TECHNICAL MEMORANDUM

To: Housing Authority of the City of Santa Barbara

From: Waterways Consulting, Inc.

Date: February 10, 2016

Re: Gardens on Hope – Creek Setback Analysis

INTRODUCTION

The Housing Authority of the City of Santa Barbara hired Waterways Consulting to evaluate an additional recommended building setback associated with Arroyo Burro Creek and the proposed *Gardens on Hope* apartments project. In addition, Waterways was asked to review a Restoration Feasibility Analysis of Arroyo Burro Creek prepared by Questa Engineering (2014). This technical memorandum summarizes our evaluation of the recommended widened setback with respect to the Housing Authority's proposed *Gardens on Hope* project and the shared desire to enhance the associated reach of Arroyo Burro Creek.

ARROYO BURRO CREEK

The proposed *Gardens on Hope* apartments project is located on a vacant and flat lot east of Arroyo Burro Creek, upstream of the Highway 101 road crossing, and downstream of South Hope Avenue crossing. This reach of Arroyo Burro Creek was drastically modified (circa 1966) from a meandering natural channel to a straightened concrete-lined trapezoidal conveyance channel. For this reason, the existing reach of Arroyo Burro Creek offers little to no aquatic habitat and is considered a significant impediment to fish passage (Stoecker, 2002).

The concrete banks extend to height of approximately 10 feet on either side of the channel. The right bank (looking downstream) continues at steep slope for approximately 20 vertical feet to the edge of the La Cumbre Plaza parking lot. The right bank, above the concrete, is well vegetated. The left bank (looking downstream) extends approximately 10 vertical feet above the concrete bank and is sparsely vegetated, however, there are some established oak trees along the top of bank.

A technical memorandum dated November 4, 2014 and titled "Mid-Arroyo Burro Restoration Feasibility Analysis" was prepared by Questa Engineering for the City of Santa Barbara Creeks Division. The analysis evaluated potential channel enhancements to remove the existing concrete and create a more natural riparian corridor. The analysis discusses existing flood conditions as a result of the undersized culvert at Highway 101 creating a backwater effect within the project reach. Conceptual plan-view and cross-sections were prepared with this analysis and show the removal of the existing concrete, re-sloping of the banks, and the construction of a floodwall at the top of the slopes. The Questa memorandum does not discuss setback recommendations. The complete Questa analysis can be found in Attachment A of this memo.

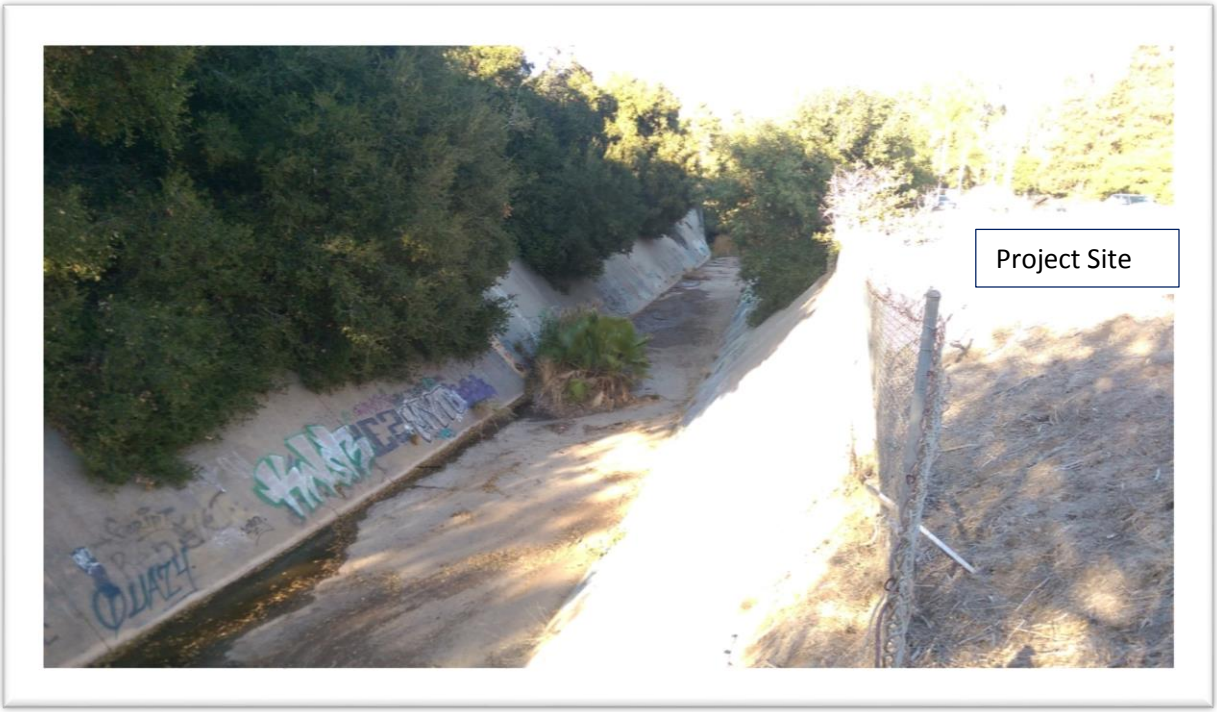


Photo looking upstream at Arroyo Burro Creek adjacent to the proposed apartments site.

Photo showing existing vegetation along top of left bank adjacent to proposed project.

HYDRAULICS

According to Table 6 of the FEMA Flood Insurance Study (FIS) for Santa Barbara County, 2015 (Attachment B), a 100-year flood event has a water surface elevation of 172.4 feet at the apartments project site. This elevation is approximately the same elevation as the theoretical top of bank (1.5:1 slope from toe of channel) and approximately 2 feet below the proposed finished floor elevation of the apartments. The 100-year floodplain encroaches slightly onto the project parcel and significantly onto the downstream parcel (car dealership), as shown in Figure 2 of the Questa technical memorandum (Attachment A). 100-year flood elevations are relatively flat for this reach of Arroyo Burro Creek and are controlled by a backwater effect from an undersized culvert at Highway 101. It should also be noted that the modeled 100-year event would overtop Highway 101 at an elevation of approximately 170 feet.

BUILDING SETBACK

According to the Santa Barbara City Municipal Code, Section 28.87.250 - *Development Along Creeks*, no development may occur with twenty-five (25) feet of the top of either bank of Mission Creek within the City of Santa Barbara. For the purposes of this analysis, a similar setback width of 25 feet is considered for Arroyo Burro Creek. The intent of such a setback, as described in Section 28.87.250 of the City Code, is to:

1. prevent undue damage or destruction of developments by floodwaters;
2. prevent development on one parcel from causing undue detrimental impact on adjacent or downstream properties in the event of flood waters; and
3. protect the public health, safety, and welfare.

In addition to the intents of the City Code, a 25 foot setback would provide ecological benefits, specifically in the preservation and/or restoration of a riparian buffer. Riparian buffers provide numerous benefits to creeks including filtering/infiltration of stormwater, reducing bank erosion potential, and providing cover/shading for aquatic species.

WIDENED SETBACK CONSIDERATIONS

The Housing Authority accepts the importance of a 25 foot setback and has proposed a project that remains outside of this critical area and allows for the future enhancement of Arroyo Burro Creek as conceptualized by Questa. It is our understanding, however, that the City of Santa Barbara Creeks Division is requesting a widened setback of 50 feet from the Arroyo Burro Creek top of bank to the proposed *Gardens on Hope* apartments project. Subsequently, the Housing Authority has asked Waterways to evaluate the benefits of such a widened setback.

With respect to the three *Legislative Intents* described above, the following discussion considers the difference between a 25 foot and 50 foot setback.

DAMAGE OR DESTRUCTION OF DEVELOPMENTS BY FLOODWATERS

As discussed above, the 100-year predicted flood elevation is 172 feet under existing conditions, which corresponds approximately to the existing top of bank. The proposed enhancements, which include replacing the concrete banks and channel bottom with natural substrate and vegetation. This change, as discussed in Questa's memo, would increase channel roughness and result in higher (+/- 1 ft) flood elevations. A floodwall set 3 feet above the predicted floodplain elevation is proposed to help mitigate

flooding risk to the adjacent parcel. The proposed finished grade behind the floodwall is relatively flat all the way to the proposed building. Therefore, in the event that the floodwall is overtopped or fails, the flooding risk can be assumed to be the same for a 25-foot setback as it is for 50-foot setback. In other words, the flooding risk for this project is correlated to vertical changes rather than horizontal.

