
B2	15626500610	Temorary Fencing	1000	LF	$ 5.05	$ 6.77	$ 6,770.00
B3	N/A	SWPPP Preparation and Implementation	1	LS	$ 15,000	$ 18,000.00	$ 18,000.00
B4	312514160200	Erosion Control Blanket	5000	SY	$ 1.73	$ 2.09	$ 10,450.00
B5		Dust Control	50	acre-day	$ 80.00	$ 96.00	$ 4,800.00
B6	31251416100	Silt Fence	1000	LF	$ 1.45	$ 1.95	$ 1,950.00
B7	312514160705	Straw Wattles	1000	LF	$ 4.54	$ 5.44	$ 5,440.00
B8	N/A	Stream Seperation System	1	LS	$ 15,000	$ 18,000.00	$ 18,000.00
B9	15433701300	Dewatering Pump (Submersible) 6"	2	MO	$ 2,456	$ 2,701.05	$ 5,402.10
B10	15433701200	Dewatering Pump (Submersible) 4"	2	MO	$ 2,684	$ 3,282.18	$ 6,564.36
						Subtotal	**$ 83,376**

Concept 2							
C. Construction							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
C1	N/A	Plantable Concrete Retaining Wall	25328	SF	$ 25.00	$ 30.00	$ 759,840
C2	321216140020	Access Road (Asphatic Concrete)	6650	SF	$ 2.94	$ 3.37	$ 22,411
C3	32610100100	Pedestrian Tail (Cement Concrete)	307	SY	$ 13.76	$ 16.61	$ 5,094
C5	323213101900	Handrail	15.3	LF	$ 376	$ 422.95	$ 6,471
C6	313713100200	Rip-rap and Rock linning (Gravel/Cobble)	1667	SY	$ 79.24	$ 109.15	$ 181,917
C7	31113450500	Flood Wall, Footing	2845	LF	$ 6.59	$ 9.41	$ 26,771
C8	31113855120	Flood Wall, Wall	8535	SF	$ 39.54	$ 72.23	$ 616,440
						Subtotal	**$ 1,618,944**

D. Planting and Seeding							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
D2	TBD	Trees and Shrubs - 1 Gallon, incl. plant/mulch/amendments/installation	60	EA	$ 20.00	$ 24.00	$ 1,440.00
D2	TBD	Trees and Shrubs - 5 Gallon, incl. plant/mulch/fertilizer/installation	10	EA	$ 90.00	$ 108.00	$ 1,080.00
D3	TBD	Trees and Shrubs - 15 Gallon, incl. plant/mulch/fertilizer/installation	40	EA	$ 250.00	$ 300.00	$ 12,000.00
D4	TBD	Hydroseed	0.689	AC	$ 3,500.00	$ 4,200.00	$ 2,892.56
D5	TBD	Period - 120 days	1	LS	$ -		$ -
						Subtotal	**$ 17,413**

E. Irrigation							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
E1	TBD	Irrigation System - Temporary Drip	110	EA	$ 50.00		$ 5,500.00
E2	TBD	Period - 120 days	1	LS	$ -		$ 550.00
						Subtotal	**$ 6,050**

Concept 2							
F. Additional Costs							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
F1	N/A	Real Estate Costs - Park to Ash	0.25	AC	$3,321,225.38	$ 3,985,470.45	$988,396.67
F2							
						Subtotal	**$ 988,397**

TOTAL	**$ 2,155,004**
Real Estate	**$ 988,397**
Design (20%)	**$ 431,001**
Permitting (10%)	**$ 215,500**
Management (10%)	**$ 215,500**
Contingency (25%)	**$ 538,751**
GRAND TOTAL	**$ 4,544,154**

Concept 2A							
A. Demolition							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
A1	024113175050	Removal of Pavement and curb	6066	SY	$ 7.98	$ 10.79	$ 65,447.34
A2	024113601755	Fencing Demo, Chain link, 6' high	600	LF	$ 2.76	$ 3.96	$ 2,376.00
A3	024113175400	Concrete pavement 7"-24" thick plain	1093	CY	$ 101.22	$ 137.44	$ 150,267.73
A4	312316130900	Excavating Soil	20409	BCY	$ 7.95	$ 10.53	$ 214,905.60
A5	312323203312	Hauling and Disposal Asphalt	1517	LCY	$ 9.18	$ 11.53	$ 17,485.25
A6	312323203312	Hauling and Disposal Concrete	1640	LCY	$ 9.18	$ 11.53	$ 18,909.20
A7	312323203312	Hauling and Disposal Soil + Rock	25715	LCY	$ 9.18	$ 11.53	$ 296,496.26
A8	24113980200	Remove sod, edging, planters and tree guying	27.5	MSF	$ 79.40	$ 116.64	$ 3,207.60
						Subtotal	**$ 769,095**

B. Site Preparation							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
B1	N/A	Misc. Removal	1	LS	$ 5,000.00	$ 6,000.00	$ 6,000.00
B2	15626500610	Temorary Fencing	1000	LF	$ 5.05	$ 6.77	$ 6,770.00
B3	N/A	SWPPP Preparation and Implementation	1	LS	$ 30,000.00	$ 36,000.00	$ 36,000.00
B4	312514160200	Erosion Control Blanket	5000	SY	$ 1.73	$ 2.09	$ 10,450.00
B5	N/A	Dust Control	50	acre-day	$ 80.00	$ 96.00	$ 4,800.00
B6	31251416100	Silt Fence	1000	LF	$ 1.45	$ 1.95	$ 1,950.00
B7	312514160705	Straw Wattles	1000	LF	$ 4.54	$ 5.44	$ 5,440.00
B8	15433701300	Dewatering Pump (Submersible) 6"	2	MO	$ 2,456.00	$ 2,701.05	$ 5,402.10
B9	15433701200	Dewatering Pump (Submersible) 4"	2	MO	$ 2,984.00	$ 3,282.18	$ 6,564.36
						Subtotal	**$ 83,376**

