Appendix D. Additional Data Collection and Design for SR-02

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Agua Hedionda Watershed Restoration Opportunity Site: SR-2

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1 Introduction

As part of the *Agua Hedionda Watershed Management Plan* (WMP, Tetra Tech 2008) opportunities for stream restoration were identified that would allow for progress towards the goal of watershed restoration and stream stability. The purpose of this report is to select one of those opportunities and further develop the concept by performing additional technical analyses (i.e. hydrology, hydraulics, sediment transport) and preparing 10% concept level designs. The opportunity identified as SR-2 from the *Agua Hedionda WMP Bioengineering Report* (Tetra Tech 2008) was selected for further development. It was selected for the following reasons:

- Adjacent high quality riparian vegetation would be protected by stream stabilization
- Stream erosion is occurring and is a potential contributor to sediment in the lagoon
- Other projects (sewer upgrades) are in the planning stage which provides partnering opportunities
- There is a project proponent (the City of Vista)
- Land acquisition in not required (land is owned by City of Vista)

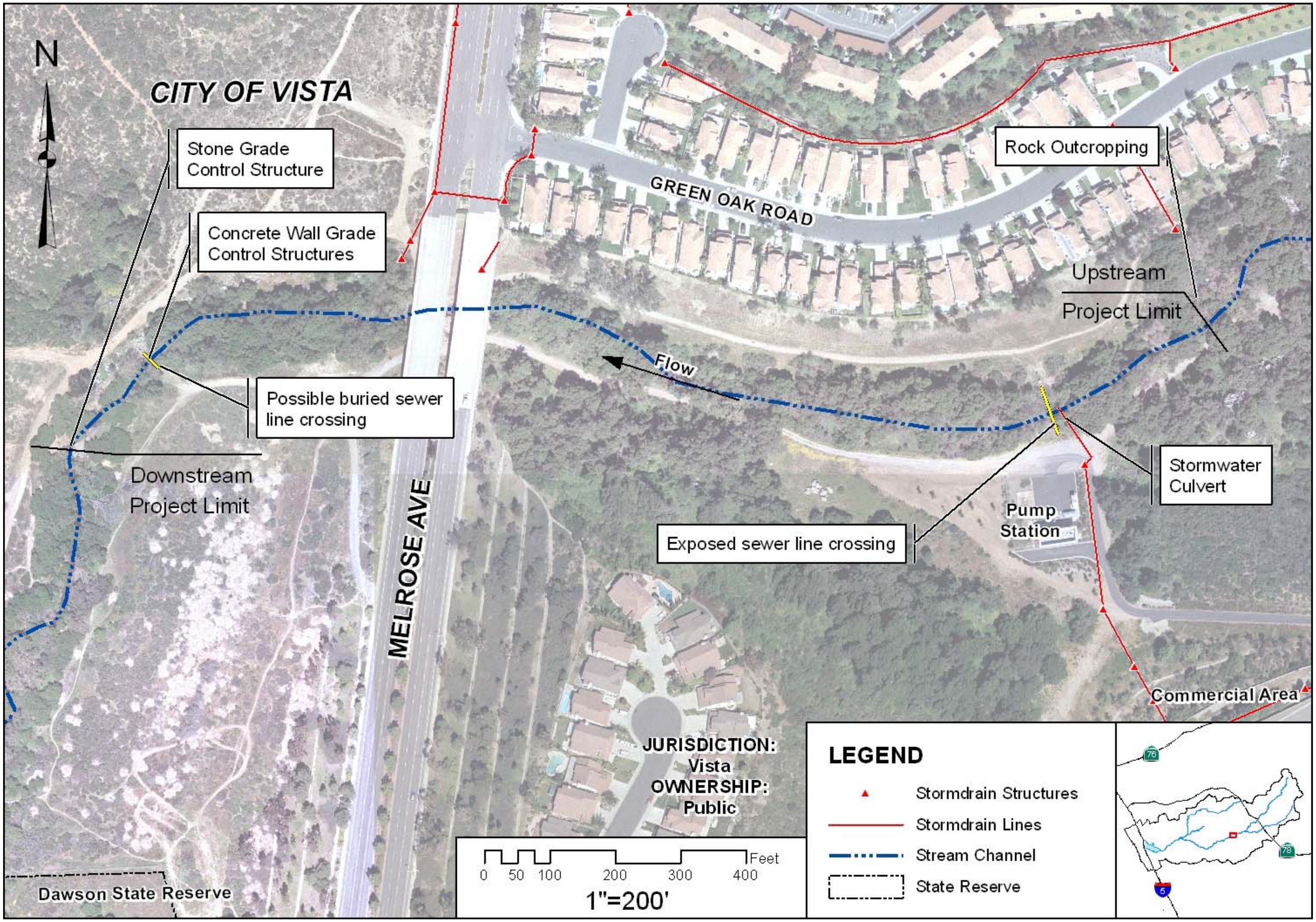
1.1 SITE SR-2

SR-2 is located along Agua Hedionda creek downstream of the Buena Creek confluence. As presented in the WMP, restoration at this site would focus on stabilization of the stream bed and banks. The reach features include a typical pool and riffle morphology, with long shallow pools filling much of the channel in low flow periods. Rock outcroppings are apparent in some areas, with a particularly large one at the upstream limit of the project site that acts as a natural grade control. Adjacent to the stream, is a Buena Sanitation District sewerage pump station (Buena Lift Station). The outflow pipeline from the pump station crosses the creek and is exposed which acts as a grade control and catches debris from up stream. The exposed sewer crossing also presents a potential water quality concern should it become damaged. Just upstream of the sewer crossing is a 60-inch RCP storm drain outlet, which drains a large commercial area on the hilltop to the south. The Melrose Avenue bridge crosses near the center of the project reach. The channel is lined with rip rap under the bridge, acting as another grade control structure with little natural habitat or vegetation. Downstream of Melrose Avenue there is a concrete wall grade control structure. It is composed of an upstream wall which has failed, and a section 15 feet downstream which is damaged and failing. It is assumed that this grade control structure was placed to protect an additional sewer crossing. Futher downstream at the lower project site limit is a rock grade control structure. These stream features are shown on Figure 1.1.

The project reach upstream limit is a large rock outcropping and pool, which functions as a natural grade break and control, and the downstream limit is just downstream of a loose stone grade control. The upstream limit of the project was selected as it provides a naturally stable reach and changes in the stream further upstream are unlikely to impact the project. The downstream limit of the project was selected as a location where there is evidence of inspection and maintenance activities to ensure the stream stability to protect the upstream sewer crossing. The project is within the City of Vista and on property owned by the City of Vista. The total length of the opportunity reach is approximately 2,500 feet.

The most comprehensive current data on the state of the channel is found in the October 2007 field survey information conducted by members of the team developing the WMP. Field survey of channel conditions was undertaken from September 30 to October 3, 2007 to familiarize participating parties with the current state of the creek. A memorandum of the survey was assembled for reference (Memorandum, Tetra Tech 2008). Typical channel widths at the project site are approximately 10 feet, varying from pool to riffle conditions as bed formations change such as gravel beds and bars to sand beds. Bank heights are typically 6-10 feet, with steep bank slopes ranging from 1-to-1, to almost vertical. The available topographic data does not reflect the steep banks and entrenched channel. Additional surveying is required to refine channel geometry for improved hydraulic analyses and for design of restoration features. The average channel slope is approximately 0.7%. The channel slope is steeper at the upstream end of the reach, flattening out in the center of the reach approaching Melrose Bridge, then steeper again downstream of Melrose Bridge crossing. The channel slope begins to flatten out again at the downstream end of the reach.

Figure 1-1 Site SR-2



2 Hydrology

Site specific hydrology is necessary to support the hydraulic analyses and design development. Available data was collected and evaluated for the hydrologic analysis with sufficient detail to provide peak discharges for a range of event sizes. Previous work was accumulated and compared to determine the flood frequency curve for the project location. It should be noted that no gages were available in the watershed; therefore no flood frequency analysis has been performed. Hydrologic data is currently being collected under the Melrose Bridge through the Regional Stormwater Monitoring Program as part of San Diego County Municipal Stormwater NPDES Permit, Order No. 2007-001, which can be evaluated for further study phases.

2.1 Previous Hydrology Reports

The following reports and data were reviewed to obtain hydrology information pertaining to the site:

1. "*Flood Plain Delineation Study, Agua Hedionda Creek from Downstream of Buena Creek Confluence to Downstream of Melrose Drive, City of Vista, San Diego County, California*", prepared by SAAD Consultants for the U.S. Army Corps of Engineers, Los Angeles District, June 2002. Hydrology included in this report is based on development of drainage area relationships using information presented in the *2006 FEMA Flood Insurance Study*.
2. "*Flood Insurance Study, San Diego County, California and Incorporated Areas*", Federal Emergency Management Agency, revised September 2006. Hydrology in this report is based on rainfall-runoff modeling performed by Nolte & Associates.
3. HEC-1 model obtained from Chang Consultants and associated watershed map obtained from Rick Engineering.

2.2 Review of Data

The discharge information available from the sources identified above are listed in Table 2-1. In addition to the available information the discharges downstream of the project site were estimated using the National Flood Frequency (NFF) Program nationwide urban regression equations and rural regression equations which are assumed to be the upper and lower limits of the flood frequencies.

Table 2-1 Peak Discharge Comparison

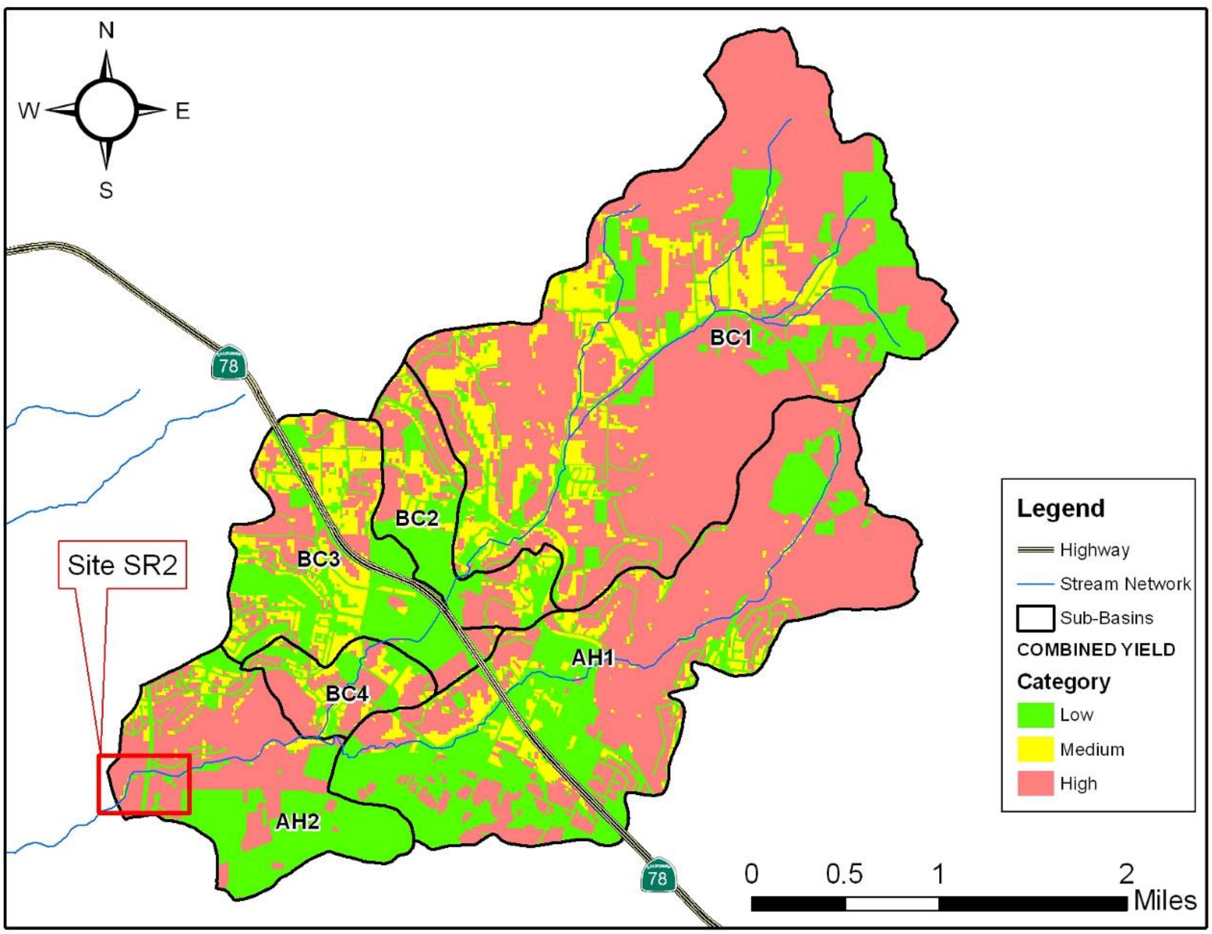
Location	Drainage Area (sq mi)	Peak Discharges (cfs)				Reference
		10-year	50-year	100-year	500-year	
Agua Hedionda Creek at Confluence with Buena Creek	6.30[1]	1,600	4,800	7,000	15,500	FEMA FIS
	9.21	-	-	5,481	-	Original HEC-1 Model
	9.30	3,510	5,089	5,555	-	HEC-1 Model
Buena Creek at Mouth	6.30	1,880	3,520	4,100		FEMA FIS
	6.41	2,413	3,530	3,847	-	HEC-1 Model
Downstream of Project Site	10.67	1,720	5,150	7,510	16,100	SAAD Report
	10.43	3,265	5,192	5,726	-	HEC-1 Model
	10.43	4,050	10,700	14,600	26,000	NFF Urban Regression Equations
	10.43	950	3,340	4,730	11,000	NFF Rural Regression Equations
1. The 6.30 might be a typo in the FEMA FIS.						