Table 6 of the FEMA FIS states that average floodway velocity for this reach of Arroyo Burro are 11.7 feet per second. High velocities typically occur where flows are concentrated; in this case within the concrete channel. As floodwaters overtop the channel banks and spread out onto the flat floodplain, velocities drop dramatically. In addition, the longitudinal profile of the floodplain is relatively flat and the 100-year flood profile is backwatered (flat) by the undersized Highway 101 culvert. Therefore, the risk of damage due to erosion on the floodplain is relatively low and that risk is can be assumed to be the same within the 25-foot setback as it would be within a 50-foot setback.

DETRIMENTAL IMPACT ON ADJACENT OR DOWNSTREAM PROPERTIES IN THE EVENT OF FLOOD WATERS

FEMA flood profiles (Attachment B) show that flood elevations for this entire reach of Arroyo Burro Creek are controlled by the Highway 101 crossing. This is due to the fact that the culvert is undersized relative to the flows associated with large storm events. Therefore, a widened setback of 50 feet would provide little to no hydraulic benefit to downstream flood elevations. The proposed development is currently outside of the existing 100-year flood plain. As mentioned above, the 100-year flood overtops highway 101 at approximately 170 feet (finished floor elevations for Gardens on Hope are 174.8 feet).

PUBLIC HEALTH, SAFETY, AND WELFARE

The existing channel banks are steep with the concrete portions at approximately a 1:1 slope. The earthen bank above the concrete have approximately a 1.5:1 slope. An existing chain link fence at the top of bank protects the public from the steep slope. Urban channels such as this are often prone to further incision and/or bank erosion which can result in steep, vertical, or overhung banks that are void of vegetation and prone to failure. The existing concrete channel and the upstream and downstream culvert crossings help to alleviate the risk of channel incision and bank erosion. The proposed concepts presented in the Questa memo include widening the channel and/or lessening the slopes with vegetated banks; such changes would also help to minimize the risk of channel erosion. The risk to the public, from this perspective, can be mitigated within the channel area. Additional measures such as fencing and floodwalls can be achieved within a 25 foot setback.

The ecological benefits of a riparian buffer can also be considered under public health and welfare. In this case, there is potential benefit to increasing the setback from 25 feet to 50 feet as it allows for additional area to restore a riparian buffer. However, the urban nature of this reach and the proposed development require the consideration of other uses within the setback; such as walking/biking trails, stormwater management, and passive recreation. For these reasons, it is unlikely that widening the setback from 25 feet to 50 feet will result in significant ecological benefits to Arroyo Burro Creek.

ALTERNATIVE CONCEPTS

Waterways was asked by the Housing Authority to consider alternative channel enhancement concepts that enhance the ecologic resources of Arroyo Burro Creek, while still considering the urban nature of the area and the proposed *Garden on Hope* project. It should be noted that Waterways does not see any issues with concepts proposed by Questa Engineering as these would enhance ecologic resources and allow for the *Garden on Hope* project to be constructed outside of a 25 foot setback.

ALTERNATIVE 1

Alternative 1, as presented in **Figure 1**, calls for the removal of a portion of the concrete channel bottom and the placement of Engineered Streambed Material (ESM) to create a low flow channel and small bench. The enhanced channel bottom would focus low flows and create flow depth complexity necessary to improve Steelhead passage and improve habitat for other aquatic species. The concrete banks would be preserved to minimize disturbance to the existing slope and riparian vegetation, and to help alleviate the risk of bank erosion and channel migration.

The cross sectional area for this alternatives is approximately the same as existing conditions, however channel roughness would increase along the channel bottom due to the placement of ESM resulting in slightly higher flood elevations. A floodwall set to height of 3 feet above 100-year flood elevations (as also proposed by Questa) is proposed at the top of bank. This alternative has not been modeled for hydraulic impacts at this stage.

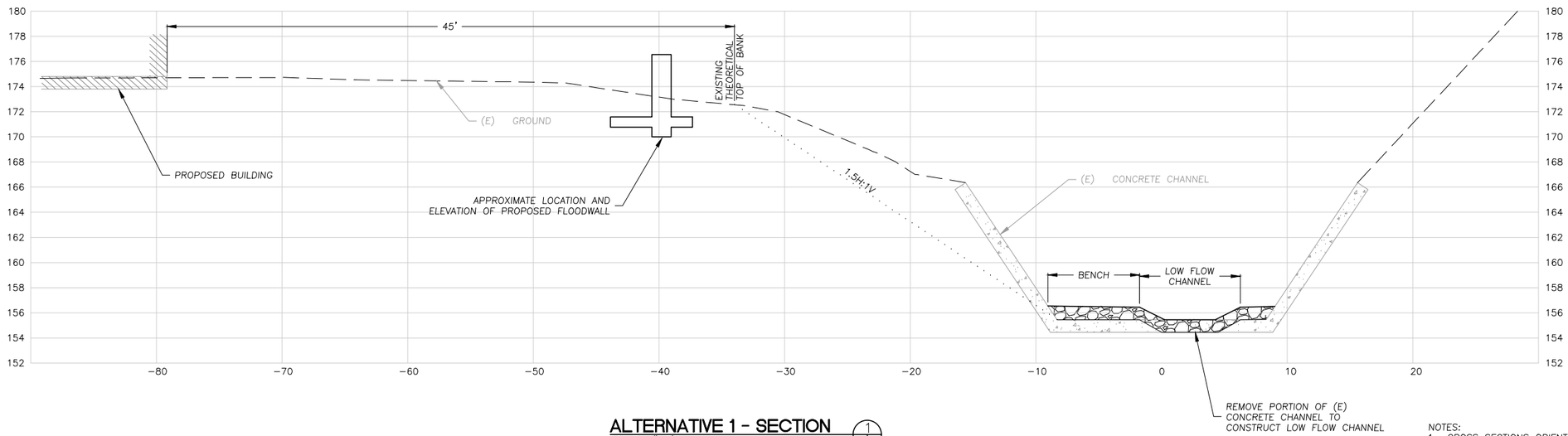
Alterative 1 does not change the existing left bank slope and therefore results in a 45 foot setback from the theoretical top of bank to the proposed apartments.

ALTERNATIVE 2

Alternative 2, as presented in **Figure 1**, calls for the removal of the concrete channel bottom as well as the left bank. Similar to Alternative 1, ESM would be placed within the channel to create a low flow channel and small bench. The left bank could be graded to a 1.5:1 or 2:1 slope and planted with native riparian vegetation. The right bank would remain concrete to minimize disturbance to the existing slope and riparian vegetation higher on the slope.

The cross sectional area for this alternatives are slightly greater than existing conditions, however channel roughness would increase along the channel bottom and left bank due to the placement of ESM and the restoration of riparian vegetation. This would result in slightly higher flood elevations.
A floodwall set to height of 3 feet above 100-year flood elevations (as also proposed by Questa) is proposed at the top of bank. This alternative has not been modeled for hydraulic impacts at this stage.

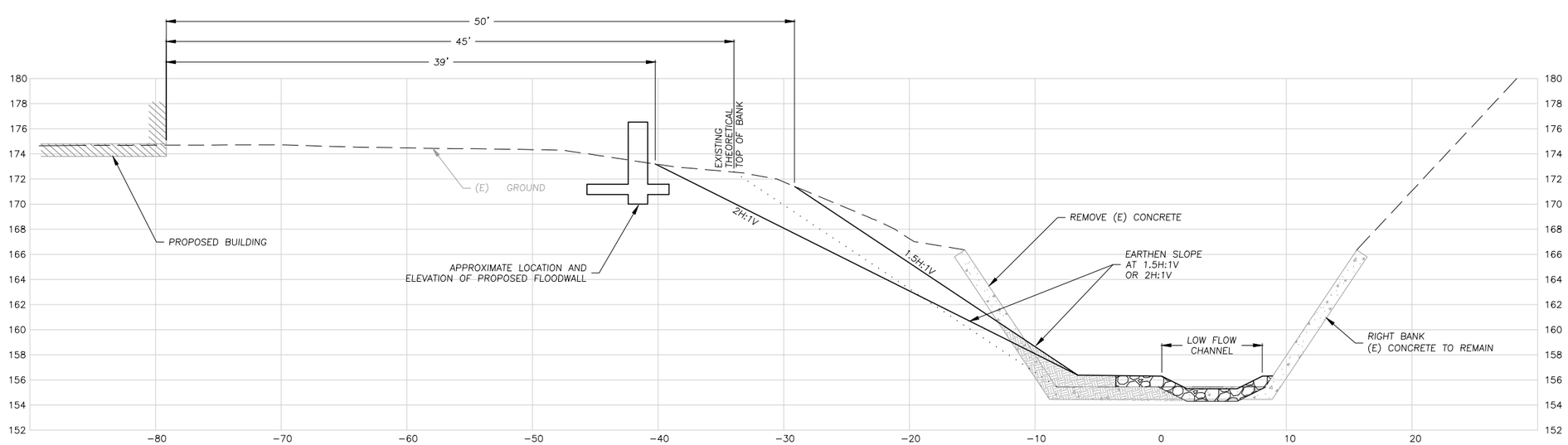
Alternative 2 maintains a 50 foot setback using a 1.5:1 slope and a 39 foot setback using 2:1 slope from the new top of bank to the proposed apartments.