Concept 2A							
C. Construction							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
C1	N/A	Plantable Concrete Retaining Wall	45632	SF	$ 25.00	$ 30.00	$ 1,368,960
C2	321216140020	Access Road (Asphatic Concrete)	12670	SF	$ 2.94	$ 3.37	$ 42,698
C3	32610100100	Pedestrian Tail (Cement Concrete)	573	SY	$ 13.76	$ 16.61	$ 9,523
C4	5521350210	Handrail	20	LF	$ 376.00	$ 422.95	$ 8,459
C6	313713100200	Rip-rap and Rock linning (Gravel/Cobble)	556	SY	$ 79.24	$ 109.15	$ 60,639
C7	31113450500	Flood Wall, Footing	2845	LF	$ 6.59	$ 9.41	$ 26,771
C8	31113855120	Flood Wall, Wall	8535	SF	$ 39.54	$ 72.23	$ 616,440
						Subtotal	**$ 2,133,490**

D. Planting and Seeding							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
D1	TBD	Trees and Shrubs - 1 Gallon, incl. plant/mulch/amendments/installation	60	EA	$ 20.00	$ 24.00	$ 1,440.00
D2	TBD	Trees and Shrubs - 5 Gallon, incl. plant/mulch/fertilizer/installation	10	EA	$ 90.00	$ 108.00	$ 1,080.00
D3	TBD	Trees and Shrubs - 15 Gallon, incl. plant/mulch/fertilizer/installation	40	EA	$ 250.00	$ 300.00	$ 12,000.00
D4	TBD	Hydroseed	1.500	AC	$ 3,500.00	$ 4,200.00	$ 6,300.00
D5	TBD	Planting Maintenance and Guarantee Period - 120 days	1	LS	$ -		$ 630.00
						Subtotal	**$ 21,450**

E. Irrigation							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
E1	TBD	Irrigation System - Temporary Drip	110	EA	$ 50.00	$ 60.00	$ 6,600.00
E2	TBD	Irrigation Maintenance and Guarantee Period - 120 days	1	LS	$ -		$ 660.00
						Subtotal	**$ 7,260**

Concept 2A							
F. Additional Costs							
Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
F1	N/A	Real Estate	0.247179	AC	$ 3,321,225.38	$3,985,470.45	$ 985,124.60
F2	N/A	Lambert Bridge	5100	SF	$ 500.00	$ 600.00	$ 3,060,000.00
						Subtotal	**$ 4,045,125**

TOTAL	**$ 6,074,672**
Real Estate	**$ 985,125**
Design (20%)	**$ 1,214,934**
Permitting (10%)	**$ 607,467**
Management (10%)	**$ 607,467**
Contingency (25%)	**$ 1,518,668**
GRAND TOTAL	**$ 11,008,333**

Concept 3							
A. Demolition							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
A1	024113175050	Removal of Pavement and curb	9248	SY	$ 7.98	$ 10.79	$ 99,784
A2	024113601755	Fencing Demo, Chain link, 6' high	600	LF	$ 2.76	$ 3.96	$ 2,376
A3	024113175400	Concrete pavement 7"-24" thick plain	1421	CY	$ 101.22	$ 137.44	$ 195,318
A4	312316130900	Excavating Soil	39791	BCY	$ 7.95	$ 10.53	$ 419,000
A5	312323203312	Hauling and Disposal Asphalt	2487	LCY	$ 9.18	$ 11.53	$ 28,674
A6	312323203312	Hauling and Disposal Concrete	2132	LCY	$ 9.18	$ 11.53	$ 24,578
A7	312323203312	Hauling and Disposal Soil + Rock	50137	LCY	$ 9.18	$ 11.53	$ 578,077
A8	24113980200	Remove sod, edging, planters and tree guying	30	MSF	$ 79.40	$ 116.64	$ 3,499
						Subtotal	**$ 1,351,307**

B. Site Preparation							
Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
B1	N/A	Misc. Removal	1	LS	$ 5,000	$ 6,000.00	$ 6,000
B2	15626500610	Temorary Fencing	1000	LF	$ 5.05	$ 6.77	$ 6,770
B4	N/A	SWPPP Preparation and Implementation	1	LS	$ 30,000.00	$ 36,000.00	$ 36,000
B5	312514160200	Erosion Control Blanket	5000	SY	$ 1.73	$ 2.09	$ 10,450
B6	N/A	Dust Control	50	acre-day	$ 80.00	$ 96.00	$ 4,800
B7	31251416100	Silt Fence	1000	LF	$ 1.45	$ 1.95	$ 1,950
B8	N/A	Stream Seperation System	1	LS	$ 15,000	$ 1.00	$ 1
B9	15433701300	Dewatering Pump (Submersible) 6"	4	MO	$ 2,456	$ 2,701.05	$ 10,804
B10	15433701200	Dewatering Pump (Submersible) 4"	4	MO	$ 2,984	$ 3,282.18	$ 13,129
						Subtotal	**$ 89,904**