The SAAD results show good agreement with the FEMA FIS which is expected since they are both based on the same rainfall runoff modeling. The results also compare well with the HEC-1 model. All results fall within the range indicated by the NFF urban and rural regression equations. The SAAD values were averaged across many data points developed in the watershed and are assumed to represent the best estimate of flows and were adopted as the project flood frequency curve.

2.3 WATERSHED SEDIMENT YIELD

A preliminary sediment yield analysis was performed to identify sediment contributions to the watershed. An analysis of the land use (open space vs. developed), slope (steep or mild), and soil type (erosive or non-erosive) was made to categorize the yield potentials. The results are shown in Figure 2-1 below and indicate the significant area above the project site has a high yield potential. This supports the assumption used in the sediment transport analysis that transport is limited by the potential (i.e. the hydraulics) of the reach rather than limited by supply.

Figure 2-1 Watershed Sediment Yield



3 Hydraulics

3.1 INTRODUCTION

A hydraulic analysis was performed using the U.S. Army Corps of Engineers (COE) HEC-GeoRAS and HEC-RAS program. HEC-GeoRAS is a GIS extension developed by the COE and ESRI software company to facilitate the utilization of GIS data and digital elevation models to cut cross sections and develop data for export to the HEC-RAS model. The discharges used in this model were based on the 2-, 5-, 10-, 25- , 50-, and 100-year hydrology developed by the SAAD report discussed in Section 2.

3.2 MODEL DEVELOPMENT

The study reach for the hydraulic analysis extends further upstream and downstream than the limits of the restoration project reach. This is required for hydraulic modeling purposes. The study reach extends 2650 feet upstream from Melrose Bridge, into the downstream limits of Green Oak Ranch. This is about 150 feet upstream of the City of Vista property line, or 1400 feet upstream from the rock outcrop demarcating the upstream end of the restoration project. The study reach extends 1700 feet downstream from Melrose Bridge, approximately 1250 feet downstream from the lower end of the project reach at the lower rock grade control structure (see Exhibit 1 in the Appendix). The total study reach length is 4500 feet (the project reach is approximately 1850 feet).

Cross sections used in this model were developed from the 2005 Topographic shapefile provided by the cities of Vista and Carlsbad. The cross sections were cut utilizing HEC-GeoRAS. The model using the Topo file was developed from approximately 170 feet upstream of the Green Oak Ranch property boundary to approximately 350 feet downstream of the Dawson Reserve property boundary. Cross sections were located approximately every 100 feet, with additional sections at bridges and existing structures within the channel. The HEC-GeoRAS model was imported into HEC-RAS and a series of discharges were included to estimate channel hydraulics under various flow conditions.

Manning's n-values, a measure of the channel roughness, were estimated in the field utilizing Arcement & Schneider's "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains" (USGS, 1989) to be approximately 0.062 for the channel upstream of Melrose Bridge, 0.035 for the rip rap channel under Melrose Bridge, and 0.067 for the channel downstream of Melrose bridge. The bank n-values were set to 0.063 upstream of Melrose Bridge, 0.026 under Melrose Bridge, and 0.068 downstream of Melrose Bridge. Table 3.1 lays out resistance factors for the model.

Table 3-1 Resistance Values (n-values)

n-Value - Channel

Resistance Factor	DS of Melrose	Under Melrose	US of Melrose
XS Irregularity	0.01	0	0.01
Channel variation	0.003	0	0.003
Obstructions	0.015	0.01	0.015
Vegetation	0.01	0	0.005
Bed Base n-value	0.025	0.025	0.025
Meandering	1.07	1	1.07
TOTAL	0.0674	0.0350	0.0621

n-Value - Banks

Resistance Factor	DS of Melrose	Under Melrose	US of Melrose
XS Irregularity	0.003	0	0.003
Variation (n/a)	n/a	n/a	n/a
Obstructions	0.01	0.001	0.01
Vegetation	0.03	0	0.025
Bed Base n-value	0.025	0.025	0.025
Meandering (n/a)	1	1	1
TOTAL	0.0680	0.0260	0.0630

3.3 Existing Conditions Results

An analysis of the HEC-RAS results show that a 5-year storm event is contained in the channel while larger events escape the channel and are contained on the floodplain. This indicates that the 5-year flow is the channel-forming or bankfull discharge and is a significant flow in the restoration analysis. The following table identifies the values for several hydraulic parameters for the 5-year flow and the 100-year flow. The 100-year flow results are shown because they are a typical consideration for regional facility design. Restoration projects typically have a lower design level but it is a conservative assumption to say that the design parameters will fall within the range presented in the table below.

Table 3-2 Existing Conditions Hydraulics

Reach	Avg. Channel Dimensions		Flow velocity, fps		Flow depth, ft		Flow width, ft		Energy slope, ft/ft	
	Width (ft)	Depth (ft)	5 year	100 year	5 year	100 year	5 year	100 year	5 year	100 year
Reach 1 – upstream reach beginning at the rock outcrop	57	10.0	6.1	9.9	7.7	11.5	41	120	0.0058	0.0038
Reach 2 – includes the exposed sewer crossing	67	9.1	3.5	8.0	8.6	12.5	62	136	0.0033	0.0044
Reach 3 – includes Melrose Avenue bridge	73	8.2	4.5	7.8	7.3	11.9	64	150	0.0060	0.0039
Reach 4 – downstream reach including the failed grade control structures	63	8.9	4.2	7.1	8.2	14.6	69	151	0.0062	0.0036

4 Geomorphology and Sediment Transport

Stream morphology through the SR-2 site is composed of a series of riffles and pools. There is a large pool at the rock outcropping forming the upstream end of the project site, followed by a gravel riffle. Other pools tend to form immediately upstream of grade control structures such as an exposed sewer line near the pump station, at the rip-rap lined channel under the Melrose Bridge overpass, at a concrete wall control structure downstream of the bridge, and a stone grade control at the downstream end of the project site. Some of these pools are very long and shallow, forming flat or backwater pools in the channel about 1-2 feet deep. Riffles tend to follow after the pools. Distance between riffles are usually referenced based on a multiple of the channel widths. In the project reach the channel width is approximately 20 feet. The riffles begin approximately 3 to 7 channel widths apart. Erosion in the channel occurs at the toe of the banks, undermining large oak trees and other riparian vegetation which grow on the tops and sides of the banks. The intensity of the erosion varies from sub-reach to sub-reach, but the trend is universal throughout the project site. Erosion occurs most significantly in pools where deeper waters directly attack the exposed steep banks and throughout the channel during storm events when the banks are exposed to higher energy flows. This widespread erosion is the evidence of the channel’s natural response to the hydraulic regime to reach a state of equilibrium. Left unchecked, this natural response will likely lead to deeper channels that continue to widen as the banks fail. This will cause significant impacts to the adjacent habitat as well as increasing the sediment load into the channel which can be carried downstream to the lagoon. A desire to avoid these negative effects leads to the need for grade stabilization throughout the project site.

4.1 Sediment Transport Modeling

A preliminary investigation of the sediment transport potential of the project reach was performed. Further development of the design will require a more in-depth analysis; however, early results can be used as part of the planning process by considering the sediment movement that is expected through the site. A design criterion of the project is to develop a channel that can not only carry a certain amount of flow, but can also carry a certain amount of sediment. In this way the sediment inflow from upstream is balanced such that minimal maintenance is required. However as with all restoration projects, regular inspections are also a necessary activity to verify the performance.

4.1.1 Sediment Curves

Information on the sediment present in the system is required as part of the input to the sediment transport model. Bed (invert) and bank material was characterized at four locations in the SR-2 opportunity. The characterization locations included 300 ft upstream of the rock outcrop that forms the upper limit of the project reach (Sites 1i & 1b), 100 ft upstream of the sewer line crossing (Sites 2i & 2b), 150 ft upstream of the failing concrete wall grade control structure (Sites 3i & 3b), and 40 ft upstream of the stone grade control structure (Sites 4i & 4b). The “i” in the site name indicates it reflects the invert while the “b” reflects the bank. Soil gradation curves are shown on Figure 4.1 for the bed material and Figure 4.2 for the bank material at the four sites.

The sediment curves for the bed and bank at each site are similar throughout the study reach. Some variability can be expected even at the same location indicating that the sediment is similar throughout the project site with little variation from the upstream to the downstream limit of the project. A composite curve of all sites is shown on the sediment curve graphs and is considered to be representative of the sediment transported through the project reach. This composite curve was used in the sediment analysis.

The material contained in the channel bed includes a fairly even distribution of sands (coarse, medium, and fine) and fine gravels. While the bank material will contribute to the process, the material found in the bed dominates the sediment transport capacity. The bank material includes sand (medium and fine) as well as silts and clays. The bank material is dominated by the fine sands. However, the clay portion provides some measure of stability to the bank.

