Prepared for

CITY OF REDDING CALIFORNIA

Sewer Ponds Stormwater Retrofit Preliminary Design Report

Redding, CA

Prepared by

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Geosyntec Project #: LA0443

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1 INTRODUCTION

1.1 Background

As part of the Redding Stormwater Resource Plan (Geosyntec 2018), the City of Redding (City) identified an opportunity to divert and treat stormwater flows from Boulder Creek (Creek) through three adjacent abandoned Sewer Ponds (Project). The Project area is shown below in Figure 1. The goal of the Project is to provide water quality and flood control benefits, including pollutant reduction through a bioretention system and peak flood flow attenuation through multiple basins.

At the point of diversion, the Creek collects runoff from an approximately 1,800-acre drainage area consisting mostly of residential, industrial, and open space land uses. Initial watershed analysis during the Redding Stormwater Resource Plan identified elevated water quality concerns for 413 acres or 23% of the project drainage area. The Creek downstream of the project empties into the Sacramento River which has a TMDL for cadmium, copper, and zinc. Additionally, the Creek is designated by US Fish and Wildlife Service as critical habitat for Steelhead and Chinook Salmon (U.S. FWS, 2017). During recent storm events (2017), flooding has occurred just downstream of the Project at Boulder Creek Elementary School. The Project overlies the Enterprise groundwater basin, which is designated for municipal supply use, and may provide recharge benefit via infiltration to this basin.

Figure 1. Sewer Ponds Existing Project Footprint

The proposed Project includes installing a diversion system within the Creek (allowing for low flows to bypass the ponds, to sustain existing riparian habitat), a conveyance system to two sedimentation basins, diversion of two storm drains to the second sedimentation basin, conveyance of captured flows to a bioretention basin, and discharge of treated water and high flows back to the Creek. Additionally, space will be allocated to incorporate proposed components of the Boulder Creek Trail and signage to educate the public about the project's multiple benefits. The purpose of this report is to present the methodology and results of the preliminary design and sizing analyses performed to achieve the Project goals and recommend future actions to complete the Project design.

1.2 Preliminary Investigation

Geosyntec reviewed City-provided as-builts and utility shapefiles and additional utility information from the City's Electric Department.

A site visit was conducted on Tuesday, May 22 and Wednesday, May 23, 2018 to assess the project feasibility and refine the proposed concept originally outlined in the City's Stormwater Resource Plan (Geosyntec 2018). Two constant head infiltration tests were conducted within the ponds (one in Pond 1 and one in Pond 3) and demonstrated infiltration may be feasible, although additional evaluations should be completed to determine whether the shallow depth to the seasonal high groundwater table may cause extended periods of ponding.

The results of this preliminary investigation are included in the Sewer Ponds Stormwater Retrofit Field Feasibility Assessment Summary Memo (Appendix A) and were used to develop initial design sizing and layout as described in the following sections.

2 PRELIMINARY DESIGN OVERVIEW

This section presents a summary of the key design inputs and calculated values required to effectively size and implement the Project to meet the design goals of improving water quality and flood control.

The spillway width, the conveyance between sedimentation basins 1 and 2, and the sedimentation basin 2 overflow spillway were designed to convey the peak flowrate of the 25 year 24-hour storm event from the 1,800-acre drainage area upstream of the Project location. The capacity of the basins is limited by the current footprint of the ponds and by the Creek water elevation. Between storm events the storage volume will be limited by the diversion spillway elevation or Creek water elevation (whichever is higher). The bioretention basin outlet underdrain was designed to drain the volume of the basins within 72 hours to meet vector control requirements.

During future design stages, it will be important that communication is established with the California Department of Fish and Wildlife and other regulatory agencies to determine Creek minimum flowrate and fish passage constraints. Since these requirements have yet to be established, design assumptions were made and should be reviewed and revised after receiving feedback from the applicable regulatory agencies. It was assumed that certain instream flowrates must be maintained within the Creek (i.e. bypass the Project) in order to maintain the Creek's existing habitat. For design calculations, it was assumed that natural, unimpacted flowrates must remain for flows up to one foot of depth in the Creek. The Creek diversion spillway was therefore designed to only accept flows when the Creek water depth exceeds one foot.

Preliminary design parameter values are shown in Table 1, and calculations are provided in Appendix B. Appendix C includes a preliminary site plan and detail sheet, while Appendix D contains a preliminary project work plan, cost estimate, and schedule. Additional design details and analysis will be required during later stages of design as outlined in Section 3 below.