Concept 3

C. Construction

Item Number	RS Means Code	Description	Quantity	Unit	Bare Cost	O&P	Cost
C1	N/A	Plantable Concrete Retaining Wall	39840	SF	$ 25.00	$ 30.00	$ 1,195,200
C2	321216140020	Access Road (Asphatic Concrete)	93970	SF	$ 2.94	$ 3.37	$ 316,679
C3	32610100100	Pedestrian Tail (Cement Concrete)	847	SY	$ 13.76	$ 16.61	$ 14,063
C4	5521350210	Handrail	28	LF	$ 376.00	$ 422.95	$ 11,937
C6	313713100200	Rip-rap and Rock linning (Gravel/Cobble)	5333	SY	$ 79.24	$ 109.15	$ 582,133
C7	31113450500	Flood Wall, Footing	2845	LF	$ 6.59	$ 9.41	$ 26,771
C8	31113855120	Flood Wall, Wall	6235	SF	$ 39.54	$ 72.23	$ 450,323
						Subtotal	**$ 2,597,106**

D. Planting and Seeding

Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
D1	TBD	Trees and Shrubs - 1 Gallon, incl. plant/mulch/amendments/installation	60	EA	$ 20	$ 24.0	$ 1,200
D2	TBD	Trees and Shrubs - 5 Gallon, incl. plant/mulch/fertilizer/installation	10	EA	$ 90	$ 108.0	$ 900
D3	TBD	Trees and Shrubs - 15 Gallon, incl. plant/mulch/fertilizer/installation	40	EA	$ 250	$ 300.0	$ 10,000
D4	TBD	Hydroseed	1.200	AC	$ 3,500	$ 4,200.0	$ 4,200
D5	TBD	120 days	1	LS	$ -		$ 1,630
						Subtotal	**$ 17,930**

E. Irrigation

Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
E1	TBD	Irrigation System - Temporary Drip	110	EA	$ 50		$ 5,500
E2	TBD	120 days	1	LS	$ -		$ 550
						Subtotal	**$ 6,050**

Concept 3

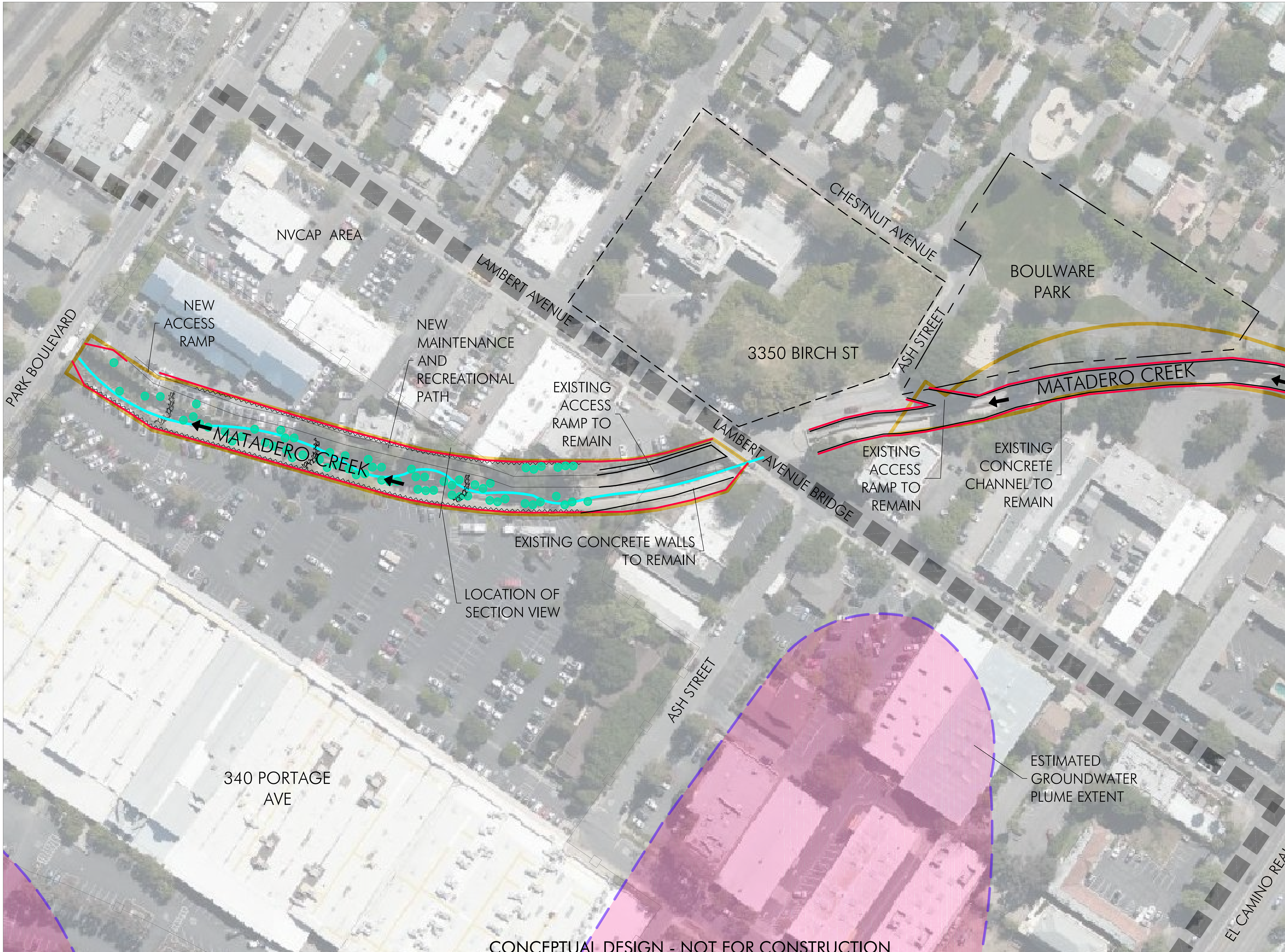
F. Additional Costs

Item Number	RSMeans Code	Description	Quantity	Unit	Unit Cost	O&P	Cost
F1	N/A	Real Estate	0.806	AC	$ 3,321,225.38	$ 3,985,470.45	$ 3,212,289.19
F2	N/A	Lambert Bridge	6000	SF	$ 500.00	$ 600.00	$ 3,600,000.00
						Subtotal	**$ 6,812,289**