Figure 4-1 Invert Material Gradation Curve

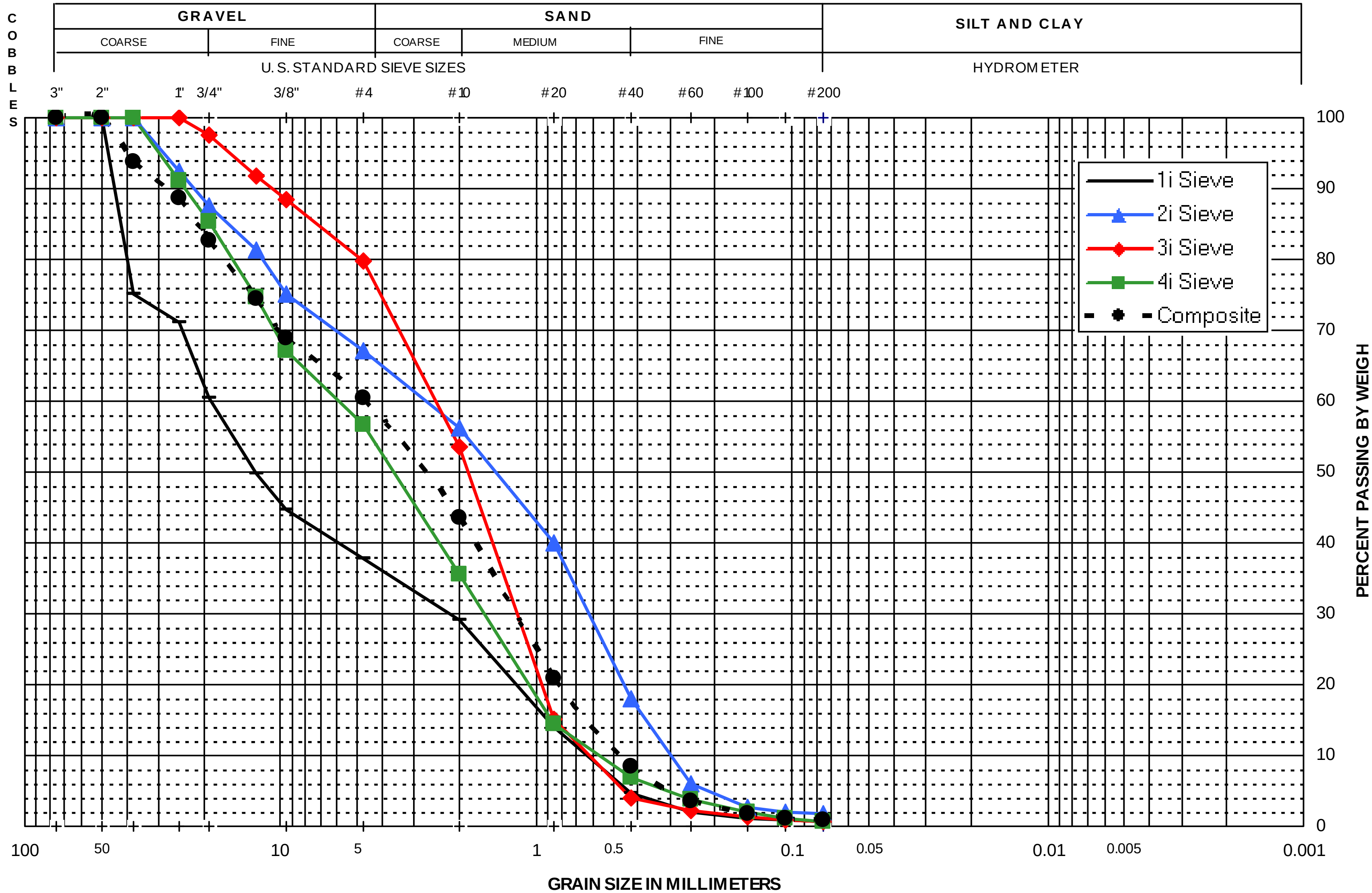
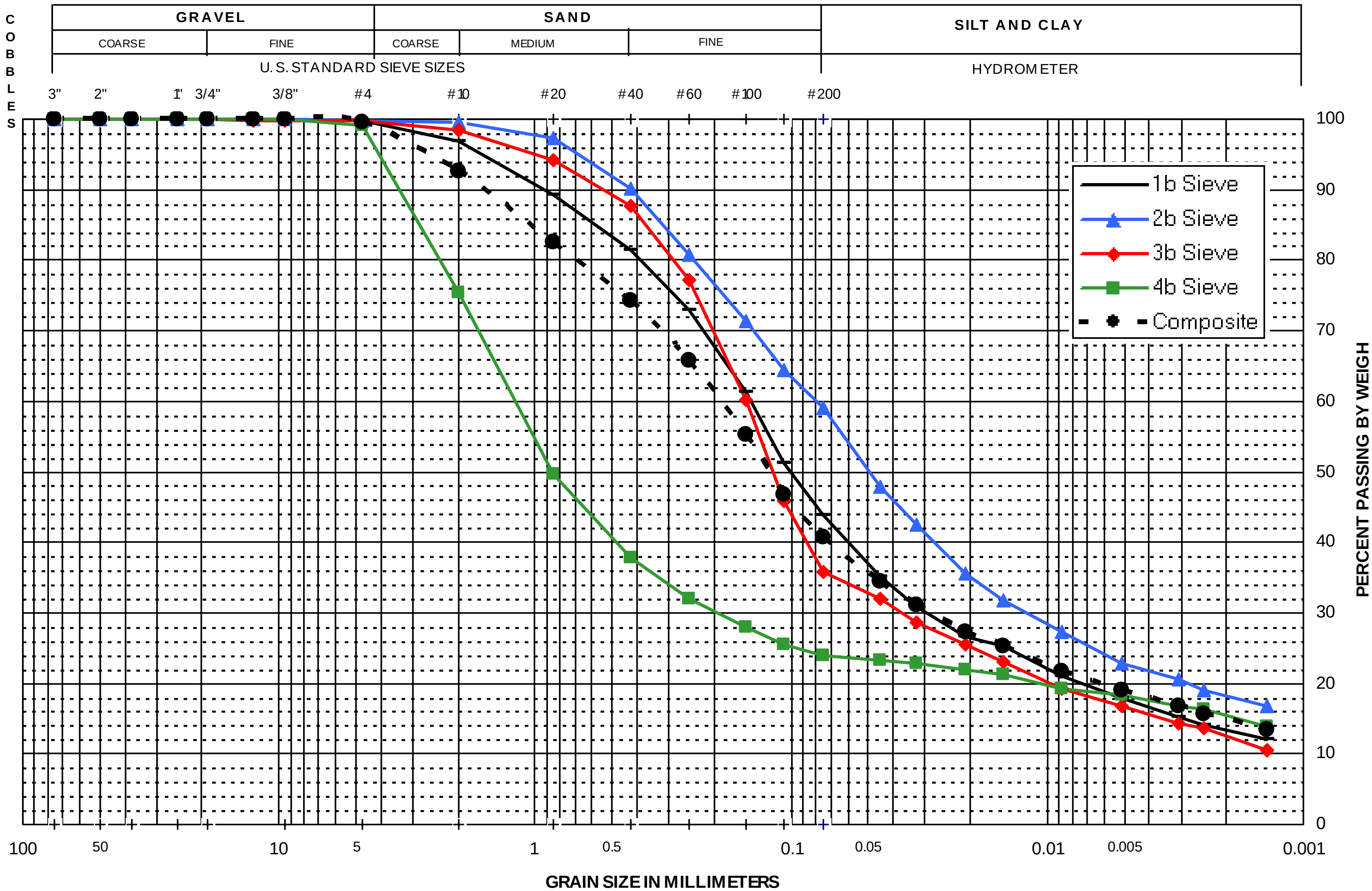


Figure 4-2 Bank Material Gradation Curve



4.1.2 SAM Analysis & Results

Sediment transport analyses were performed using SAM. The SAM Sediment Hydraulic Design Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid engineers in analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects (Copeland *et. al.* 1997). SAM combines the hydraulic information and the bed material gradation to compute the sediment transport capacity for a given cross section and a given discharge for a single point in time. A number of sediment transport functions are available for this calculation. Based on the median size of the bed material and the channel hydraulics, the Yang D50 equation was selected to assess the sediment transport capacity of the channel.

The project reach was divided into four reaches and average hydraulic parameters were calculated for each reach based on the HEC-RAS output. The 5-year flow is largely contained within the channel and was used as the focus of the sediment transport computations. Once the flow escapes the channel, energy is dissipated on the floodplain and sediment transport capacity is reduced. The 5-year flow occurs at a frequent enough interval to shape the channel. The following table identifies the reaches used in the sediment transport and the average hydraulic parameters. These parameters are also shown in Figures 4-3 through 4-5.

Table 4-1 Sediment Transport Reaches

Reach	Cross Sections	Avg 5-year velocity	Avg 5-year depth	Avg 5-year top width
Reach 1 – upstream reach beginning at the rock outcrop	45-32	6.1	4.1	42
Reach 2 – includes the exposed sewer crossing	31-22	3.5	4.4	62
Reach 3 – includes Melrose Avenue bridge	21-11	4.5	3.7	64
Reach 4 – downstream reach including the failed grade control structures	10-01	4.2	4.1	69

Based on the hydraulic results from the HEC-RAS model, the bed material sediment curves, and the Yang, D50 sediment transport equation, the following sediment transport capacities were identified for each reach. It is important to note that other sediment transport equations provide very different values for the sediment transport rate. For example using the Laursen (Copeland) equation rather than Yang D50 provides an estimate that increases by order of magnitude. Further studies can investigate the transport values. However, the numbers shown in Table 4-2 can be used to assess the trends.

Table 4-2 Sediment Transport Potential

Reach	5-year sediment transport (tons/day)
Reach 1	170
Reach 2	32
Reach 3	93
Reach 4	71