ALTERNATIVE 1 - SECTION

SCALE: 1"=5'

NOTES:
1. CROSS SECTIONS ORIENTED LOOKING DOWNSTREAM.
2. PROPOSED REMOVAL OF CONCRETE WOULD REQUIRE EVALUATIONS FROM A STRUCTURAL ENGINEER AND GEOTECHNICAL ENGINEER.
3. PROPOSED 1.5:1 OR 2:1 SLOPES WOULD REQUIRE EVALUATION FROM A GEOTECHNICAL ENGINEER.
4. PROPOSED FLOODWALL TO BE DESIGNED BY STRUCTURAL ENGINEER. FLOODWALL ELEVATION TO BE SET AT A MINIMUM OF 3 FEET ABOVE 100-YEAR FLOOD ELEVATION. FLOODWALL ELEVATIONS TO BE DETERMINED. HYDRAULIC MODELING HAS NOT BE DONE FOR THESE ALTERNATIVES.



ALTERNATIVE 2 - SECTION

SCALE: 1"=5'

WATERWAYS CONSULTING INC.
Santa Cruz, CA | watways.com | Portland, OR

ARROYO BURRO CREEK SETBACK ANALYSIS
CONCEPTUAL CROSS SECTIONS

BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

1

REFERENCES

Stoecker, M.W. and Conception Coast Project. 2002 Steelhead assessment and recovery opportunities in Southern Santa Barbara County, California. Conception Coast Project, Santa Barbara, CA.

ATTACHMENT A

Technical Memorandum

Date: November 4, 2014

Subject: Mid-Arroyo Burro Restoration Feasibility Analysis

To: City of Santa Barbara, Creeks Division

From: Sydney Temple P.E.
Questa Engineering Corporation

Introduction

The following is a description of the initial modeling effort to test the ability of the Arroyo Burro channel to undergo restoration between Highway 101 and Hope Avenue. This restoration would include the removal of the concrete channel where feasible, to be replaced by a reconfigured natural creek bed and bank slopes with native riparian vegetation. This memorandum examines the existing hydrologic and hydraulic conditions of the creek, and tests the feasibility of removing all or a portion of the concrete channel. The goal of the project is to restore this section of Arroyo Burro in order to improve water quality and wildlife habitat without increasing the risk of flooding or erosion on the creek channel.

Background

Arroyo Burro flows from its headwaters in the Santa Ynez Mountains, at an elevation of 3,800 feet mean sea level, to a small tidal estuary at Arroyo Burro Beach County Park (Hendry's Beach). Tributaries to Arroyo Burro include Las Positas Creek, Barger Creek, San Roque Creek, and Lauro Canyon Creek. The watershed drains approximately 5,600 acres and the creek is approximately 7 miles long. The project reach extends from Hope Avenue downstream to the Highway 101 culvert entrance at Calle Real. This section of creek was relocated and channelized with concrete during the construction of La Cumbre Plaza in 1966. The culvert under Calle Real and Highway 101 was also expanded during the mid 1960's. The Hope Avenue Bridge was constructed in the mid 1980's.

xisting Flood Conditions

The Federal Emergency Management Agency (FEMA) conducts hydrology and flooding studies for all major creeks within urbanized areas of the U.S. These studies are used to identify flood prone risk areas and determine flood insurance rates. A table of the design hydrology for the concrete reach on Arroyo Burro per the FEMA Flood Insurance Study (FIS) is below:

Recurrence Interval	Peak flow (cfs)
500 year	10,080
100 year	5,760
50 year	4,250
10 year	1,390

The 100 year flood event is utilized for determining potential flood areas and flood insurance rates. The 100 year flood event is also commonly used as the standard design flow for all structures and improvements within major creek/river channels. In order to meet FEMA requirements, any new structure must either maintain or improve flooding conditions during the 100 year flood event.

The current floodplain for a 100 flood event is shown on the FEMA Flood Insurance Rate Map (FIRM) panel shown in **Figure 1**. The base flood elevation in this reach is considered 172 feet. **Figures 2** and **3** show how these boundaries layout on the oblique views of the project reach. **Figure 4** is a plan view of the City 1995 Lidar map with the creek stationing shown. **Figure 5** shows the existing channel cross sections.

Generally, flooding along this reach is caused by the culvert under the Highway 101. This culvert is undersized to carry the design 100-year flow and only passes approximately 4,250 cubic feet per second (cfs). At flows over approximately 1,400 cfs, water starts backing up from the culvert, and when flows reach approximately 4,800 cfs the water over tops the banks upstream of the culvert entrance and floods the auto dealership's back parking area and garage. The water then flows southeast along and Calle Real, across Highway 101, and into the adjacent residential neighborhood. Computer modeling indicates that 800 to 1,000 cfs leaves the channel and flows across Highway 101.**Figure 1. Current FEMA Floodplain Boundaries**

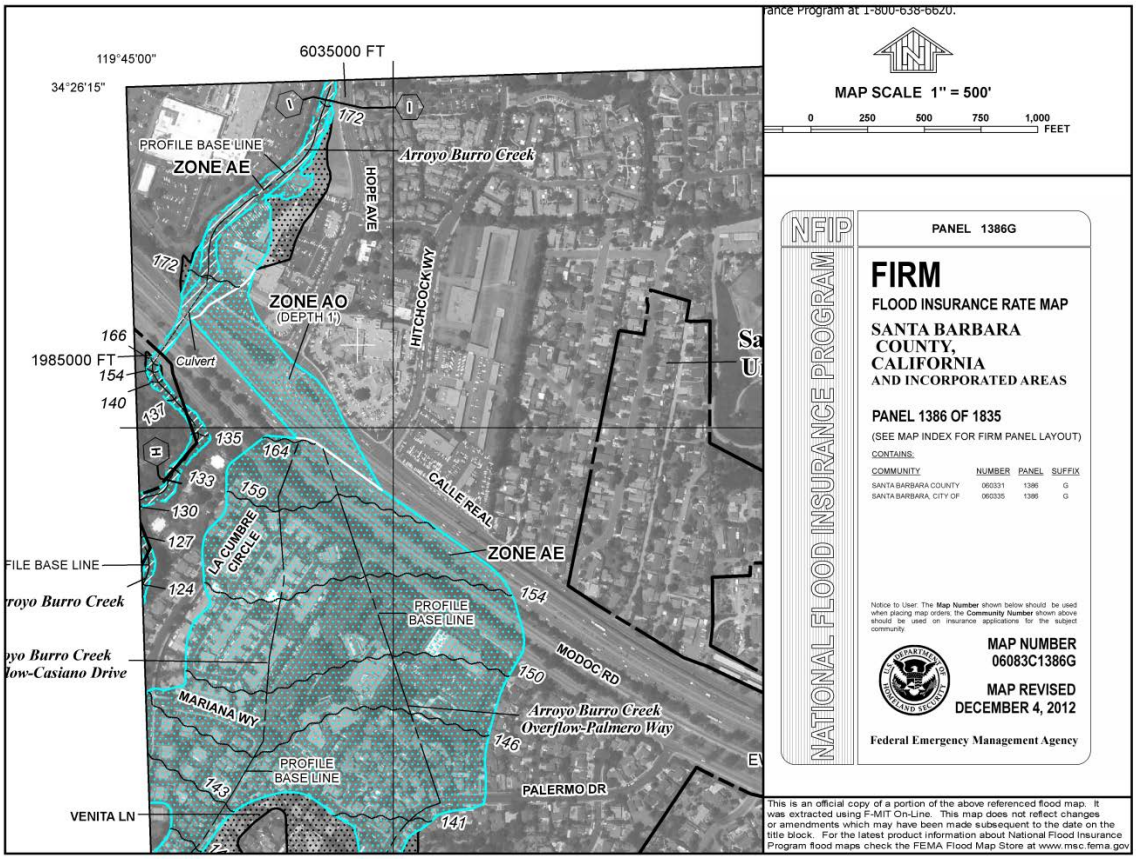


Figure 2. Project Reach Overview Looking North

Figure 3. Overflow Area Looking Southeast

Refined Existing Condition Channel Performance

The original FEMA model had limited cross sections in the subject reach. The original model was altered and several new cross sections were added to the model to better quantify the flood elevations in the creek reach. New cross sections were added at stations 163+00, 165+00, 168+00 and 170+00.