Table 1. Preliminary Design Parameters

System Design Element	Parameter	Value
Precipitation	25-yr 24-h storm intensity (in/h)	0.286[1]
	85th percentile 24-h storm depth (in)	0.91[2]
Boulder Creek	Creek watershed area (ac)	1,800
	Longitudinal bed slope “S”	0.0029
	Manning’s coefficient “n”	0.035
	Width (ft)	69
	Depth from banks (ft)	5
	25-yr 24-h Creek depth (ft)	2.5
	25-yr 24-h Creek flowrate (CFS)	225
Storm Drains	Storm drain 1 (24” HDPE) drainage area (ac)	3.9
	Storm drain 2 (30” HDPE) drainage area (ac)	9.6
Diversion Spillway	Minimum base width (ft)	29
	Side slope	3:1
	Base height above Creek bed (ft)	1
Sedimentation Basin 1	Approximate area (ft^2)	70,000
	Ponding depth after a storm (ft)	1
	Total depth (ft)	5
Sedimentation Basin 2	Approximate area (ft^2)	120,000
	Ponding depth after a storm (ft)	1.5
	Total depth (ft)	5.5
Basin 1 and 2 Connection Culvert	Cross-sectional area (ft^2)	16
Basin 2 Overflow Spillway	Minimum base width (ft)	65
	Side slope	3:1
	Base height above basin bottom (ft)	4.5
Bioretention Basin	Approximate area (ft^2)	110,000
	Ponding depth after a storm (ft)	2
	Total depth (ft)	6
	Outlet flowrate (CFS)	1.8
	Filter soil depth (in)	12
	Pipe bedding depth (in)	12

[1] "NOAA Atlas 14 Point Precipitation Frequency Estimates: CA". *NOAA's National Weather Service*, 2018, Accessed 11 Sept 2018.

[2] City of Redding. *Post-Construction Standards Plan.*

2.1 Boulder Creek and Storm Drain Diversions

An inlet spillway was provided along the bank to divert stormflows from the Creek into the ponds. After coordination with the applicable agencies, additional fish protection measures such as appropriate screens to prevent fish passage over the spillway may be required. The 25-year 24-hour flowrate was determined to be 225 CFS for the Project site based on the rational formula. Manning's equation was then applied to determine a water depth of 2.5 ft in the Creek based on the cross-sectional area and the wetted perimeter just upstream of the diversion spillway during the 25-year 24-hour event.

The Creek diversion spillway was designed as an earthen trapezoidal weir with a base width of 126 ft to maximize the potential area for creek flows to enter the spillway[3]. The Francis weir equation and the triangular weir equation were used to calculate a minimum width of the spillway as 29 ft, assuming the same flowrate and water elevation in the creek. This design is conservative because the total Creek flow will not be conveyed through the weir. The final spillway location and width should be set to promote diversion of creek flows into the sedimentation basin and should be designed based on future hydrologic and hydraulic modeling according to predicted water depths within the Creek for specific design events. The design should also consider that the spillway elevation will control the ponding depth in the three basins (e.g., a higher spillway will raise the ponding depth of the basins).

In addition to the Creek diversion, two storm drains from the adjacent community will be diverted to sedimentation basin 2 via 24-inch and 30-inch storm drains. The drainage areas to these storm drains are approximately 3.9 acres and 9.6 acres, respectively.

2.2 Sedimentation Basins

To provide capture and detention of wet weather flows and an opportunity for settling of sediment and particulate-bound pollutants, the existing northwest and southeast ponds (Ponds 1 and 3, respectively) are proposed for use as sedimentation basins and will provide necessary pretreatment prior to the bioretention basin. This is essential to delay clogging of the bioretention media.

A culvert is proposed to convey flows from sedimentation basin 1 to sedimentation basin 2. To convey the 25-year 24-hour storm peak flowrate, the culvert was sized with a cross-sectional area of 16 ft^2. A box culvert is recommended due to the large cross-sectional area and the depth of this culvert should be minimized to make sure enough cover is provided over the culvert with the existing grades. Alternatively, the area could be re-graded to provide the required cover, but the proposed grading plan must not impede the existing natural drainage path. Future design analysis should also evaluate whether a backflow prevention device can be incorporated at the exit of this culvert, to prevent return flows into sedimentation basin 1.

[3] Preliminary design spillway width based on initial desktop and field visit evaluation of the curvature of the creek and likely flow path.