Figure 4-3 Average 5-yr Velocity

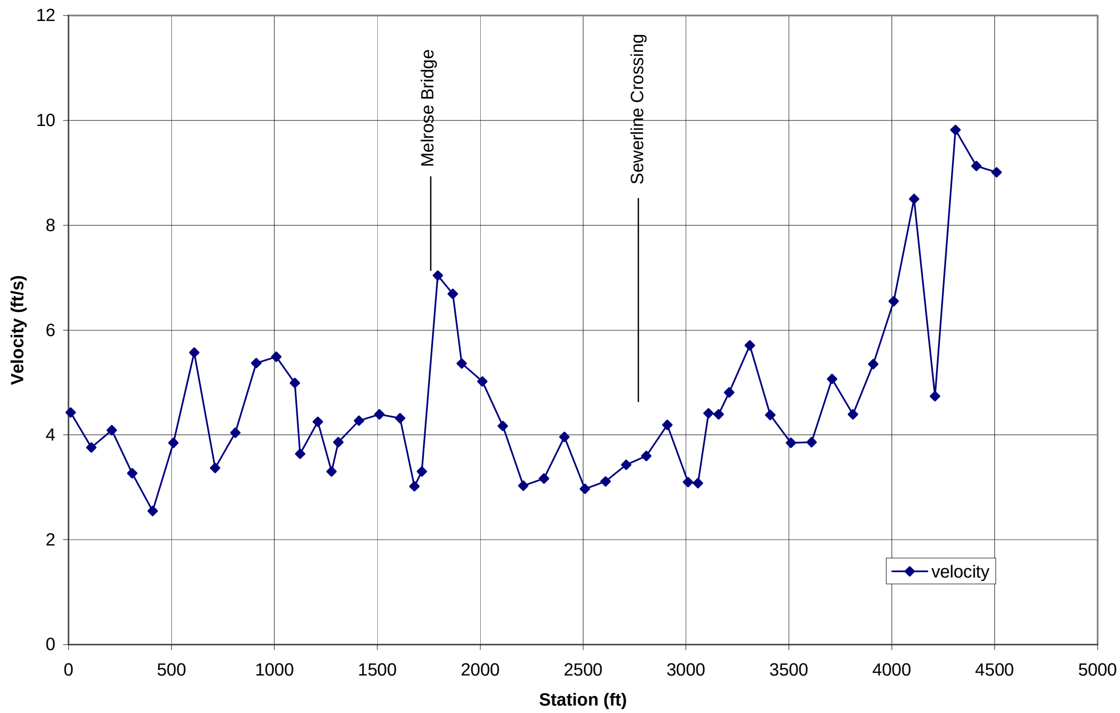


Figure 4-4 Average 5-yr Depth

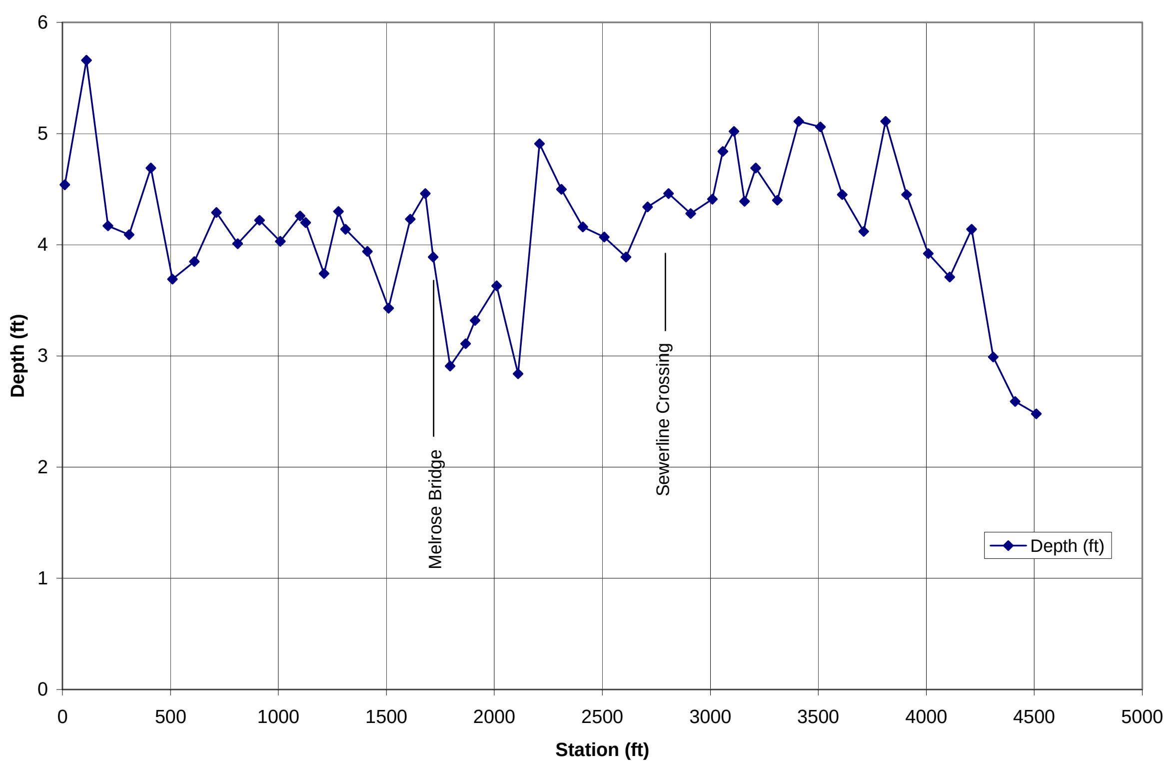
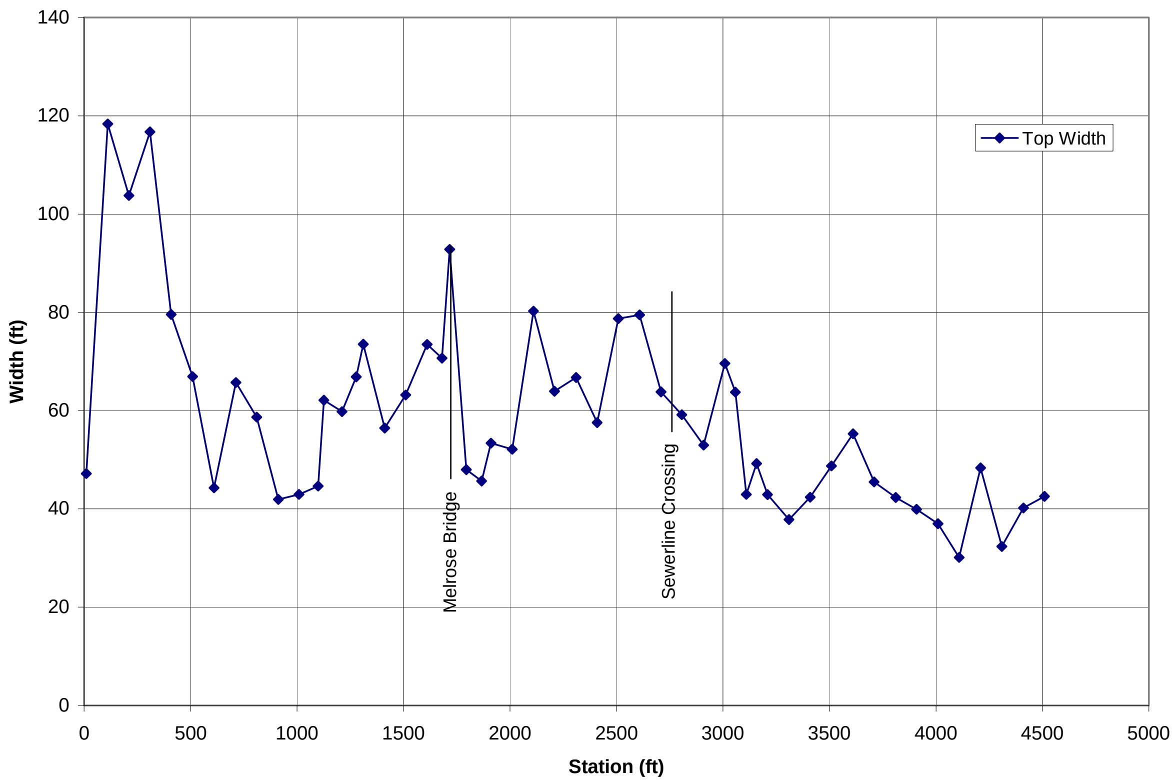


Figure 4-5 Average 5-yr Top Width



These values show that the upper project reach has a significant sediment transport potential. However this is a stable reach due to the influence of the bedrock controls and would likely act as a pass through reach for upstream supply. Reach 2 has a lower transport rate and likely experiences aggradation. This corresponds to the field investigations which show sediment aggradation upstream of the exposed sewer line. Reach 3 and 4 have similar transport rates that are higher than those calculated for Reach 2. This indicates a potential for erosion due to the lack of supply from Reach 2. Restoration alternatives will provide a better balance to the sediment transport rates throughout the project area in order to achieve an equilibrium state.

5 Design

5.1 Design Approach

One goal of the Agua Hedionda Watershed Master Plan is to "Restore watershed functions, including hydrology, water quality, and habitat, using a balanced approach that minimizes negative impacts". In the project site SR-2, bank stability is threatened by incision of the invert, and particularly the undermining of the toe of the banks, leading to failure and increased channel widths. These two processes are inter-related and are likely a symptom of urbanization in which discharges into the creek are increased in both volume and magnitude, while simultaneously sediment supply is reduced. These processes are further explained in the WMP.

While the extent of the current instabilities are likely due to unnatural processes, a certain amount of channel erosion and movement is part of the natural process. It is helpful to think of the goal as sustainable erosion rather than complete immobility of the channel. In a naturally functioning river, one bank tends to erode while another is built up. Riparian habitat may be lost on one bank, but new growth is encouraged on the aggrading bank.

The approach to the design of the grade stabilization is to provide overall stabilization to the channel to support the natural habitat but still allow for sustainable erosion. This study is an early conceptual stage of the project. Additional work needed is described in the last section as well as part of the alternative discussion. While three alternatives for grade stabilization are identified herein, further phases of this project should allow for addition brainstorming that could lead to modifications of these alternatives or new alternatives.

5.1.1 Alternative 1 – Rock Grade Control

Alternative 1 consists of utilizing regularly spaced grade control structures (GCS) composed of very large rocks (approximately 3-4 foot diameter). These rocks would be placed to naturally form a slope over a length to mimic the natural riffles of the stream. The slope between the top of a downstream GCS and the bottom of the upstream GCS would be 0%. This will promote the natural development of an equilibrium slope between the two structures. The equilibrium slope is the slope at which a channel neither aggrades nor degrades significantly over time.

Each GCS would have a drop of 2 feet. This drop height was selected because it is reasonable compared to the drop seen over the natural grade control reaches and is low enough to allow for acceptable aesthetics. Stone chosen for the GCS can be selected to match existing rock outcroppings along the stream. Consideration will need to be given to the location of the upstream rock outcropping, the exposed sewer line, and the rip-rap lined channel beneath Melrose Bridge, which are static. The drop structures vary in distance from approximately 150 feet to 500 feet apart. This allows for six drops over the entire length covering a total elevation change of 10 feet. The proposed structures are designed to mimic the appearance and function of the natural pools and riffles that exist in the channel (See Exhibit 2 in the Appendix). There are currently approximately 23 natural riffles within the project reach. GCS's would be sited in such a way to be incorporated with those natural features.

One benefit to placing a GCS in the channel is that it will provide useful information on the equilibrium slope that naturally forms in the watershed's streams, facilitating the design of other mitigation or restoration projects in the watershed. However, grade control structures require significant ground disturbance to implement, both along the banks and immediately upstream and downstream of the structure. Vegetation is typically destroyed in the construction and grading of the terrain surrounding the structure, requiring replanting and possibly a long recovery time. This includes not only small shrubs, plants, and aquatic flora, but large trees that currently exist along the banks and are high priorities for protection.

The following table identifies the costs associated with the conceptual alternative as described above. The cost estimate is based on concept plans and should be used for planning purposes, not capital budget allocation. The costs are adequate for seeking grant funding, however, appropriate escalation factors should be applied.

Table 5-1 Alternative 1 Concept Plan Costs

Site SR-2 Alternative 1 (Stone Grade Control Structures)					
Item	Units	Quantity	Unit Price	Cost	Assumptions
mobilization	LS	1	$50,000	$50,000	
material for 6 grade stabilizers	CY	2778	$135	$375,000	1 ton select rock - machine placed
replant disturbed area	LS	120	$500	$60,000	20 trees at each stabilizer
cut	CY	5556	$15	$83,333	
fill & compact	CY	2778	$5	$13,889	replace cut
disposal	CY	2778	$20	$55,556	dispose cut
25% construction contingency	LS	1	25%	$121,250	
construction cost				$759,028	
design & permitting cost				$300,000	
total cost				$1,059,028	

The next step in developing this alternative would be to identify specific sites that would be appropriate for the location of the GCS. The location should consider the vegetation that would be impacted and what locations will have the least negative impact to the most desirable vegetation. Identification of the highest value riparian vegetation would assist in these decisions. Based on selected locations, additional hydraulic analyses should be performed to determine the impact of the GCSs on water surface elevation.