CONSTRUCTION TOTAL	**$ 7,662,297**
Real Estate	**$ 3,212,289**
Design (20%)	**$ 1,532,459**
Permitting (10%)	**$ 766,230**
Management (10%)	**$ 766,230**
Contingency (25%)	**$ 1,915,574**
GRAND TOTAL	**$ 15,855,079**

APPENDIX C –CONCEPT DESIGN DRAWINGS


ALMA ST
RAILROAD
PARK BLVD
OLIVE AVE
340 PORTAGE AVE
MATADERO CREEK
LAMBERT AVE
BIRCH ST
3350 BIRCH ST
ASH AVE
BOULWARE PARK
MATADERO CREEK
ESTIMATED GROUNDWATER PLUME EXTENT
ACACIA AVE
PORTAGE AVE
EL CAMINO REAL
SITE PLAN LEGEND
SYMBOL
DESCRIPTION
MATADERO CREEK CENTERLINE
NVCAP BOUNDARY
340 PORTAGE AVE (APPROX.)
FLOW
3350 BIRCH BOUNDARY
VALLEY WATER EASEMENT
PLUME EXTENT (APPROX.)
JOHN BOULWARE PARK
N
0'
400'



WRA ENVIRONMENTAL CONSULTANTS

CITY OF PALO ALTO MATADERO CREEK RE-NATURALIZATION

PALO ALTO, CALIFORNIA

CONCEPT 1 PLAN VIEW

LEGEND

- ROCK VANE
- VW EASEMENT
- PLANTINGS
- FLOODWALL
- CREEK CENTERLINE
- PLANTABLE WALL
- NVCAP BOUNDARY
- PLUME EXTENT
- 340 PORTAGE

N

0 100

SCALE: 1 " = 100'

DATE: SEPTEMBER 2020
FIGURE BY: BSS, BMM
IMAGE SOURCE: AUTOCAD ROADS MAP

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wra ENVIRONMENTAL CONSULTANTS

CITY OF PALO ALTO MATADERO CREEK RE-NATURALIZATION FEASIBILITY STUDY

PALO ALTO, CALIFORNIA

CONCEPT 1A PLAN VIEW

LEGEND

- ROCK VANE
- VW EASEMENT
- PLANTINGS
- FLOODWALL
- CREEK CENTERLINE
- PLANTABLE WALL
- NVCAP BOUNDARY
- PLUME EXTENT
- 340 PORTAGE

N

0 100

SCALE: 1 " = 100'

DATE: SEPTEMBER 2020
FIGURE BY: BSS, BMM
IMAGE SOURCE: AUTOCAD ROADS MAP

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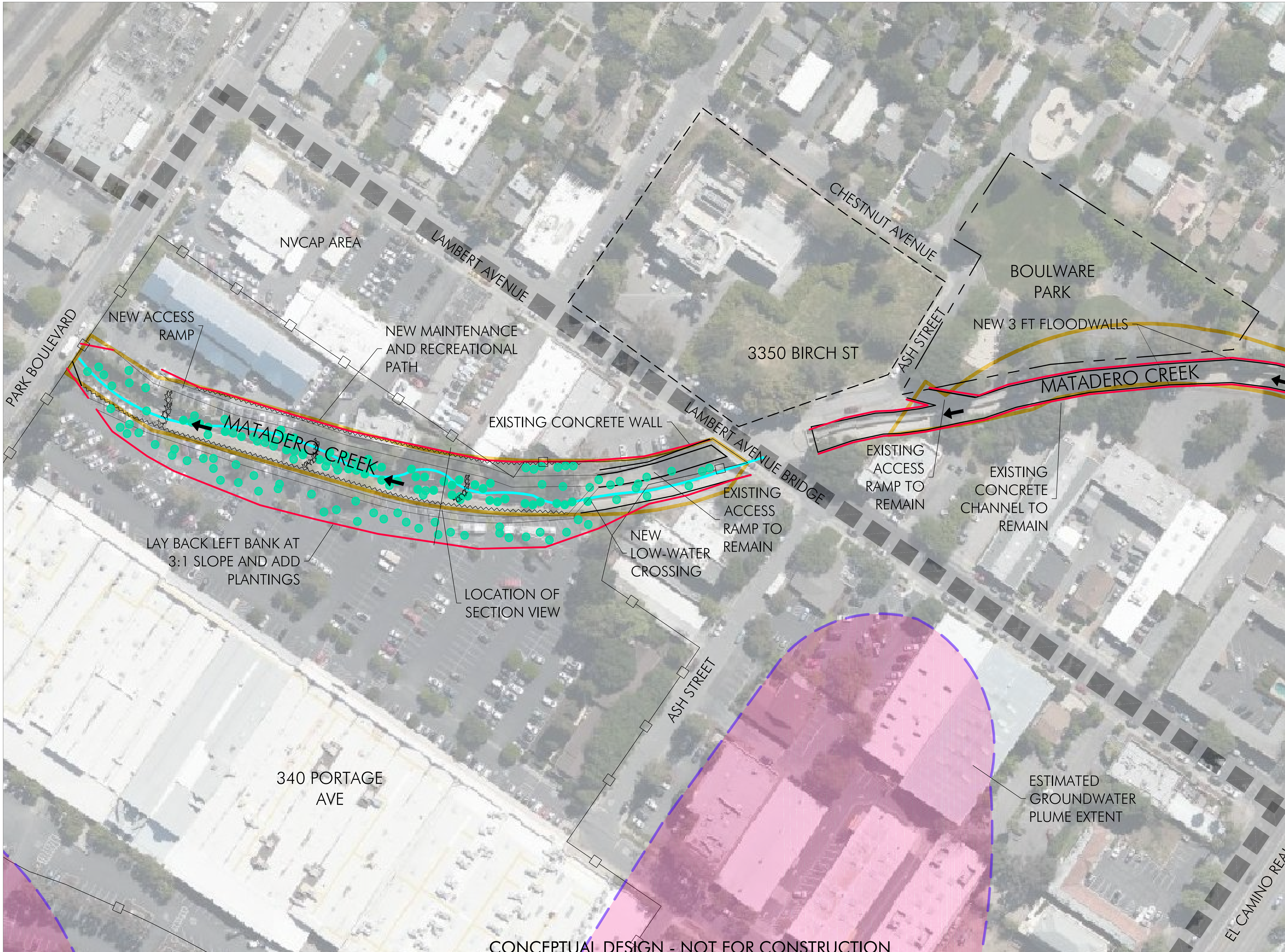