An overflow spillway outlet was designed to maintain one foot of freeboard in sedimentation basin 2. This overflow spillway was sized with a base width of 65 ft to convey the 25-year 24-hour peak flowrate (consistent with the culvert flowrate). While the spillway is not expected to over top by water in the basin during the 25-year 24-hour storm event because the maximum water elevation in the Creek during a 25-year 24-hour storm event (597.5 ft) would be at an elevation lower than the spillway base (599 ft), this overflow spillway is provided to satisfy typical flood control requirements.

Two outlet structures in sedimentation basin 2 are provided to convey water to the bioretention basin. Orifice plates are included to slowly release water into the basin and are designed to meet vector control drain time requirements for sedimentation basin 2. Additionally, sedimentation basin 2 is bisected by a gabion basket filled with boulders to extend the flow path within the basin and promote settling and use of the full surface area.

2.3 Bioretention Basin

The northeast pond (Pond 2) will be converted into a bioretention basin to provide additional treatment for the captured stormwater. A trench is proposed to evenly distribute the flow around the bioretention basin where the stormwater will flow through topsoil, a filter soil layer (or a layer of advanced media selected to target specific pollutants), and finally a gravel storage layer. Underdrains will then convey the treated flow to an outlet structure, which will then discharge treated water through a pipe back to the Creek. If nitrate reduction becomes a Project goal, an upturned elbow can be provided in the outlet structure to promote a permanently saturated zone at the bottom of the bioretention basin to promote denitrification. The filter soil depth will be approximately 12 inches and the gravel layer (typically 12 inches) will include gradation of rock sizes sized to convey the design flowrate and prevent bleeding of the filter soil. Orifice control in the outlet structure will be designed to limit surface ponding to 72 hours and not constrain the sedimentation basin drain time. The required design flowrate to be conveyed through the bioretention basin was calculated to be 1.8 CFS, which is approximately 0.8 inches per hour over the entire basin footprint.

The end of the underdrain will include a cap and riser pipe along with specified orifices to convey the design treatment flowrate through the media. An overflow grate will also be provided and sized to convey the peak flowrate from the 25-year 24-hour storm event. An overflow spillway is also proposed to convey excess flows as necessary.

2.4 Water Quality Capture Benefits

The preliminary project analysis presented in the City's Stormwater Resource Plan (Geosyntec 2018) demonstrated that 89% of the 85th percentile 24-hour storm could be captured by the Project. However, due to Project modifications and identified constraints that were evaluated during the design, including only being able to divert a portion of Creek flows, this high volume capture may not be feasible. Based on the preliminary design, it was estimated that 33% of the 85th percentile

24-hour storm will be captured and treated. This can be improved if the inlet spillway can be moved upstream and closer to the creek bottom to divert more of low flows (but not baseflows).

To determine the runoff volume from the 85th percentile 24-hour storm that would be captured and treated, a hydrologic and BMP hydraulic modeling analysis utilized the rational formula (for flow rate), manning's equation (for water elevation), and a water balance equation at 30 minute time steps to account for the flow into the basins through the diversion spillway, the flow out of the basins through the bioretention basin, and the flow back out of the diversion spillway when the Creek depth drops during the falling limb of the storm. A unit hyetograph was used to determine the storm intensity at the 30-minute time steps. These values were used to determine the average intensity during the watershed time of concentration (2.5 hours) for each time step. To more accurately quantify the Project's stormwater capture and treatment benefits (including long-term volume capture), a detailed watershed continuous simulation modeling and drainage analysis should be completed during a subsequent design stage.

3 RECOMMENDED NEXT STEPS

This Report documents the preliminary design layout and sizing performed for the Project. Before implementation of the Project can be confirmed to be feasible and taken to final design, additional analyses and steps should be performed, including:

- A site topographical survey to obtain detailed elevation and constraint information, with a specific emphasis on the portion of the Creek adjacent to the spillway and the inlet/exit of all conveyances to the ponds;
- Existing abandoned sewer pond soil samples should be tested for contamination from previous use as a wastewater disposal facility. The results of these tests will determine whether the pond soil must be replaced and what disposal considerations apply;
- A detailed modeling and drainage study to evaluate the fluctuation of Creek flow depths and to solidify the hydraulic design of the proposed Project. A HEC-RAS model and analysis is required to satisfy the City of Redding drainage design requirements;
- Regulatory agency coordination including the California Department of Fish and Wildlife to determine what design modifications are required to meet instream flow and fish protection and passage needs;
- Creek water depth measurement and calibration of a hydrologic model, followed by model application to evaluate Creek depths under various storm conditions and design options to increase the quantity of water diverted to the Project;
- Utility investigation and potholing to determine if shallow utilities will impact the proposed design, specifically the existing sewer line running under the proposed diversion spillway;
- Collaboration with the City water utility department to determine the potential alignment of a water main through the project area;
- Additional geotechnical and infiltration testing in the ponds to determine drawdown rate and the depth to groundwater, which may dictate future design modifications;