5.1.2 Alternative 2 – Newbury Riffles

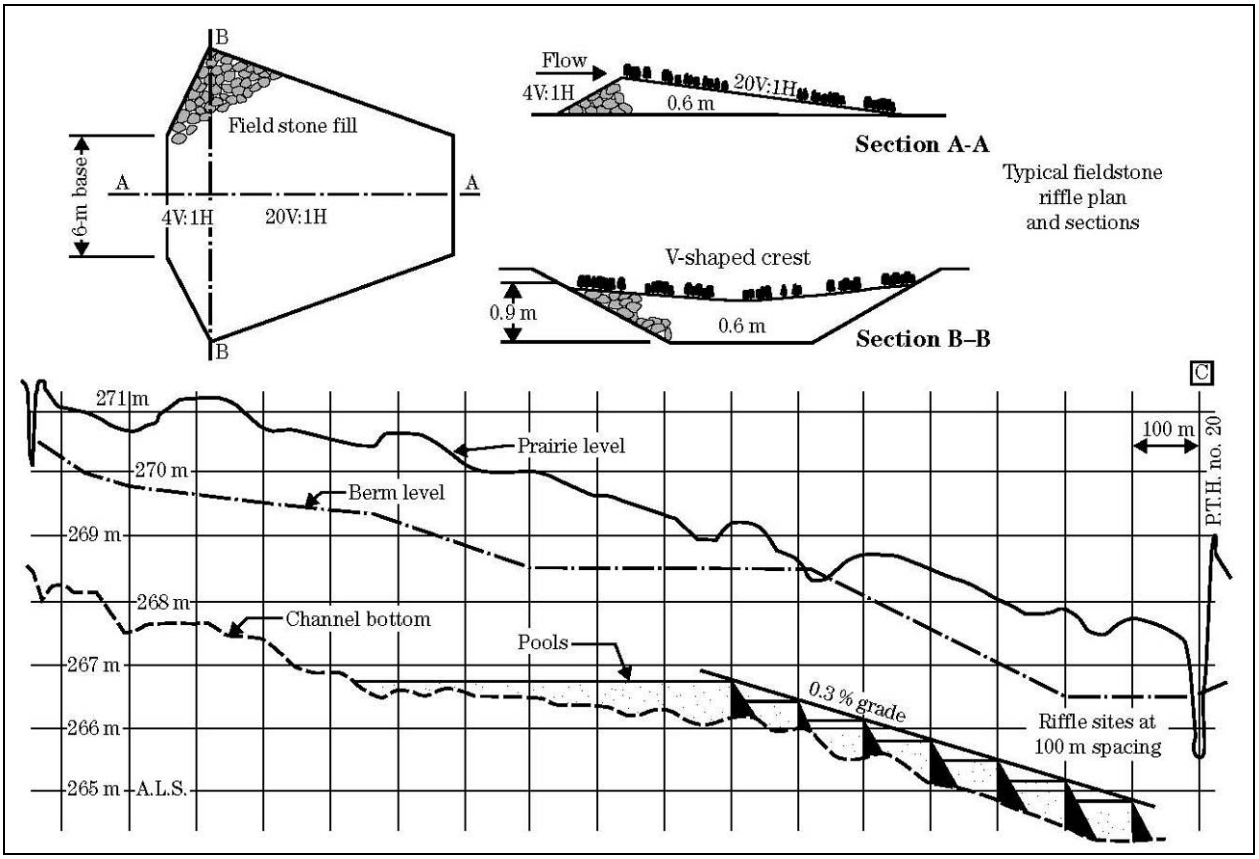
Alternative 2 consists of 'Newbury Riffles', a design concept developed by Newbury and Gaboury (1993). Each riffle structure is placed every 5-7 channel widths apart, impounding shallow pools of water. Originally designed for fish passage, a Newbury Riffle is created by placing large diameter boulders for the structure crest, followed by smaller support stones behind and in front of the large crest stones. The riffles will have a steeper (eg. 4:1) sloped upstream face, and a shallow (eg. 20:1) sloped downstream face. Smaller stone is used to fill the remaining gaps. Figure 5-1 shows a plan and profile of a typical Newbury Riffle taken from the National Engineering Handbook (NRCS, 2007, pg. TS14G-6). As the structure is composed of various sizes of stone, typically two foot sized angular stones with native smaller stones used to seal the upstream face, and other small stone to infill spaces along the bank and allow some riparian vegetation to grow, enhancing the natural look and feel of the structure as well as possibly enhancing it's stability with natural rooting.

Each riffle structure would have an average drop of approximately 2 feet. The average height of the structure itself is 2 feet. Stone chosen for the riffles can be picked to match existing rock outcroppings along the stream. Each drop structure is located 200 feet from the next (distance from top of one structure to top of the next based on 5-7 channel width distance). Consideration will need to be given to the location of the upstream rock outcropping, the exposed sewer line, and the rip-rap lined channel beneath

Melrose Bridge, which are static. The structures are sized based on the existing stream size, which for site SR-2 is approximately 20 feet wide, and 40 feet long, (See Exhibit 2 in the Appendix).

Advantages of Alternative 2 compared to Alternative 1 are a lower material cost and less disturbance of the bank (and its vegetation) due to less requirements to key the structure into the bank. Less of a key-in is required because the structure is designed to allow for some movement of the stone. Long term stability of the structure may require some maintenance after larger storm discharges to assess the movement of the riffle structure. Additionally, any large, particularly woody, vegetation that begins to grow in the structure may need to be removed if it begins to displace the structure's stonework. A failed Newbury Riffle could release a significant slug of sediment should it fail after having been in place for sufficient time as to allow the impounded pools to aggrade.

Figure 5-1 Newbury Riffle Typical Plan and Profile



The following table identifies the costs associated with the conceptual alternative as described above. The cost estimate is based on concept plans and should be used for planning purposes, not capital budget allocation.

The next step in developing this alternative would be to identify specific sites that would be appropriate for the location of the Newbury riffles. The location should consider the vegetation that would be impacted and what locations will have the least negative impact to the most desirable vegetation. Identification of the highest value riparian vegetation would assist in these decisions. Based on selected locations, additional hydraulic analyses should be performed to determine the impact of the structures on water surface elevation. Additional information on the performance and maintenance of Newbury riffles should be reviewed.

Table 5-2 Alternative 2 Concept Plan Costs

Site SR-2 Alternative 2 (Stone Newbury Riffles)					
Item	Units	Quantity	Unit Price	Cost	Assumptions
mobilization	LS	1	$50,000	$50,000	
material for 9 stone riffles	CY	600	$150	$90,000	2 ft plus smaller select rock and extra hand labor
replant disturbed area	LS	45	$500	$22,500	5 trees at each riffle
25% construction contingency	LS	1	25%	$40,625	
construction cost				$203,125	
design & permitting cost				$300,000	
total cost				$503,125	

5.1.3 Alternative 3 – Gravel Bed Augmentation

Alternative 3 consists of utilizing large amounts of gravel to raise the invert of the channel along the project reaches length. The gravel would be sized, so that it does not mobilize during the 5-year or 10-year discharge. As a preliminary concept, it is proposed that the channel bed be raised 4 feet (see Exhibit 2 in the Appendix). Under existing conditions (no change in the channel bed), the 5-year storm event begins to overtop the channel and inundate the floodplain. Inundation of the floodplain represents a natural function that could have a range of benefits to the watershed. There is limited infrastructure in the floodplain (notable exception is the Buena Pump Station) and connection of the channel and floodplain is considered a benefit to the riparian habitat. By raising the channel invert flows between the 5-year and 2-year storm event would overtop the channel and allow for more frequent inundation of the floodplain. Biological studies would be required to quantify the benefits of more frequent inundation, but it is assumed to be a positive impact to the riparian buffer. To simulate natural riffles in the stream channel, large boulders can be placed in the channel.

Alternative 3 is a non-traditional erosion control technique. Placing large amounts of gravel into the stream would have little to no negative impact on adjacent bank vegetation. Bank stabilization would minimize further channel failure which causes losses of riparian trees. However, it is likely that aquatic resources (freshwater clams, frogs, crawfish, etc.) could be negatively impacted by the change in bed material. Large boulders could be placed in the channel to simulate riffles and sculpting could be performed to mimic the deep ponds but that sandy material seen on the bed surface would no longer be present.

The following table identifies the costs associated with the conceptual alternative as described above. The cost estimate is based on concept plans and should be used for planning purposes, not capital budget allocation.

Table 5-3 Alternative 3 Concept Plan Costs

Site SR-2 Alternative 3 (Gravel Bed Augmentation)					
Item	Units	Quantity	Unit Price	Cost	Assumptions
mobilization	LS	1	$50,000	$50,000	
material for gravel	CY	8889	$50	$444,444	plus minor fill/cut
25% construction contingency	LS	1	25%	$123,611	
construction cost				$618,056	
design & permitting cost				$300,000	
total cost				$918,056	

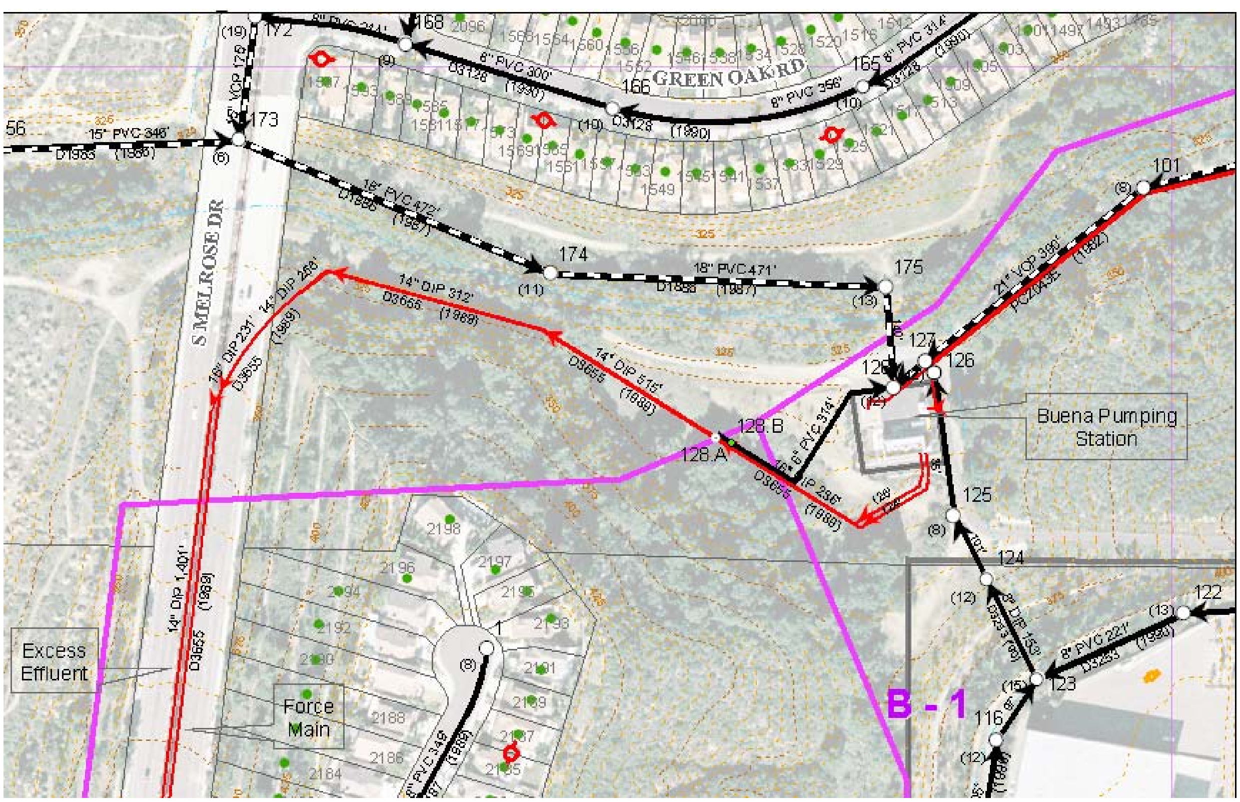
A significant step in this alternative development is to define the impacts to in-stream aquatic life. Those impacts have not been considered in the development of this alternative and should be weighed against the benefits of minimal impact to the adjacent riparian habitat. Preliminary hydraulic analyses indicate that the water surface elevation would increase substantially (i.e. on the order of 4'). An analysis of the impact on adjacent infrastructure should be made. While no residences would be impacted, adjacent trails and the pump station would be impacted during significant storm events that occur on a fairly frequent basis.

5.2 Other Projects in the Study Reach

As mentioned earlier in the report, an advantage of the SR-2 stream restoration site is that there are opportunities to integrate a stream restoration project with other projects. There are several ongoing and proposed upgrades to the sanitary sewer system in this area that are included in the City of Vista and Buena Sanitation District Sewer Master Plan Update (January 2008). In particular the replacement of the ductile iron project (DIP) force main that runs south of the creek as well as the enlargement of the 18-inch PVC pipe that crosses the creek is included in the City plan. Both lines are shown below on the portion of plan sheet 29_12 from the City of Vista's Master Plan. For these projects, in particular any enlargement of the 18" line that crosses the creek, could be coordinated with the stream restoration project in order to pool resources, limit the number of disturbances to the creek, and combine permitting efforts. It should be noted that the grade stabilization alternatives identified in the preceding sections give consideration to the particular need to stabilize the channel at the 18" exposed sewer line crossing.