The first model run included existing conditions with the added cross sections. Baseline 100-year water surface elevations for existing conditions are presented in **Table 1** below.

Table 1. Refined Existing Conditions

Creek Station	Water Surface Elevation (ft)	Channel Velocity (ft/sec)
17334	172.23	12.26
17228	172.35	11.31
17100	172.48	9.98
16914	172.58	8.81
16700	172.7	7.78
16500	172.72	7.35
16400	172.72	7.22
16300	172.76	6.9
16226	172.59	8.08
16194	169.67	14.08

In the refined existing conditions analysis, the 100 year flood elevations stay between 172.23 and 172.76 and are similar to the elevations in the existing FEMA FIRM estimates. The velocity profile for the channel is also fairly consistent from stations 16+914 to 16+226 at 7 to 9 ft/sec. This is because the concrete channel is uniform and smooth, and there are no expansions or contractions to slow or speed up the flow. Higher velocities occur as the flow exits the culvert at Hope Avenue and as it enters the downstream culvert. The modeling verifies that the FEMA mapping effort is sufficiently accurate to be utilized for comparing the flood risks associated with restoring the channel.

Channel Sensitivity to Increases in Vegetation Density

The baseline computer model was then modified to analyze the effect on flood elevations and flow velocities of increasing channel roughness from smooth concrete to a vegetated channel. "Channel roughness" is how the model takes into account the reduction in flow velocity due to vegetation, soil, and/or rocks on the channel bed and banks and is defined in the model as the "Mannings n value". The n value was increased to 0.025 to simulate a lightly vegetated channel with the same geometry as the current channel. **Table 2** shows that, as expected, increasing channel roughness slows velocities and increases water surface elevations throughout the channel. The rise in water surface elevations at stations 16+300 to 16+700 will increase the amount of overflow to the southeast by approximately 6% and increase flows across Highway 101. With the existing (concrete) channel condition, approximately 800 to 900 cfs leaves the channel at this location. With a restored vegetated channel approximately 850-1000 cfs could be expected to leave the channel – an increase of approximately 50-100 cfs.

Table 2. Vegetated channel - ***No channel geometry change, increased roughness (n value) to 0.025***

Creek Station	Water Surface Elevation (ft)	Channel Velocity (ft/sec)	Change in Water Surface elevation from Existing (ft)
17334	173.21	11.47	0.98
17228	173.28	10.4	0.93
17100	173.12	9.34	0.64
16914	172.97	8.44	0.39
16700	172.93	7.59	0.23
16500	172.88	7.12	0.16
16400	172.83	7.04	0.11
16300	172.85	6.61	0.09
16226	172.59	8.08	0
16194	169.67	14.08	0

A Manning's "n" value of 0.025 would represent a fairly sparse planting of the channel, such as widely spaced trees and low ground cover (i.e. grasses or low growing shrubs). A Manning's value of 0.045 represents a more typical natural channel "n" value. When using this "n" value, additional water surface elevation increases occur.

In conclusion, removing the concrete and revegatating the channel will increase water surface elevations and impact the flood control conditions of the channel. The next step was to investigate potential restoration designs that would mitigate this impact so that there is no net loss in flood protection for the channel.

Channel Widening Analysis

In order to determine if widening the channel would have a mitigating impact on flood elevations, we modeled several scenarios. These scenarios utilized various bank slopes and channel width configurations. Initial scenarios were run to determine if widening the channel to the maximum extent possible would mitigate the effects of the increased roughness related to channel restoration and keep water surface elevation at or below existing conditions. It was determined that the channel could not be widened enough to mitigate the increase in water surface elevations from restoration. What this general analysis did confirm is that in order to maintain similar levels of flood protection on adjacent properties structural solutions such as floodwalls and controlled overflow weirs would be required. An over flow weir is a structure that is specifically designed to have and control the flow of water over the top of the structure. In this case, the overflow weir would be positioned so that overflow water would be directed in an appropriate manner and overflow rates would not increase from existing conditions.

Conceptual Design Options

Floodwalls are required to have at least 3 feet of height above the 100-yr water surface elevation in order to be certified by FEMA. Since the 100-year water surface elevation will be approximately 173 after restoration, the top of the floodwall must be at least 176. This would mean that floodwall heights would generally range from 4 to 6 feet above the existing top of bank ground surface depending on the

channel reconfiguration scenario and the current top of bank elevations. Floodwall and overflow weir elevations could be adjusted to mitigate flood control impacts depending on the overall channel design and configuration. **Figure 6** shows the general layout of the floodwalls and the overflow weir.

Several new channel configurations were considered and modeled. The modeling indicated that small adjustments in the channel bank slopes and configuration had only minor impacts on flood surface elevations and floodwall heights. Other design constraints such as trail width, channel bank slopes, rock bank protection, and protection of the existing established oak trees were also important considerations in the overall project design. It is likely that given the flow velocity and magnitude, the toes of each bank slope and portions of the streambed would need to be fortified with some rock rip-rap to prevent scour and to keep the bed and banks stable.

Figure 7 shows some possible channel configurations. The design options revolve around the angle of the new slope, width of the bottom of the channel and whether a rock toe wall would be used to aid in producing more gentle slopes and/or protecting the maximum number of existing oak trees on the bank. After investigation of existing geomorphic studies and local observations it appears that a 15 foot channel bottom width is optimal and matches naturalized sections of the creek near the project site. However, bottom widths could be narrowed to accommodate various bank slope scenarios that would preserve the existing oak trees and reduce flood wall heights in different sections along the reach. Narrower bottom widths would likely require additional rock slope protection which would increase velocities at low recurrence flows and limit the ability to install habitat features.

The Highway 101 culvert is the primary constraint for water flow along this reach of Arroyo Burro. The culvert reduces design options for the restoration of this reach. If the culvert is replaced with a larger capacity culvert (100 year flood event) at some point in the future, the upstream water surface elevation would be reduced, which would allow the channel to be naturalized without significant impacts to the overall flood conditions in this reach and without the construction of the floodwall. At this time, however, we are not aware of any future plans by Caltrans to increase the culvert size. Therefore, this feasibility analysis is based on the assumption that the culvert will not be replaced.

Planning Level Cost Estimate

We have developed a preliminary planning level cost estimate, that assumes the concrete channel would be removed and one of the three identified channel configurations would be utilized. Small portions of concrete lining upstream of the Highway 101 culvert and downstream of the Hope Bridge culvert will be left in place to help maintain the existing flood protection, reduce any structural complications with the existing vertical walls, and provide for a stable channel bed at this location. The channel bottom would need to be reconstructed using appropriate bed material and a bank fortified with rock at the toe would need to be constructed on both sides. Earthen slopes would be carried down the bank as far as possible to enhance the channel revegetation effort. Several creek bottom grade controls would be installed to ensure long term stability. Habitat features would be installed that could include woody debris structures, boulder rock clusters and small constriction points to give the channel bottom diversity and increase aquatic habitat quality. A new permeable trail would be constructed at the top of bank. Adjacent to the path, a new floodwall and overflow weir would be installed.