wra
ENVIRONMENTAL CONSULTANTS

CITY OF PALO ALTO
MATADERO CREEK
RE-NATURALIZATION

PALO ALTO, CALIFORNIA

CONCEPT 2
PLAN VIEW

LEGEND

- ROCK VANE
- VW EASEMENT
- PLANTINGS
- FLOODWALL
- CREEK CENTERLINE
- PLANTABLE WALL
- NVCAP BOUNDARY
- PLUME EXTENT
- 340 PORTAGE

N

0 100

SCALE: 1 " = 100'

DATE: SEPTEMBER 2020
FIGURE BY: BSS, BMM
IMAGE SOURCE: AUTOCAD ROADS MAP

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ENVIRONMENTAL CONSULTANTS

CITY OF PALO ALTO
MATADERO CREEK
RE-NATURALIZATION

PALO ALTO,
CALIFORNIA

CONCEPT 2A
PLAN VIEW

LEGEND

ROCK VANE
VW EASEMENT
PLANTINGS
FLOODWALL
CREEK CENTERLINE
PLANTABLE WALL
NVCAP BOUNDARY
PLUME EXTENT
340 PORTAGE

N

0 100
SCALE: 1 " = 100'

DATE: SEPTEMBER 2020
FIGURE BY: BSS, BMM
IMAGE SOURCE: AUTOCAD ROADS MAP

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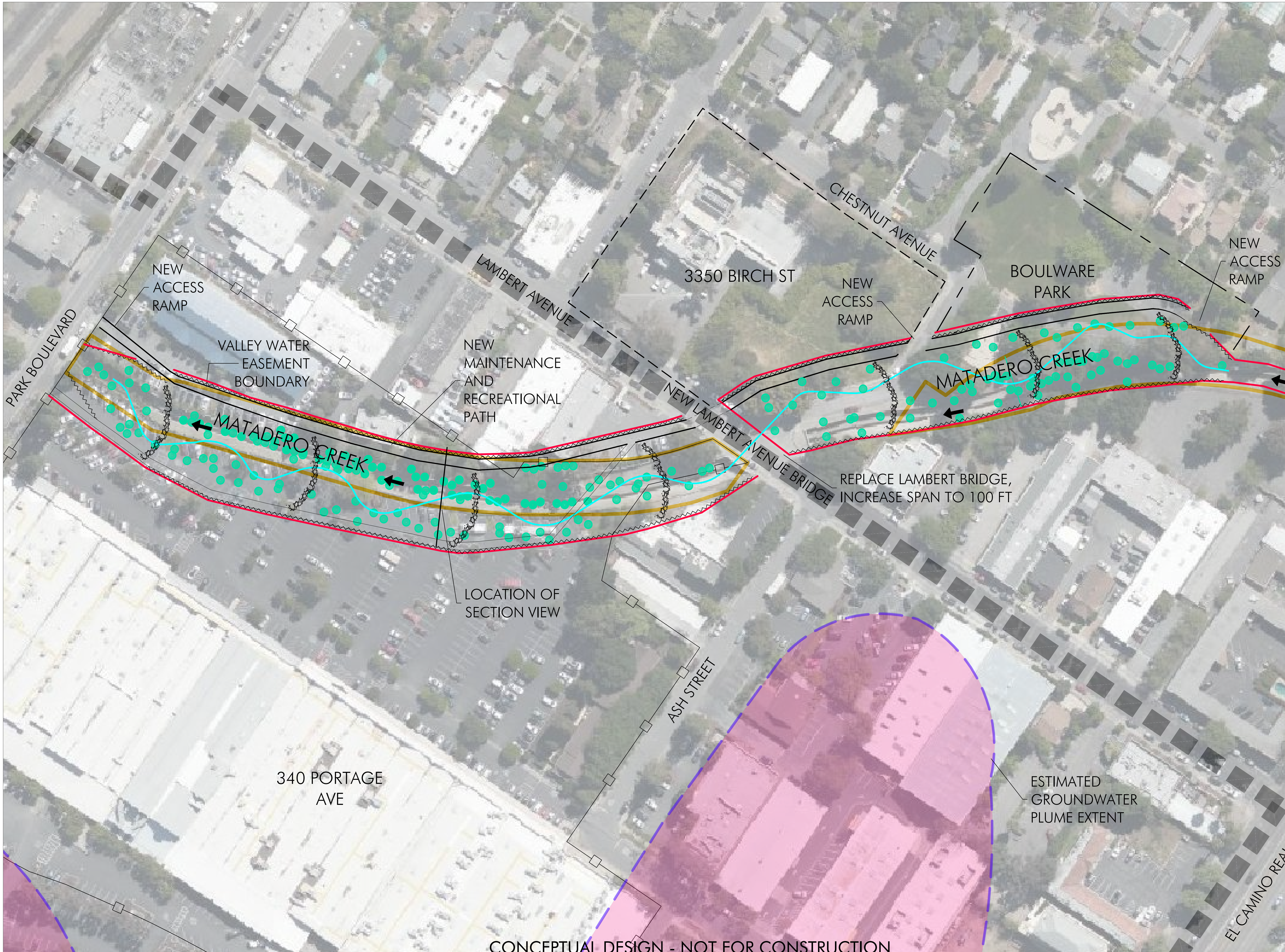