- Additional structural and hydraulic calculations to finalize design of the inlet diversion spillway, the outlet/overflow spillways, and the potential diversion of surface runoff from the Caltrans ditch; and
- Development of construction drawings including additional design details such as final elevations, sizes, and material types and quantities.

4 REFERENCES

City of Redding, 2016. *Post-Construction Standards Plan.* May 2016.

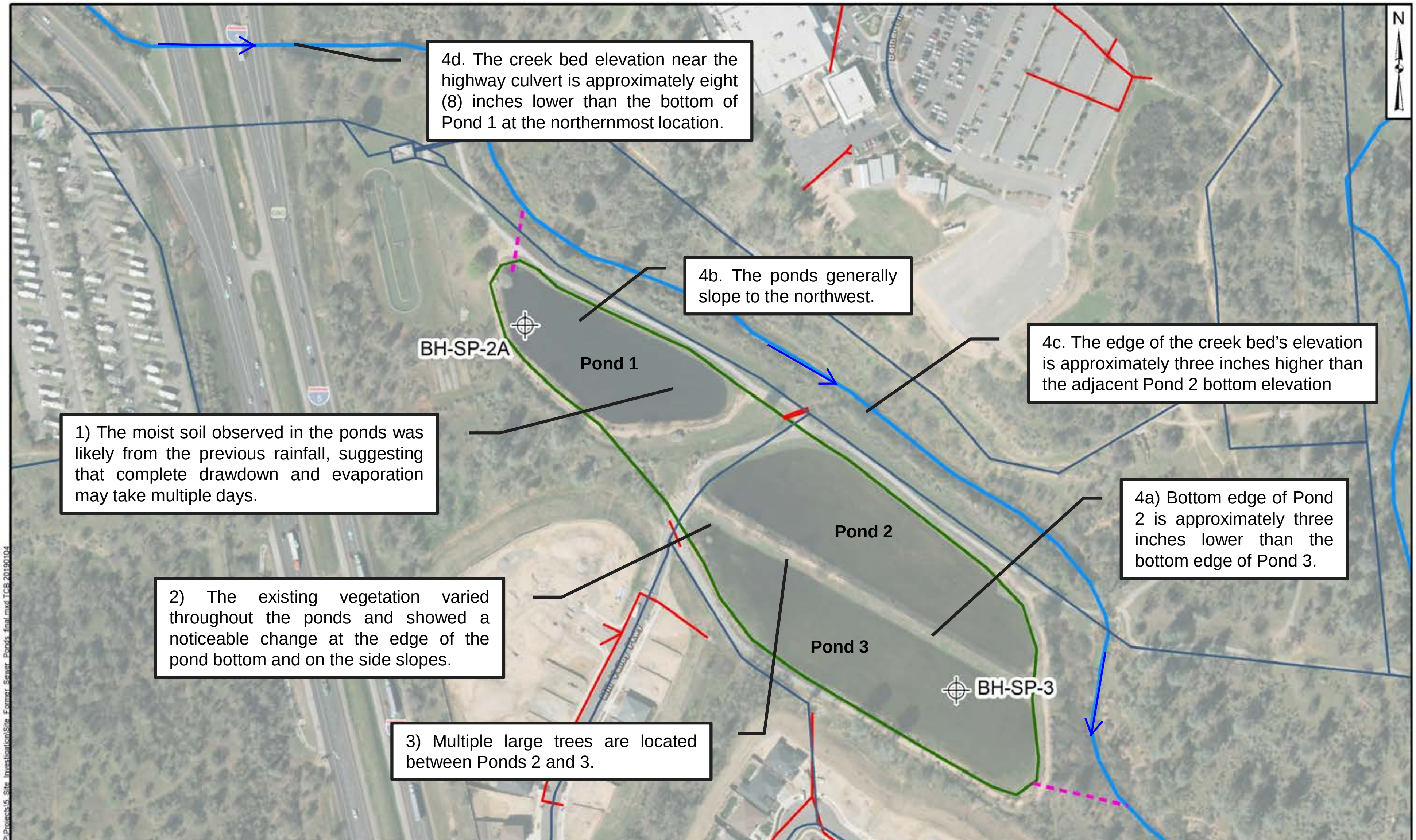
Geosyntec Consultants, 2018. *City of Redding Stormwater Resource Plan.* October 2018.