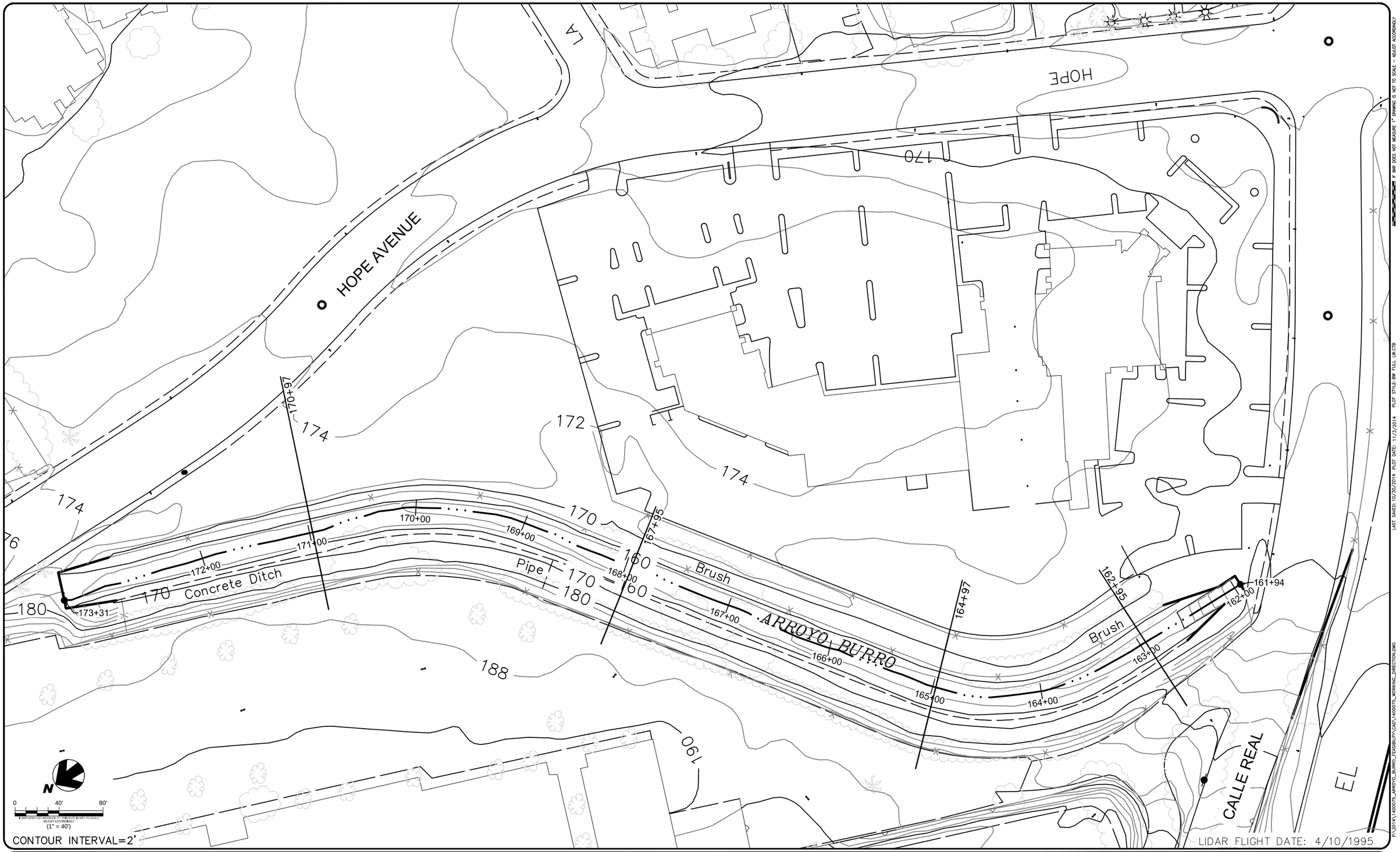
Table 3. Preliminary Planning Level Cost Estimate

No.	Item	Cost	Quantity	Units	Total Cost
1	Survey and Stakeout	$ 10,000	1	LS	$ 10,000
2	Mobilization	$ 100,000	1	LS	$ 100,000
3	Clearing & Grubbing	$ 20,000	1.4	AC	$ 28,000
4	Grade Access Rd, Gravel, Restore Access Rd	$ 35,000	1	LS	$ 35,000
5	Dewatering	$ 30,000	1	LS	$ 30,000
6	Site Protection ESA/Silt Fence	$ 5.50	1800	LF	$ 9,900
7	Demolition	$ 140	2000	TN	$ 280,000
8	Grading (Balance on site)	$ 40	1400	CY	$ 56,000
9	Planted Boulder Revetment	$ 135	3000	TN	$ 405,000
10	Boulder Grade Control Structures	$ 135	400	TN	$ 54,000
11	Boulder Bed/Reconstruct Creek Bed	$ 45,000	1	LS	$ 45,000
11	Habitat Features	$ 35,000	1	LS	$ 35,000
12	ADA Trail (3" AC/ 12" AB)	$ 10	9000	SF	$ 90,000
13	Cutoff Wall	$ 1,500	50	CY	$ 75,000
14	Flood Wall	$ 350	900	LF	$ 315,000
15	Planting	$ 35,000	1.45	AC	$ 50,750
16	Irrigation	$ 30,000	1	LS	$ 30,000
17	Erosion Control/BMP'S/SWIPP	$ 25,000	1	LS	$ 25,000
18	Construction Management	$ 55,000	1	LS	$ 55,000
				Subtotal:	$ 1,728,650
			Contingency (20%)		$ 345,730
				Total Project Cost:	**$ 2,074,380**

Conclusions

After analyzing the initial modeling results, we concluded that removing the concrete channel and restoring the subject reach of Arroyo Burro is feasible with structural flood control features such as floodwalls and overflow weirs to maintain or improve current levels of flood protection. We recommend that a portion of the concrete lining remain in the lower 100 feet of the creek reach upstream of Highway 101 culvert and for 50 feet downstream of the Hope Avenue culvert. This leaves approximately 900 feet of creek channel that could be restored in this reach.

The optimal bottom width of the channel should be approximately 15 feet, but considerations of other factors such as bank slope geometry, reducing flood wall height, and protecting existing tree resources may require the bottom width to be reduced. Semi-vertical rock walls could be installed at the toe to reduce the grading on the upper bank slopes. Changes to bottom width and bank slopes have only small impacts to 100-year water surface elevations, which can be mitigated by adjusting the height of the commensurate floodwalls and overflow weir. We estimate that the project could cost approximately two million dollars to complete (see Table 3).



ARROYO BURRO

SANTA BARBARA COUNTY

QUESTA ENGINEERING CORP.
Civil
Environmental
& Water Resources
(510) 236-6114
FAX (510) 236-2423
questa@questaec.com
P.O. Box 70356 1220 Brickyard Cove Road Point Richmond, CA 94807

REGISTERED PROFESSIONAL ENGINEER
STONEY A. TEMPLE
No. 59695
12-31-15
EXPIRES
CIVIL
STATE OF CALIFORNIA

Sht:	Rev:	Date:	By:	Description:	App'd:

Design: ST\CL
Drawn: CL
Checked: ST
Appr'd: ST

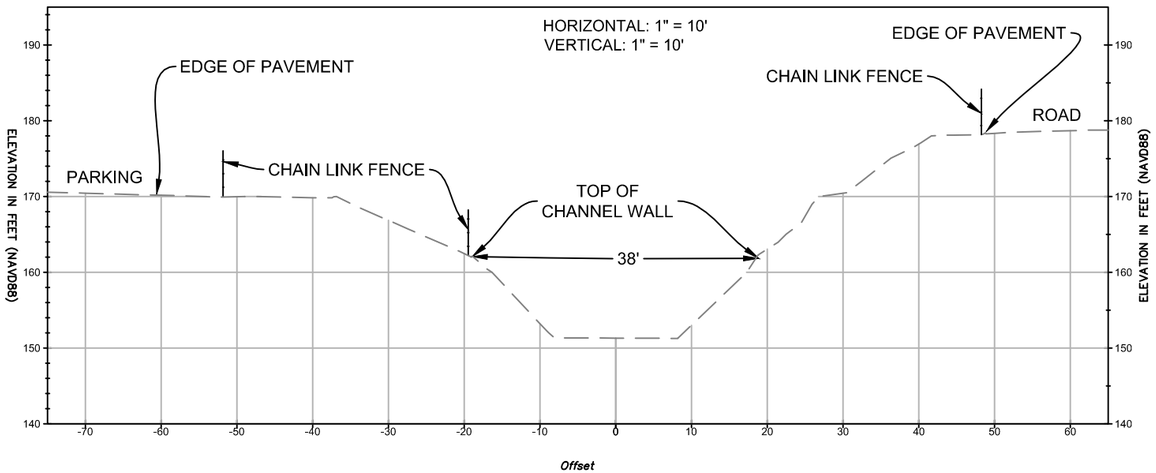
RESTORATION PLAN
CROSS SECTION LOCATIONS