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CITY OF PALO ALTO
MATADERO CREEK
RE-NATURALIZATION

PALO ALTO,
CALIFORNIA

CONCEPT 3
PLAN VIEW

LEGEND

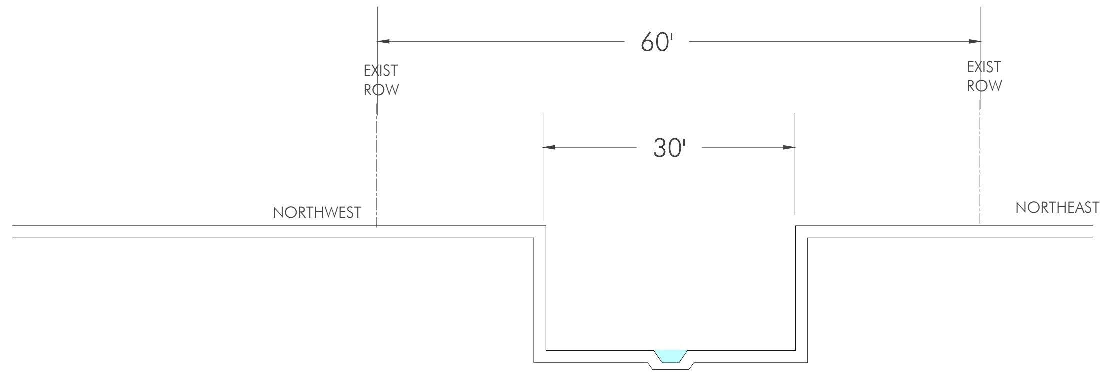
ROCK VANE
VW EASEMENT
PLANTINGS
FLOODWALL
CREEK CENTERLINE
PLANTABLE WALL
NVCAP BOUNDARY
PLUME EXTENT
340 PORTAGE

N

0 100

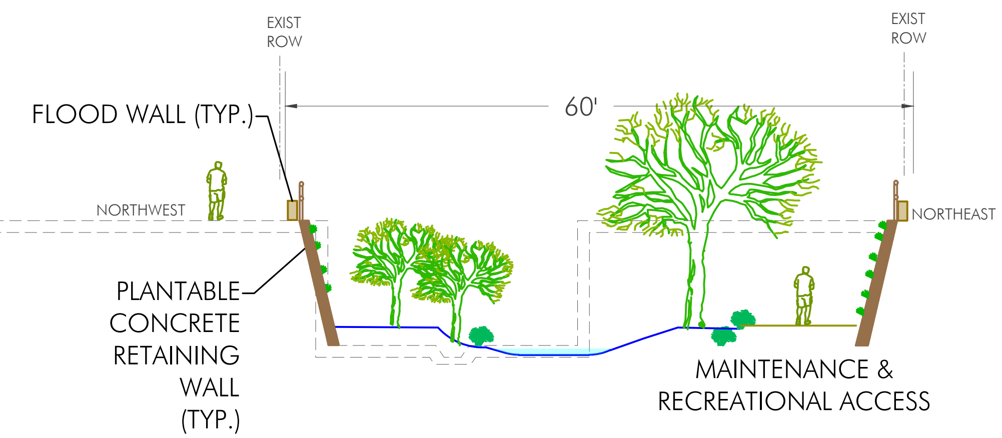
SCALE: 1 " = 100'

DATE: SEPTEMBER 2020
FIGURE BY: BSS, BMM
IMAGE SOURCE: AUTOCAD ROADS MAP



CONCEPT #0: NO ACTION ALTERNATIVE (30FT WIDTH)

- 30 FT WIDE, 12 FT DEEP CONCRETE FLOOD CHANNEL
- NO RECREATIONAL ACCESS
- NO RIPARIAN HABITAT VALUE
- VERY LIMITED AQUATIC HABITAT VALUE
- MAY CONVEY 100-YR FLOOD WITH LESS THAN 1 FT OF FREEBOARD
- MAINTENANCE ACCESS ROAD
- NO SEDIMENT OR STABILITY ISSUES

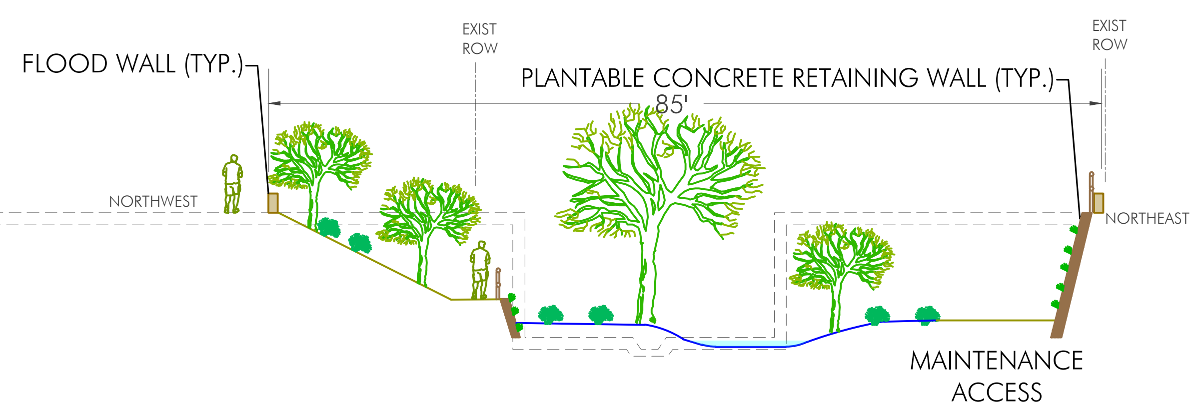


CONCEPT #1: ENHANCED EASEMENT CORRIDOR (60 FT WIDTH)