Other projects that could be combined for a larger benefit are buffer restoration and wetland restoration. In particular Buffer Restoration site No. BR-52 and Wetland Restoration site No. WR-09 are both located at the downstream end of SR-2. These projects are outlined in the WMP in Section 6.2.2.2 (Buffer Restoration) and 6.2.2.3 (Wetland Restoration). Both are high priority projects.

Figure 5-2 Locations of sewer lines in SR-2 project reach



Within the Agua Hedionda WMP several stormwater retrofit opportunities were identified. One is located south of the Buena Pumping Station and would provide an opportunity to treat urban runoff from the commercial / industrial complex to the south before it enters the creek. The possibility of integrating this project with the stream restoration should be considered.

5.3 NEXT STEPS

As part of the description of the alternatives, the next steps required for further development of that alternative had been identified. In addition to those specific project steps consideration should be given to how this project fits into the larger goal of watershed restoration.

The SR-2 alternatives will provide channel stability to a distinct and somewhat limited reach of Agua Hedionda. The upstream and downstream limits of the project were selected based on an attempt to isolate that reach from other impacts and changes in the stream. A more significant step in restoration of the watershed would be to consider restoration over a longer reach in order to see a greater impact. Many factors can contribute to the need to limit the restored reach. These factors often include cost (available resources) as well as consensus among various owners and stakeholders (a group which often grows as the project size increases.)

A consideration that could add to the significance of a single limited restoration reach is to employ a pilot project approach in which decisions are made in large part to inform future decisions for other similar projects. The spacing of the grade control structures in Alternative 1 is somewhat limited by the need to allow an equilibrium slope to develop since any prediction of the slope is very difficult and likely to be unreliable. However, once that slope develops it could be used as a reliable basis for predicting the equilibrium slope in other parts of the watershed. Alternative 2 employs Newbury Riffles, a type of grade control for which limited local performance data exists. Careful monitoring of this alternative – both its performance and maintenance needs – would provide information to base future decisions on its viability in the watershed. Implementation of Alternative 3 on a limited basis would allow for monitoring of aquatic resources and enable future planners to determine if the benefit of no impact to adjacent riparian buffers outweighs any impacts to the aquatic resources.

Further development of these alternatives would require a number of refinements. These include:

- More detailed channel topography attained by surveying the channel
- Hydrology refinements and the use of specific design flows
- Refine hydraulics with updated topography
- Refine existing sediment transport results
- Preparation of proposed conditions hydraulics and sediment transport results
- Inclusion of improvements to surrounding infrastructure and/or facilities in the design plans
- Survey and identify vegetation at the site to avoid or mitigate potential damage due to restoration improvements or other infrastructure upgrades.

6 References

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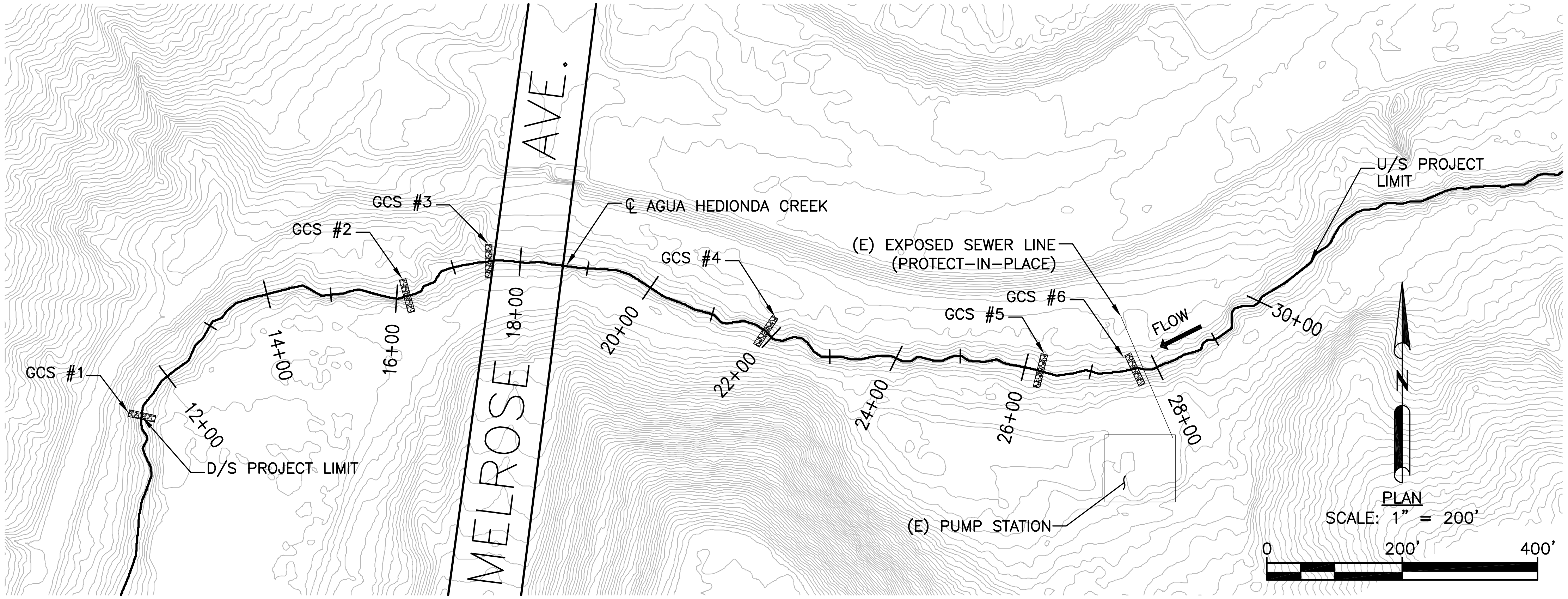
APPENDIX

Exhibit 1: Site Map and Features

N
W
E
S
Sewer Line Crossing
Old GCS
Old GCS
Rock Outcrop
Sewer Line Crossing
GREEN OAK RD
MELROSE AVE
Surveyed Sections
Surveyed Sections
Pump Station
A
B
C
D
E
F
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
45
0
250
500
1,000
Feet
Legend
Agua Hedionda
XS Cut Lines
2 ft Contours
Pacific Ocean
Agua Hedionda Watershed
Project Site
Orange
Riverside
San Diego
Pacific Ocean
Agua Hedionda Watershed

APPENDIX

Exhibit 2: Proposed Design Plan Sheets

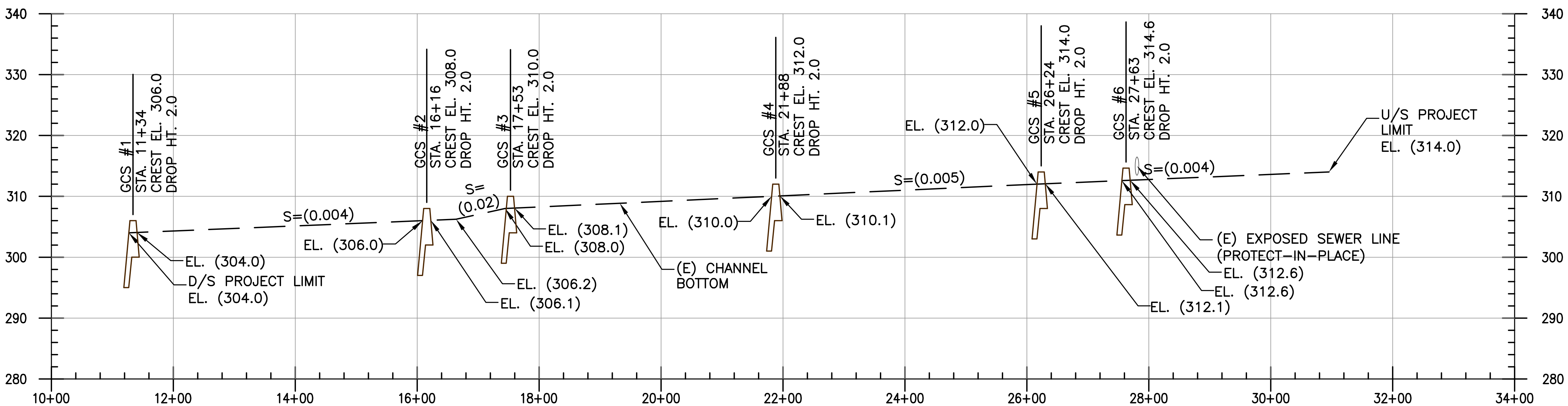


General Notes

1. These drawings are based on conceptual designs and are subject to change based on further analyses and design refinement.
2. The current channel alignment was adopted for this conceptual study, however realignment may be appropriate after channel has been filled and excavated.
3. Grade Control Structures are shown conceptually and may vary in design and dimensions based on the site specific geometry and geomorphology of each structure location. Placement of the grade control structures was based on spacing requirements.

Legend

Grade Control Drop Structure (GCS)



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PLAN & PROFILE - ALTERNATIVE 1

AGUA HEDIONDA WATERSHED
RESTORATION OPPORTUNITY
SITE: SR-2

CONCEPTUAL DRAWINGS

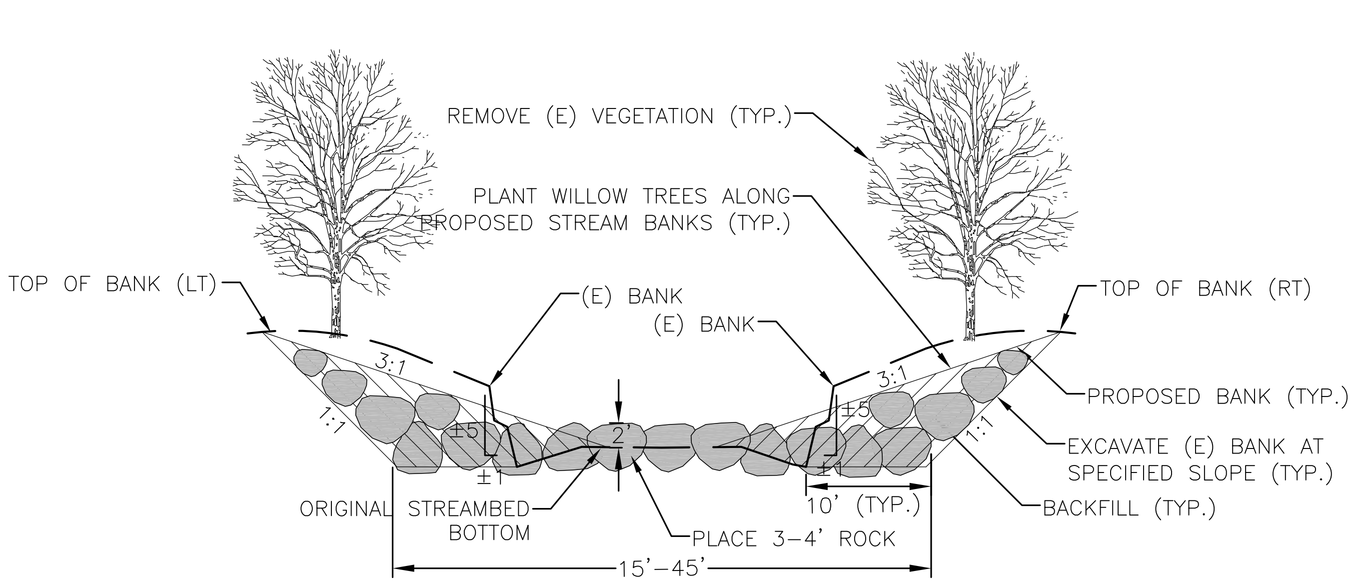
CITY OF VISTA
600 Eucalyptus Avenue
Vista, CA 92084-6240