U.S. Fish & Wildlife Service (U.S. FWS), 2017. *Threatened & Endangered Species Active Critical Habitat Report*. September 12, 2017.

APPENDIX A

SEWER PONDS STORMWATER RETROFITS

FIELD FEASIBILITY ASSESSMENT SUMMARY MEMO



Legend

- Soil Bore Hole
- Waterbody
- Wastewater Pipe
- Storm Drain
- Flow Diversion
- BMP Footprint

0 325 650 Feet

Former Sewer Ponds
Field Investigation Map

City of Redding Stormwater Resource Plan

Geosyntec consultants

Santa Barbara | January 2019

Figure 1

Geosyntec consultants

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GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING BH-SP-2A
START DRILL DATE 5/22/18
FINISH DRILL DATE 5/22/18
LOCATION Redding Sewer Ponds
PROJECT Redding SwRP
NUMBER LA0443

SHEET — **OF** —
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE		RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
1"	dk brown/black silty, wet											
2"	brown gravely sand silty, moist											
3"												
4"	some cobbles											
5"	brown gravely sandy silty increasing moisture											
10"				WL @10"								
15"												
17"				~~17~~" EOB 17"								

CONTRACTOR
EQUIPMENT
DRILL MTHD
DIAMETER
LOGGER
REVIEWER

NORTHING
EASTING
COORDINATE SYSTEM:

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING BH-~~SB~~SP-3
START DRILL DATE 5/22/18
FINISH DRILL DATE
LOCATION Redding
PROJECT NUMBER LA0443

SHEET OF
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE		RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
	1" brown/tan topsoil + veg.											
6"	light brown-orange dry hard gravely loam											
1' – 2	gravely loam, dk brown/orange, moist											1' less gravel more silty
~~2~~. – 3	gravel/rocky w/ loam moist											
3 – 4	loamy gravel, wet											
33"	water ponding											
~~5~~ 5												
6												
7												
~~8~~.												
8												
9												
~~9~~.												
~~10~~												

CONTRACTOR
EQUIPMENT
DRILL MTHD
DIAMETER
LOGGER
REVIEWER

NORTHING
EASTING
COORDINATE SYSTEM:

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Borehole	Depth bgs	Soil Name	Color	Moisture	Grain Size	Percentage (Gravel, Sand, Silt)
BH-SP-2a	0-1"	Sandy silt (ML)	Yellowish Brown (10YR 5/6)	Moist	Silt to fine sand, trace gravels	5, 15, 80
	1-2"	Silty sand with gravel (SM)	Reddish Brown (5YR 4/3)	Moist	Silt to coarse sand w/ gravel	10, 60, 30
	2-6"	Well graded sands (SW)	Red (2.5YR 4/6)	Moist	Fine to coarse sands w/ gravel	40, 60, 0
	6-17"	Gravelly sand (SP)	Red (2.5YR 4/6)	Moist	Sand and gravel	20, 80, 0
BH-SP-3	0-6"	Gravelly sand (SW)	Strong Brown (7.5YR 5/6)	Dry	Fine to coarse sand w/ gravel	30, 70 ,0
	6-12"	Gravelly sand (SW)	Brown (7.5YR 5/4)	Moist	Fine to coarse sand w/ gravel	40, 60 ,0
	12-22"	Gravelly sand (SP)	Dark Reddish brown (5YR 3/4)	Moist	Medium grain sand w/ gravel	20, 80, 0
	22-24"	Well graded gravel (GW)	Reddish Brown (5YR 4/3)	Moist	Fine to coarse sands and gravels	60, 40, 0
	24"	Poorly graded gravel (GP)	Pale yellow (2.5Y 7/4)	Moist	Large gravel clasts	100, 0, 0
	24-30"	Well graded gravel (GW)	Reddish Brown (5YR 4/3)	Moist	Fine to coarse sands and gravels	60, 40, 0
	20-33"	Well graded Gravels (GW)	Brown (7.5YR 5/4)	Moist	Fine to Coarse gravels	95, 0, 0