- EXPAND FLOOD CHANNEL TO BOUNDARIES OF VALLEY WATER EASEMENT
- REPLACE VERTICAL CONCRETE RETAINING WALLS WITH PLANTABLE STRUCTURE
- EARTHEN CHANNEL BOTTOM, GEOMORPHIC CHANNEL DESIGN
- RIPARIAN AND WETLAND PLANTINGS TO CREATE HABITAT
- MAY CONVEY 100-YR FLOOD WITH LESS THAN 1 FT OF FREEBOARD
- PEDESTRIAN PATHWAYS AND RAMPS FOR RECREATION ACCESS
- MAINTENANCE ACCESS ROAD AND RAMPS

CONCEPT #1A: ENHANCED EASEMENT CORRIDOR + BOULWARE PARK INTEGRATION

- REPLACE LAMBERT AVE BRIDGE WITH 60' SPAN
- EXPAND RETURALIZATION AREA TO INCLUDE REACH ADJACENT TO BOULWARE PARK
- MAY CONVEY 100-YR FLOOD WITH ADEQUATE FREEBOARD

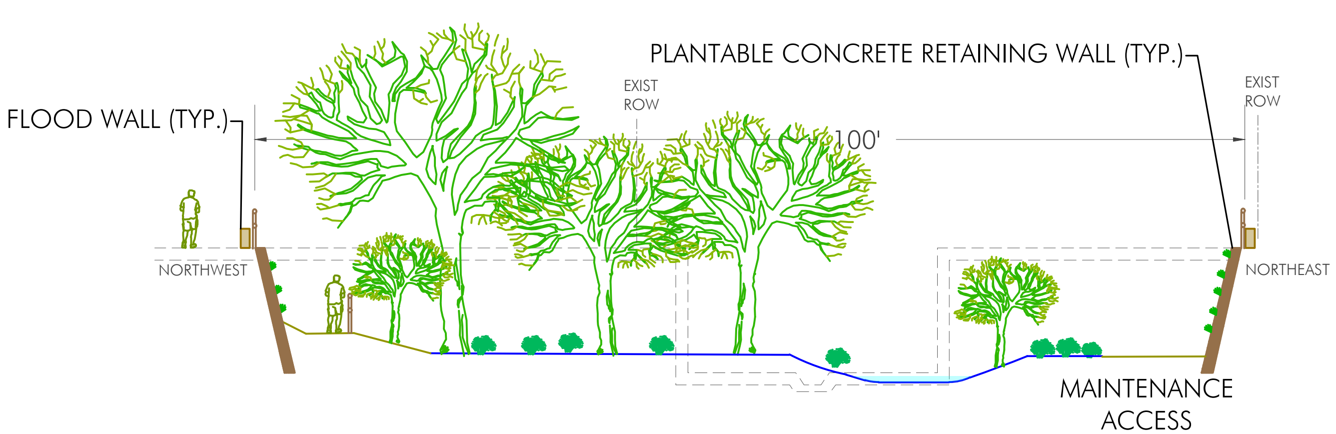


CONCEPT #2: WIDENED CORRIDOR WITH BANK ANGLE REDUCTION (85 FT WIDTH)

- ADDITIONAL RECREATIONAL AND AESTHETIC FEATURES
- EXCAVATE ONE CHANNEL BANK, TRANSITIONING FROM VERTICAL TO 3:1 (H:V)
- EARTHEN CHANNEL BOTTOM, GEOMORPHIC CHANNEL DESIGN
- RIPARIAN AND WETLAND PLANTINGS TO CREATE HABITAT
- MAY CONVEY 100-YR FLOOD WITH LESS THAN 1 FT OF FREEBOARD
- PEDESTRIAN PATHWAYS AND RAMPS FOR RECREATION
- MAINTENANCE ACCESS ROAD AND RAMPS

CONCEPT #2A: WIDENED CORRIDOR + BOULWARE PARK INTEGRATION

- REPLACE LAMBERT AVE BRIDGE WITH 85' SPAN
- EXPAND RETURALIZATION AREA TO INCLUDE REACH ADJACENT TO BOULWARE PARK
- MAY CONVEY 100-YR FLOOD WITH ADEQUATE FREEBOARD



CONCEPT #3: MAXIMUM RENATURALIZATION OF CORRIDOR (100 FT WIDTH)

- WIDEN FLOOD CHANNEL TO AT LEAST 100 FT FROM PARK BLVD TO CHESTNUT AVE
- REPLACE LAMBERT AVE BRIDGE WITH 100' SPAN
- MAXIMUM GEOMORPHIC FORM AND ECOLOGICAL FUNCTION
- PLANTABLE CONCRETE RETAINING WALLS DEFINE CORRIDOR BOUNDARY
- NEW MAINTENANCE ACCESS RAMPS
- PEDESTRIAN PATHWAYS AND RAMPS FOR RECREATION
- MAY CONVEY 100-YR FLOOD WITH GREATER THAN 1 FT OF FREEBOARD