File Name

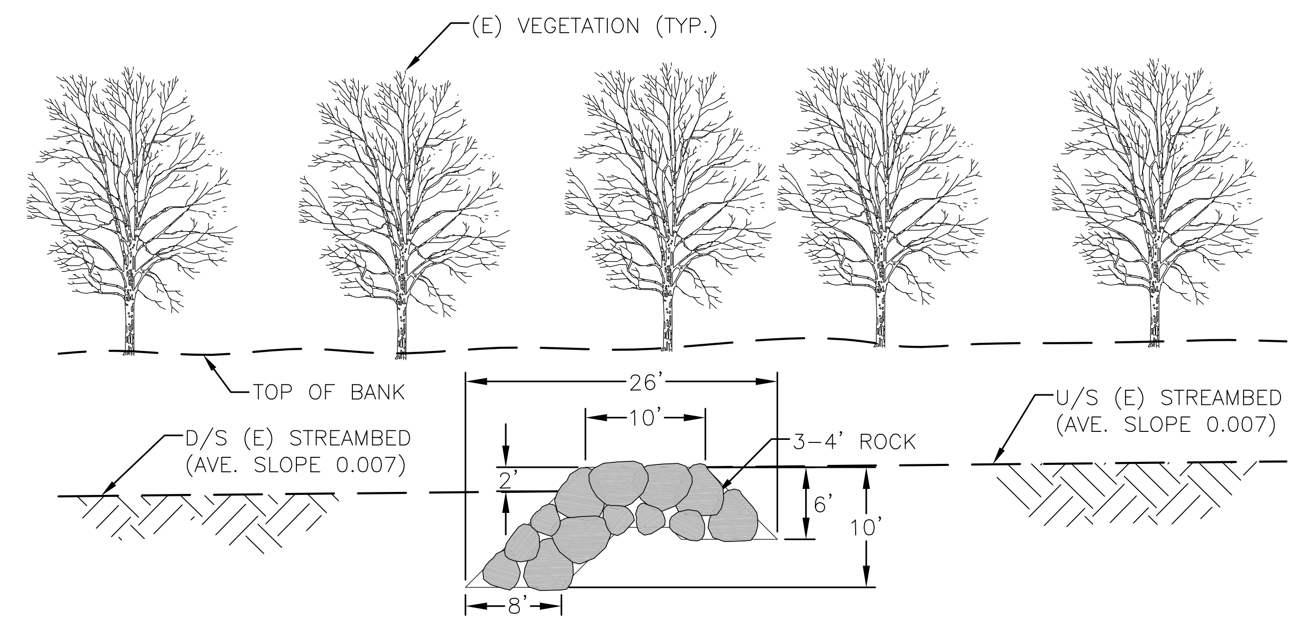
T20751_SR2_01

Drawing No.

Sheet 1 of 6



Grade Control Structure Typical Section – Alternative 1



Grade Control Structure Typical Detail – Alternative 1

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TYPICAL DETAILS – ALTERNATIVE 1
AGUA HEDIONDA WATERSHED
RESTORATION OPPORTUNITY
SITE: SR-2
CONCEPTUAL DRAWINGS

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File Name
T20751_SR2_02
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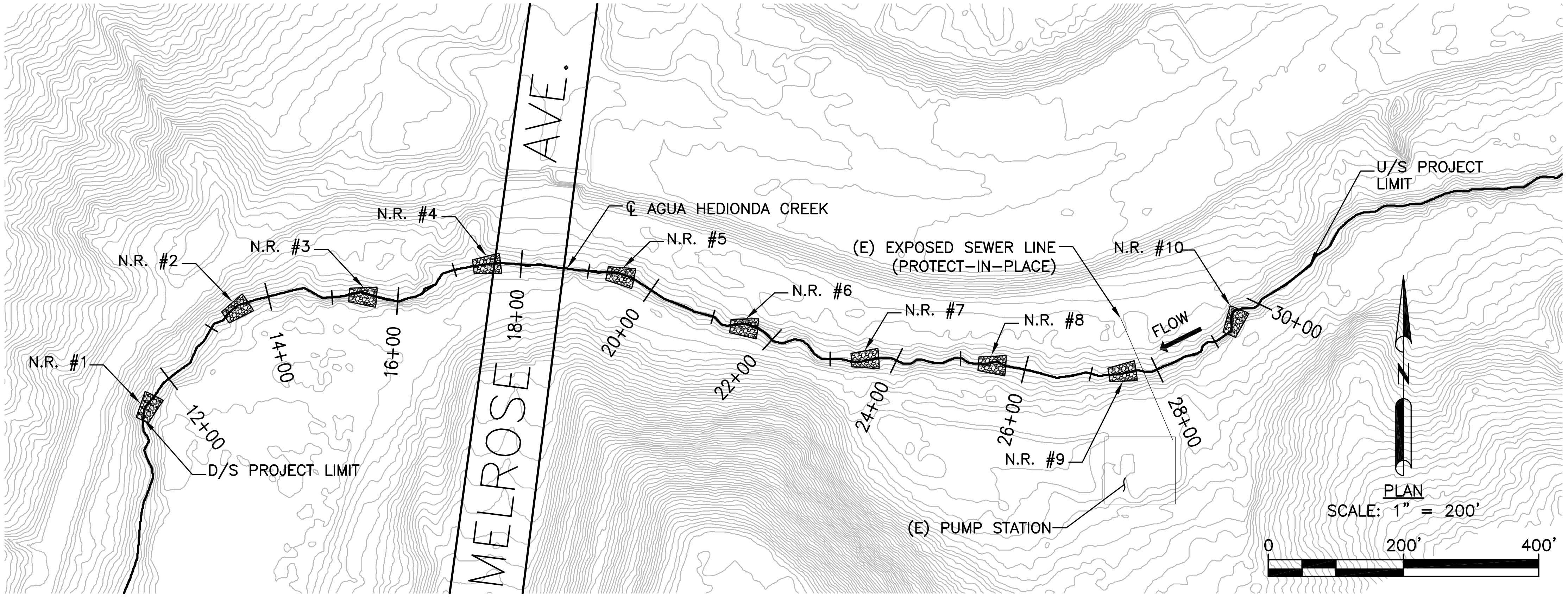
Sheet 2 of 6



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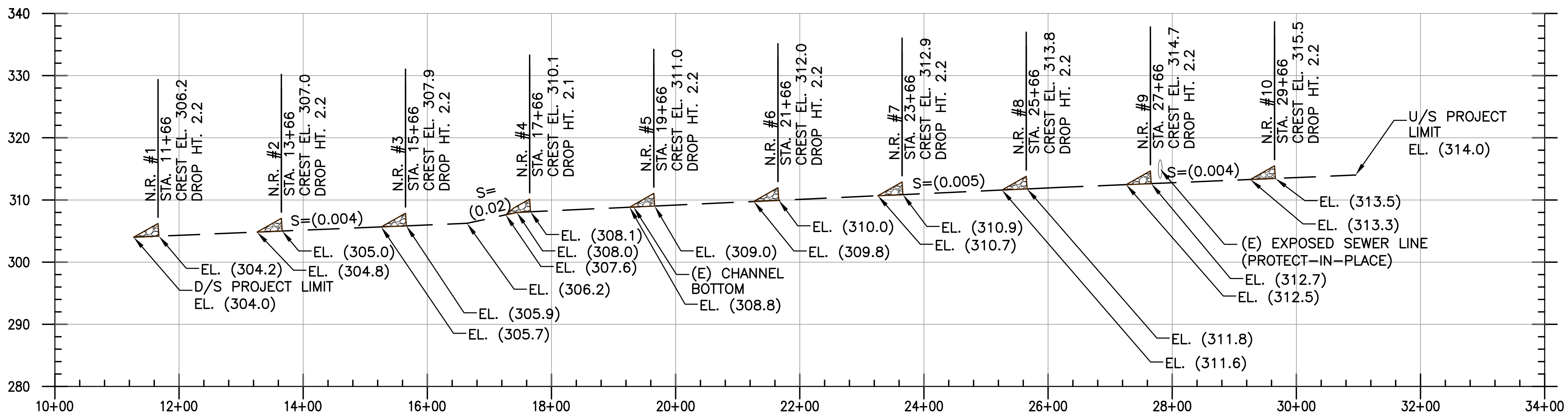
Legend

Newbury Riffle (N.R.)



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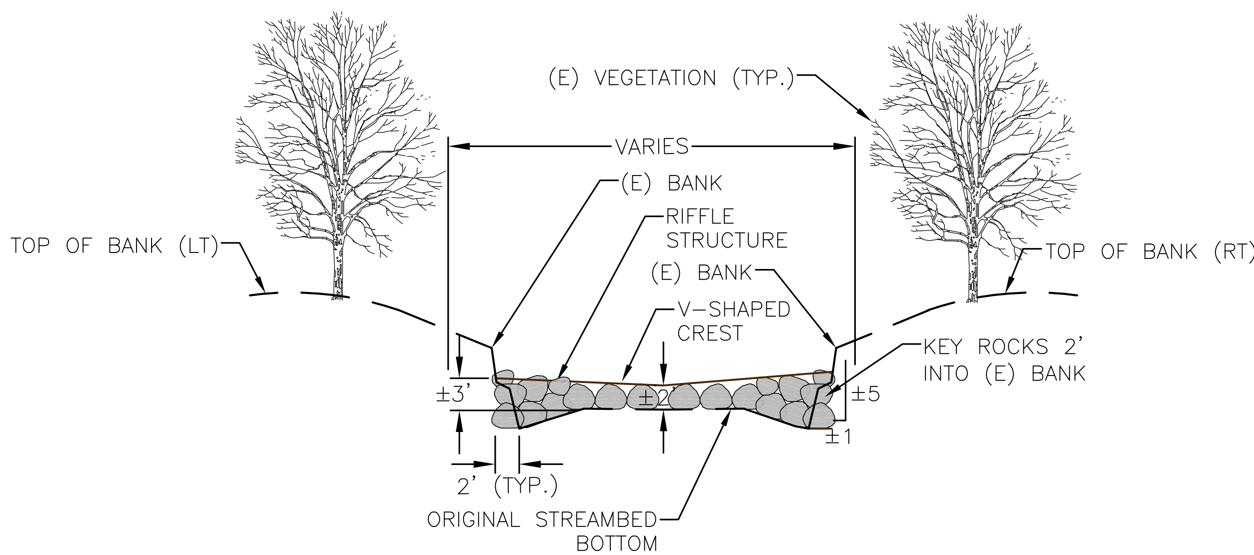
PLAN & PROFILE – ALTERNATIVE 2