ARROYO BURRO, SANTA BARBARA COUNTY

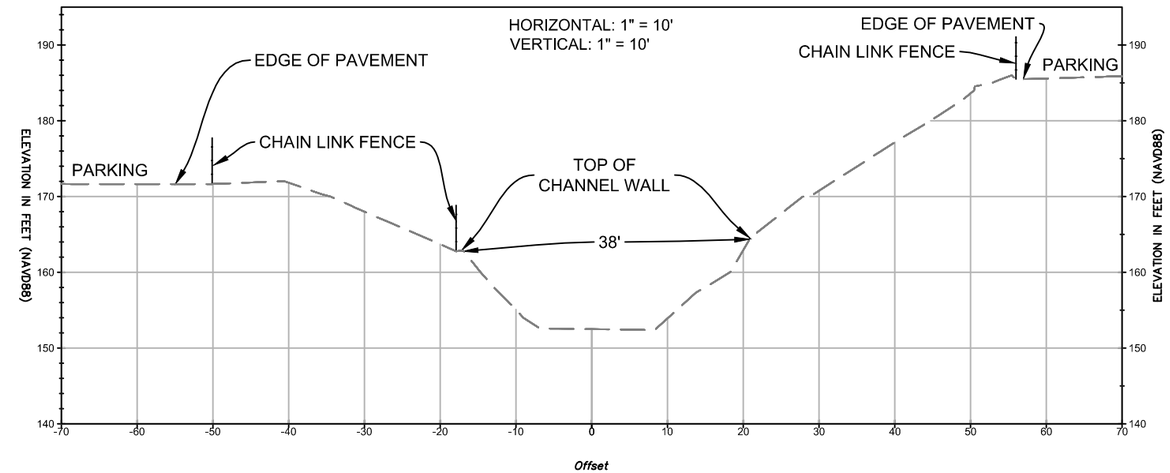
Size: D
Project: 1400075
Scale: AS NOTED
Date: 10-28-2014
Figure: 4

LAST SAVED: 10/30/2014 PLOT DATE: 11/3/2014 PLOT STYLE: BW FULL LW.CTB
P:\2014\1400075_ARROYO_BURRO_FEASIBILITY\CAD\1400075_WORKING_DIRECTION.DWG
IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY

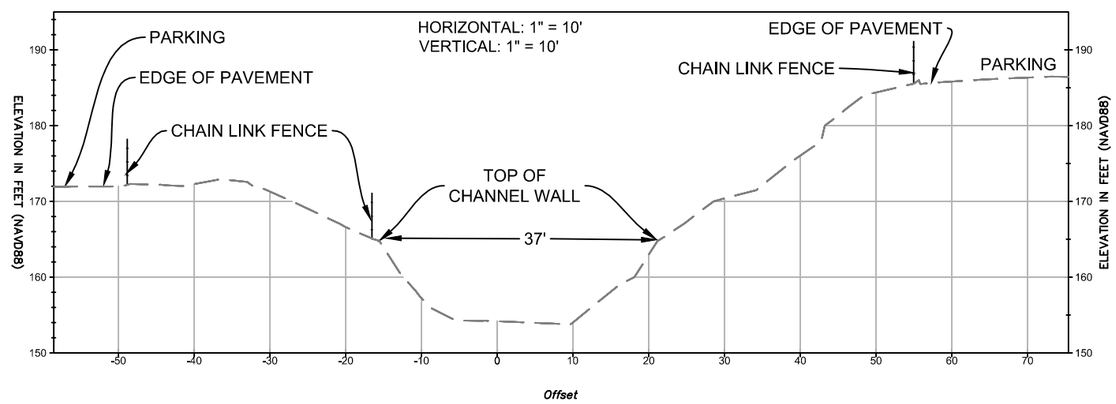
STA 162+95



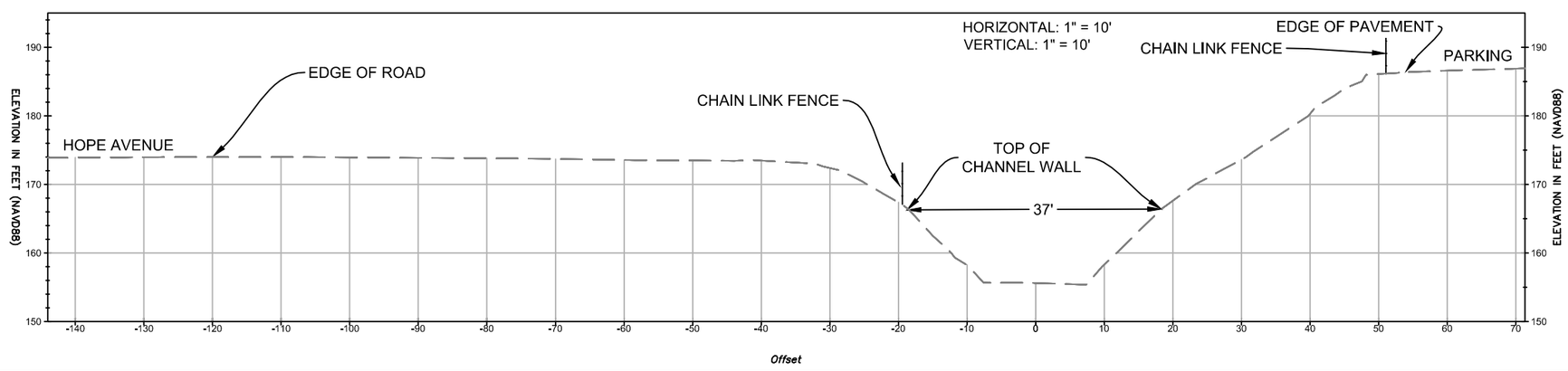
STA 164+97



STA 167+95



STA 170+97



ARROYO BURRO

SANTA BARBARA COUNTY

QUESTA ENGINEERING CORP.
Civil
Environmental
& Water Resources
(510) 236-6114
FAX (510) 236-2423
questa@questaec.com
P.O. Box 70356 1220 Brickyard Cove Road Point Richmond, CA 94807

REGISTERED PROFESSIONAL ENGINEER
STONEY A. TEMPLE
No. 59695
12-31-15
EXPIRES
CIVIL
STATE OF CALIFORNIA

Sht:	Rev:	Date:	By:	Description:	App'd:

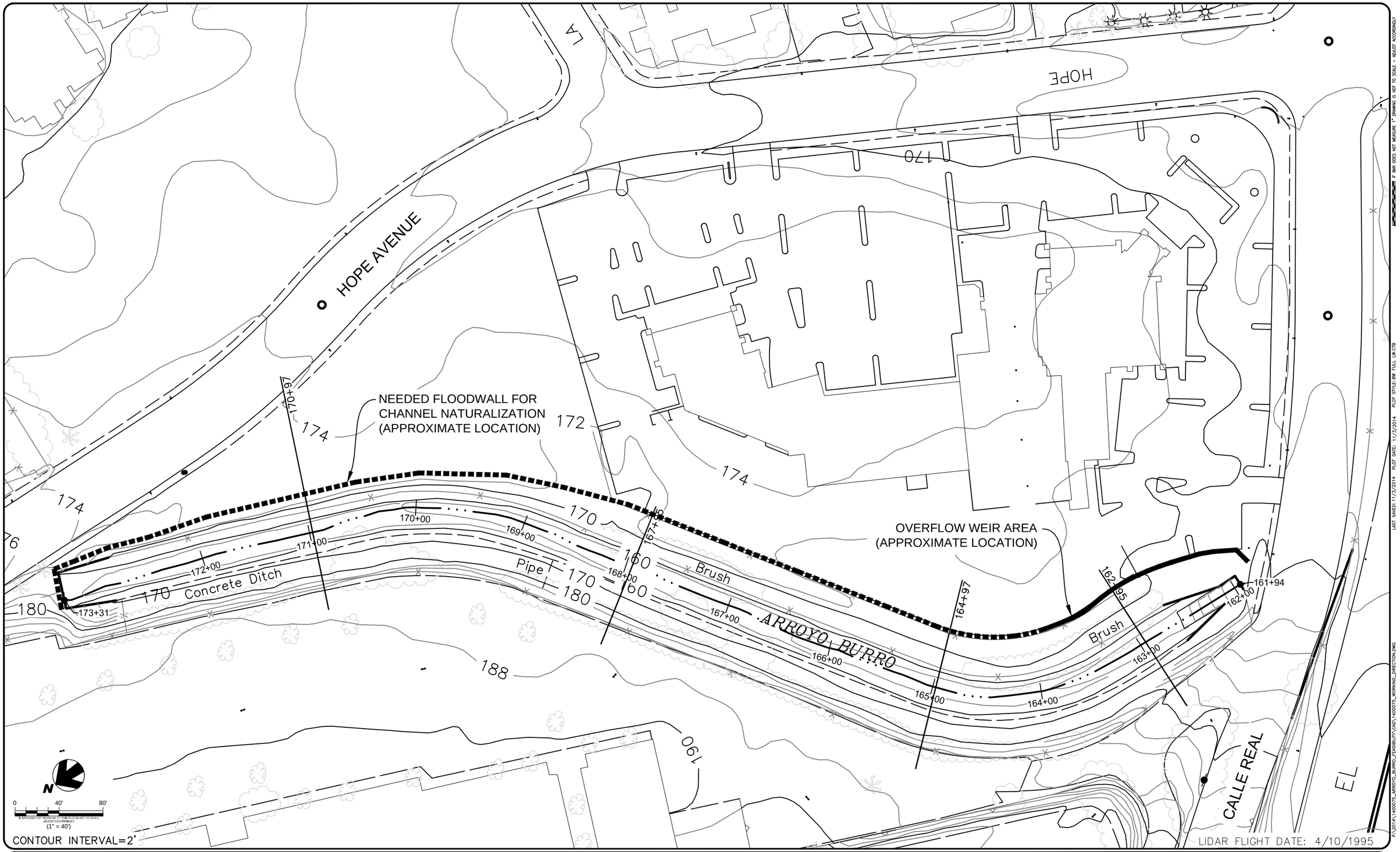
Design: ST\CL
Drawn: CL
Checked: ST
Appr'd: ST