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RE-NATURALIZATION

CONCEPTUAL
ALTERNATIVES

PALO ALTO,
CALIFORNIA

SECTION VIEWS

DATE: SEPTEMBER 2020
FIGURE BY: ACS, BSS, BMM

NOT FOR CONSTRUCTION

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APPENDIX D –SITE VISIT PHOTOS

Photos of Matadero Creek Existing Conditions

Figure 1 Existing Concrete Channel from Park Boulevard

Figure 2 Frequent Algal Blooms within Existing Channel


Figure 3 Upstream Existing Channel View from Fry's Parking Lot

Figure 4 Park Boulevard Bridge View Downstream Channel

Figure 5 Channel Station and Water Surface Elevation Marker

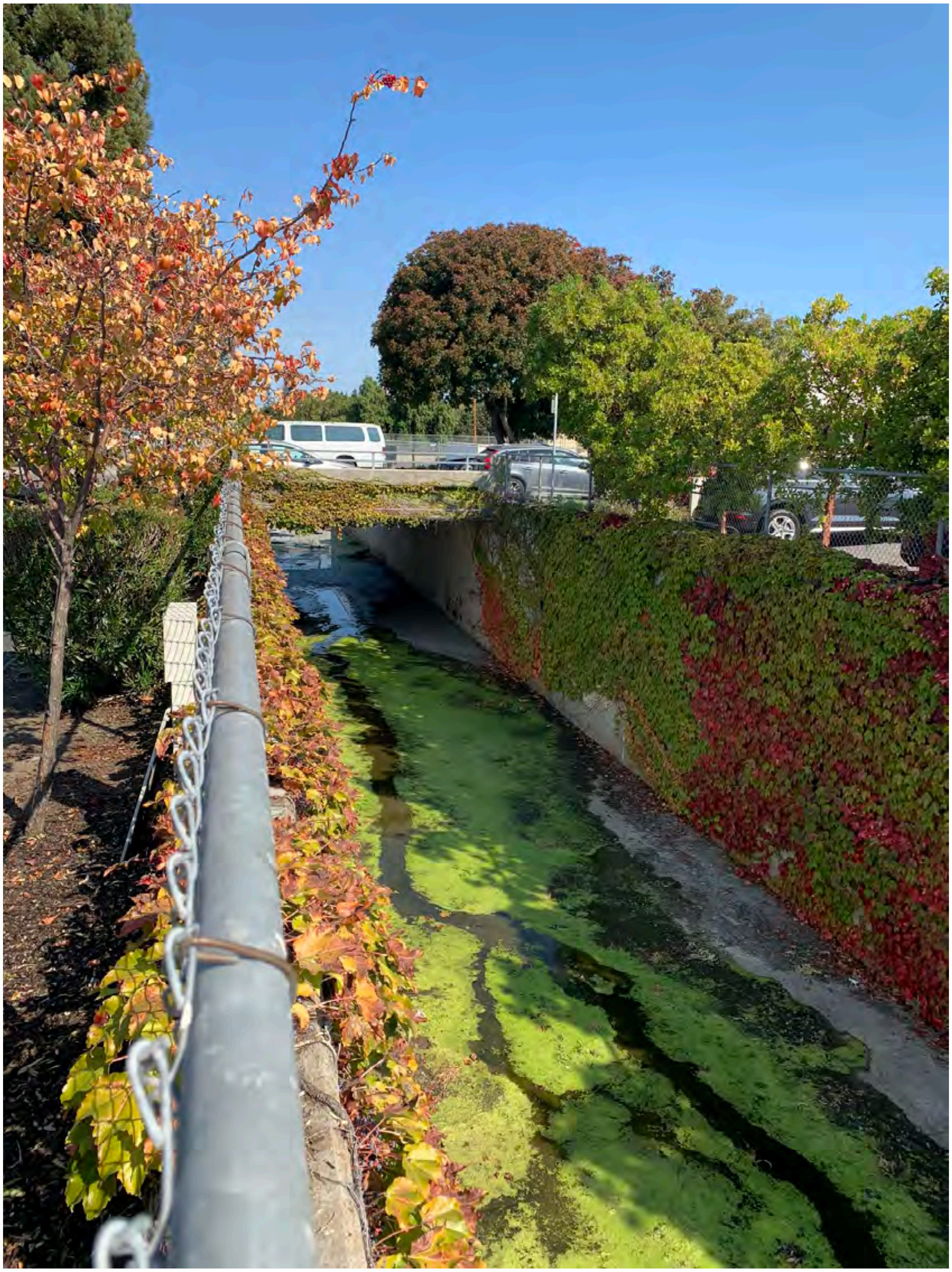

Figure 6 Existing Channel View Downstream with Park Boulevard Bridge

Figure 7 Channel Station and Water Surface Elevation with low flow conditions

Figure 8 Upstream Matadero Creek Upstream View from Lambert Boulevard Bridge

Figure 9 Valley Water Maintenance Access to Matadero Creek Upstream near Lambert Boulevard Bridge

Figure 10 Algal Blooms in Matadero Creek View from Park Boulevard

Figure 11 Graffiti, Algal Bloom and Debris Build Up


Figure 12 Concrete Channel under Lambert Boulevard Bridge with Existing Valley Water Maintenance Access from street

Figure 13 View from Lambert Bridge Facing Downstream Matadero Creek

Figure 14 Entrance to Valley Water Maintenance at John Boulware Park

Figure 15 Valley Water Maintenance Path along Matadero Creek between Lambert Boulevard Bridge and John Boulware Park

Figure 16 View of John Boulware Park from Matadero Creek Fence

Figure 17 Property Acquired by City of Palo Alto (3350 Birch Street, Palo Alto, CA)

Figure 18 Upstream Matadero Creek facing John Boulware Park