AGUA HEDIONDA WATERSHED
RESTORATION OPPORTUNITY
SITE: SR-2
CONCEPTUAL DRAWINGS

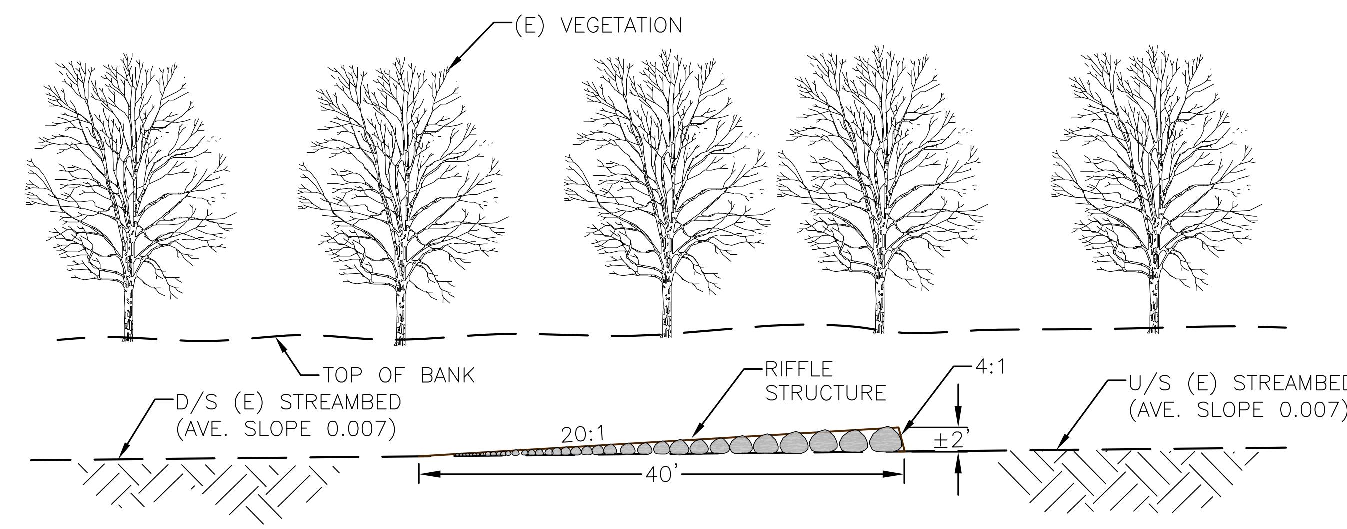
CITY OF VISTA
600 Eucalyptus Avenue
Vista, CA 92084-6240

File Name
T20751_SR2_03

Drawing No.
Sheet 3 of 6



Newbury Riffle Typical Section – Alternative 2



Newbury Riffle Typical Detail – Alternative 2

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TYPICAL DETAILS – ALTERNATIVE 2
AGUA HEDIONDA WATERSHED
RESTORATION OPPORTUNITY
SITE: SR-2
CONCEPTUAL DRAWINGS

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File Name
T20751_SR2_04
Drawing No.

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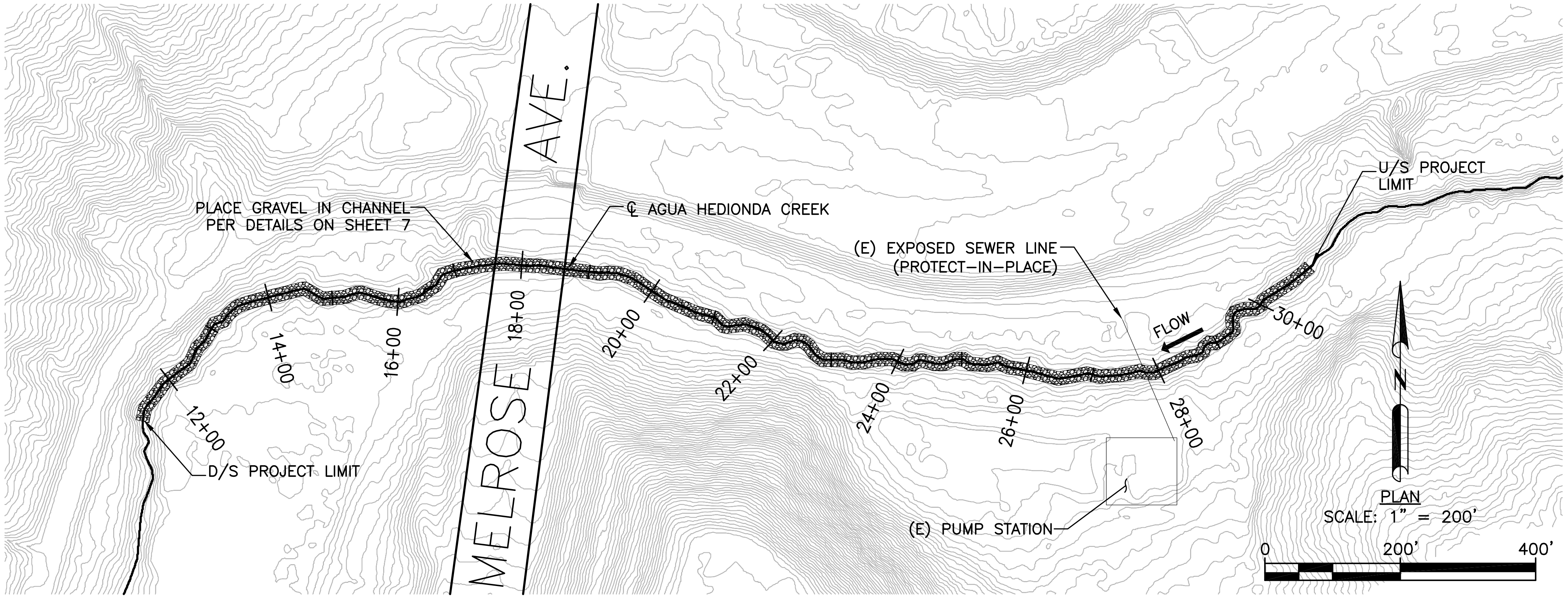
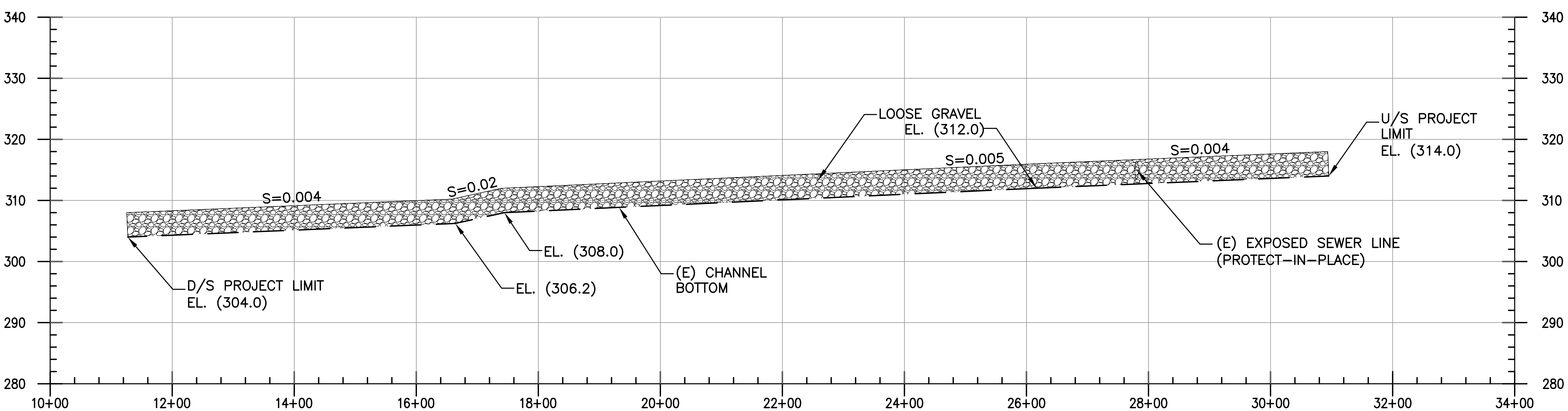


Legend

Gravel Augmented Channel



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PLAN & PROFILE – ALTERNATIVE 3
AGUA HEDIONDA WATERSHED RESTORATION OPPORTUNITY
SITE: SR-2
CONCEPTUAL DRAWINGS

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File Name
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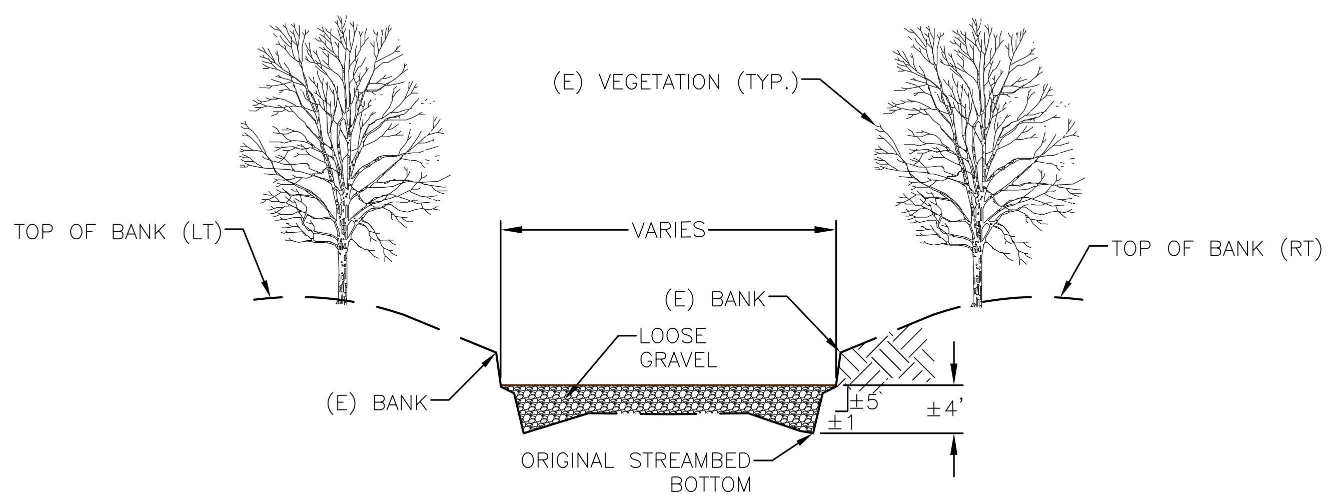
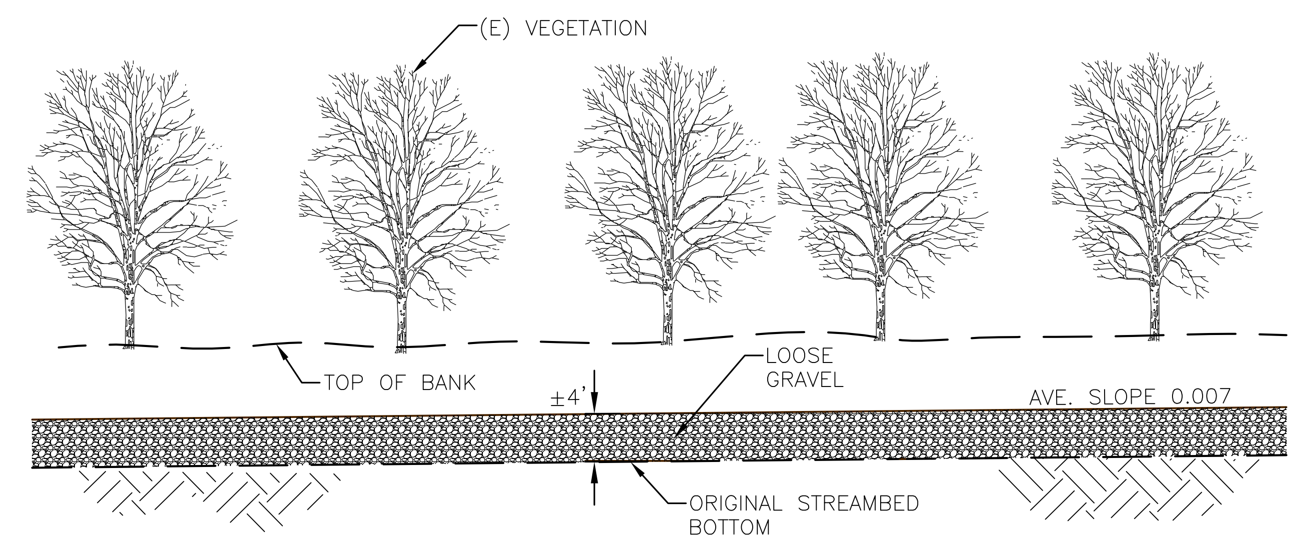
Drawing No.
Sheet 5 of 6



Loose Gravel Typical Section – Alternative 3



Loose Gravel Typical Detail – Alternative 3

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