RESTORATION PLAN
SURVEY CROSS SECTIONS

ARROYO BURRO, SANTA BARBARA COUNTY

Size: D
Project: 1400075
Scale: AS NOTED
Date: 10-28-2014
Figure: 5

P:\2014\1400075_ARROYO_BURRO_FEASIBILITY\CAD\1400075_WORKING_DIRECTION.DWG
LAST SAVED: 11/3/2014 PLOT DATE: 11/3/2014 PLOT STYLE: BW FULL LW.CTB
IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE – ADJUST ACCORDINGLY



ARROYO BURRO

SANTA BARBARA COUNTY

QUESTA ENGINEERING CORP.
Civil
Environmental
& Water Resources
(510) 236-6114
FAX (510) 236-2423
questa@questaec.com
P.O. Box 70356 1220 Brickyard Cove Road Point Richmond, CA 94807

REGISTERED PROFESSIONAL ENGINEER
STONEY A. TEMPLE
No. 59695
12-31-15
EXPIRES
CIVIL
STATE OF CALIFORNIA

Sht:	Rev:	Date:	By:	Description:	App'd:

Design: ST\CL
Drawn: CL
Checked: ST
Appr'd: ST

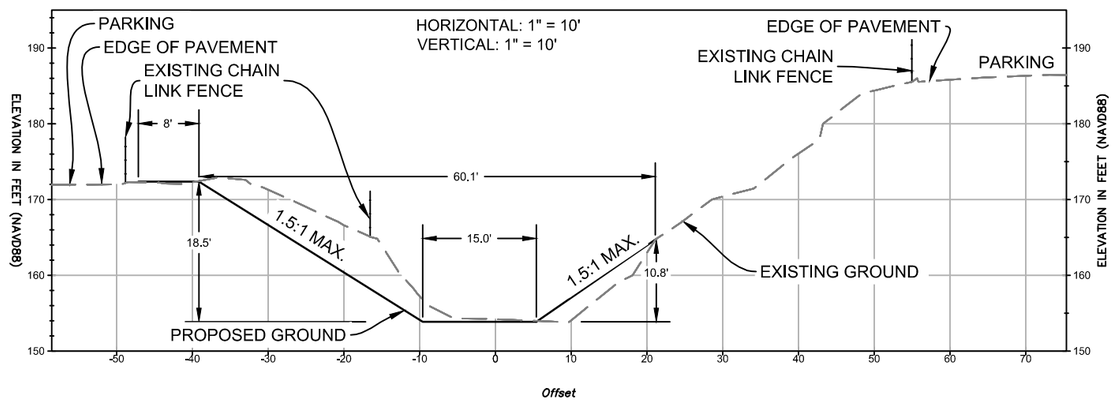
RESTORATION PLAN
CONCEPT FLOODWALL & WEIR

ARROYO BURRO, SANTA BARBARA COUNTY

Size: D
Project: 1400075
Scale: AS NOTED
Date: 10-28-2014
Figure: 6

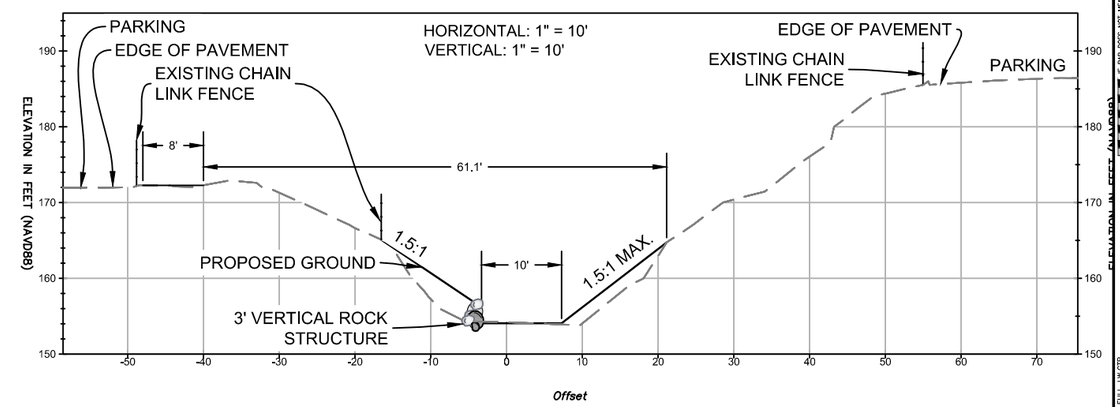
LAST SAVED: 11/3/2014 PLOT DATE: 11/3/2014 PLOT STYLE: BW FULL LW.CTB
P:\2014\1400075_ARROYO_BURRO_FEASIBILITY\CAD\1400075_WORKING_DIRECTION.DWG
IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE - ADJUST ACCORDINGLY

OPTION A



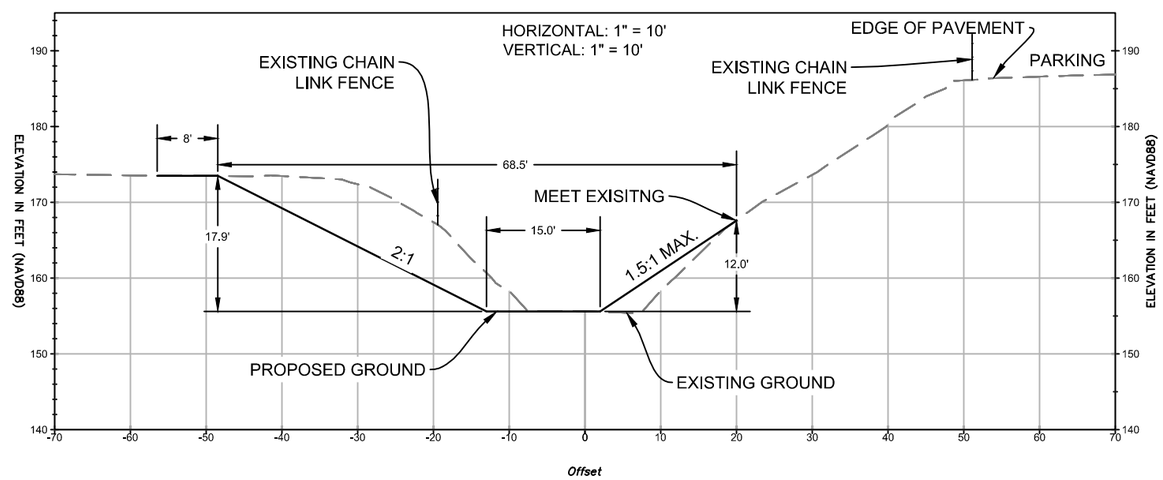
CROSS SECTION BASED ON STA 168+00

OPTION B1



CROSS SECTION BASED ON STA 168+00

OPTION B2



CROSS SECTION BASED ON STA 170+00

CONCEPT SECTIONS FOR STA 168+00 TO STA 171+75

CROSS SECTIONS BASED ON STA 170+00

ARROYO BURRO

SANTA BARBARA COUNTY

QUESTA ENGINEERING CORP.
Civil
Environmental
& Water Resources
(510) 236-6114
FAX (510) 236-2423
questa@questaec.com
P.O. Box 70356 1220 Brickyard Cove Road Point Richmond, CA 94807

REGISTERED PROFESSIONAL ENGINEER SIDNEY A. TEMPLE No. 59695 12-31-15 EXPIRES CIVIL STATE OF CALIFORNIA

Sht:	Rev:	Date:	By:	Description:	App'd:

Design: ST\CL
Drawn: CL
Checked: ST
Appr'd: ST

RESTORATION PLAN
CONCEPT CROSS SECTIONS

ARROYO BURRO, SANTA BARBARA COUNTY

Size: D
Project: 1400075
Scale: AS NOTED
Date: 10-28-2014
Figure: 7

LAST SAVED: 11/3/2014 PLOT DATE: 11/3/2014 PLOT STYLE:BW FULL LW.CTB

P:\2014\1400075_ARROYO_BURRO_FEASIBILITY\CAD\1400075_WORKING_DIRECTION.DWG

IF BAR DOES NOT MEASURE 1" DRAWING IS NOT TO SCALE – ADJUST ACCORDINGLY

ATTACHMENT B

FLOOD INSURANCE STUDY

VOLUME 2 OF 3

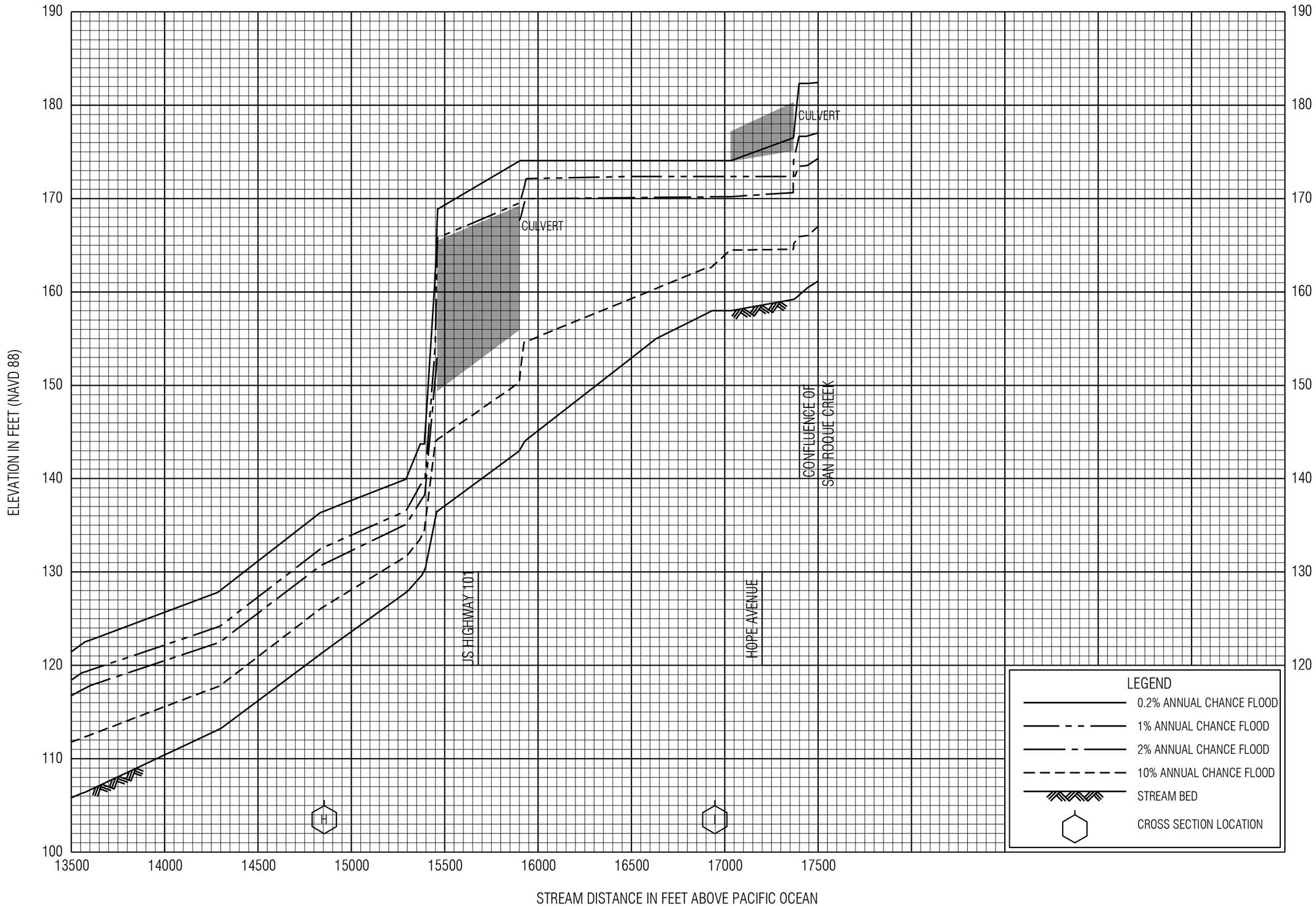
SANTA BARBARA COUNTY, CALIFORNIA
AND INCORPORATED AREAS

Community Name	Community Number
BUELLTON, CITY OF	060757
CARPINTERIA, CITY OF	060332
GOLETA, CITY OF	060771
GUADALUPE, CITY OF	060333
LOMPOC, CITY OF	060334
SANTA BARBARA, CITY OF	060335
SANTA BARBARA (UNINCORPORATED AREAS)	060331
SANTA MARIA, CITY OF	060336
SOLVANG, CITY OF	060756

REVISED: November 4, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
06083CV002C



FLOOD PROFILES

ARROYO BURRO CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

SANTA BARBARA COUNTY, CA

AND INCORPORATED AREAS

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Arroyo Burro Creek								
A	638[1]	136	531.7	11.3	8.3	8.3	8.3	0.0
B	3,398[1]	56	515.1	11.6	32.3	32.3	32.3	0.0
C	5,386[1]	80	648.9	9.2	45.3	45.3	45.3	0.0
D	6,592[1]	63	669.0	8.9	58.5	58.5	58.5	0.0
E	8,264[1]	65	417.5	13.7	68.0	68.0	68.0	0.0
F	11,434[1]	51	549.6	9.0	102.4	102.4	102.5	0.1
G	13,187[1]	64	408.4	11.5	115.6	115.6	115.6	0.0
H	14,844[1]	51	549.6	9.0	132.4	132.4	132.4	0.0
I	16,932[1]	46	491.9	11.7	172.4	172.4	172.4	0.0
J	17,672[1]	21	130.8	14.1	178.3	178.3	178.3	0.0
K	18,647[1]	28	217.4	8.5	194.8	194.8	194.8	0.0
L	21,521[1]	27	141.7	13.0	257.3	257.3	257.3	0.0
M	23,214[1]	28	122.5	11.8	306.8	306.8	306.8	0.0
N	24,899[1]	79	189.7	7.6	352.8	352.8	352.8	0.0
Arroyo Paredon Tributary								
A	0[2]	52	103	7.7	35.4	32.6[3]	32.6	0.0
B	630[2]	24	87	9.2	52.5	52.5	52.5	0.0
C	990[2]	21	74	10.8	65.7	65.7	65.7	0.0
D	1,205[2]	77	535	1.5	84.4	84.4	84.4	0.0
E	1,300[2]	40	207	3.9	84.3	84.3	84.4	0.1

[1]Feet above Pacific Ocean
[2]Feet above confluence with Arroyo Paredon
[3]Elevation computed without consideration of backwater effects from Arroyo Paredon

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

SANTA BARBARA COUNTY, CA AND INCORPORATED AREAS

FLOODWAY DATA

ARROYO BURRO CREEK – ARROYO PAREDON TRIBUTARY