Well Infiltration Test- Time and Volume Measurements

Project	LA0443	Ground Elev. (ft)	605	Notes:
Boring ID	BH-SP-2A	GWT Depth bgs (ft)	0.83	
Date	5/22/2018	Depth to Botttom of Well (ft)	1.42	
Tested By	MC, AQ	Radius of Well (ft)	0.27	
Ground Temp (^{o}C)	29	Depth to water surface in well (ft)	0.17	
Flow Rate (gpm)	0.0499	Height of water in well (ft)	1.25	

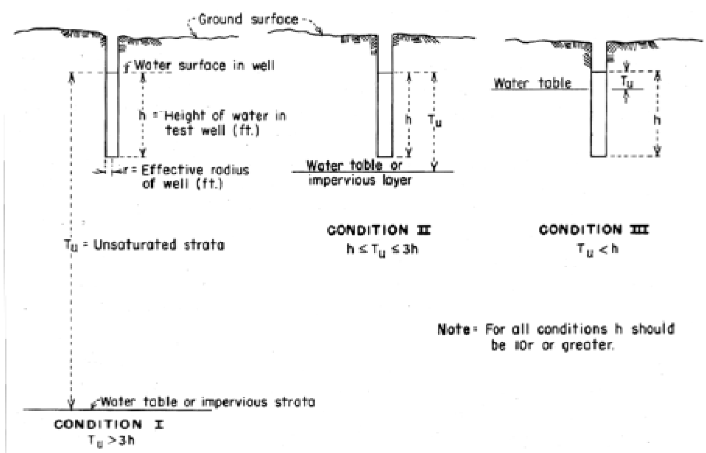
Time		Totalizer Reading (gal)	Difference (gal)	Accum Flow (gal)	Water Temperature	
Clock	Accum (min)				Well	Tank
	-		0.00	0.00		
	0	0.00	0.00	0.00		
20.25	20.25	1.00	1.00	1.00		85 F
18.25	38.50	2.00	1.00	2.00		85 F
21.67	60.17	3.00	1.00	3.00		85 F

Well Infiltration Test- Time and Volume Measurements

Project	LA0443	Ground Elev. (ft)	603	Notes:
Boring ID	BH-SP-3	GWT Depth bgs (ft)	2.71	
Date	5/22/2018	Depth to Botttom of Well (ft)	2.75	
Tested By	MC, AQ	Radius of Well (ft)	0.33	
Ground Temp (^oC)	29	Depth to water surface in well (ft)	0.29	
Flow Rate (gpm)	1.47	Height of water in well (ft)	2.46	

Time		Totalizer Reading (gal)	Difference (gal)	Accum Flow (gal)	Water Temperature	
Clock	Accum (min)				Well	Tank
	-	10,009.50	0.00	0.00		
	0	10,033.30	23.80	23.80		
	5	10,040.72	7.42	31.22		
	10	10,048.43	7.71	38.93		
	15	10,056.18	7.75	46.68		
	20	10,063.55	7.37	54.05		
	25	10,070.82	7.27	61.32		
	30	10,078.31	7.49	68.81		
	35	10,085.70	7.39	76.20		
	40	10,092.99	7.29	83.49		
	45.25	10,100.75	7.76	91.25		
	50.5	10,108.59	7.84	99.09		
	55	10,115.33	6.74	105.83		
	60	10,122.84	7.51	113.34		
	65	10,130.41	7.57	120.91		
	70	10,137.97	7.56	128.47		
	75	10,147.14	9.17	137.64		
	80.5	10,154.08	6.94	144.58		
	85.5	10,161.82	7.74	152.32		
	90	10,168.79	6.97	159.29		
	95	10,176.55	7.76	167.05		

Boring ID	Flow Rate, q q		Temperature Correction V	Head h	Well Radius r	Water Surface to GWT Depth T_u	Saturated Hydraulic Conductivity k_{20}			Condition
	gpm	ft^3/hr		ft	ft	ft	ft/hr	cm/s	in/hr	Condition
BH-SP-2A	0.049861	0.400	0.83	1.3	0.271	0.67	7.6E-02	6.4E-04	0.914	3
BH-SP-3	1.470	11.8	0.83	2.5	0.333	2.4	3.5E-01	3.0E-03	4.19	3



Condition 1:

$$K_s = \frac{Q(\mu_T/\mu_{20})}{2\pi H^2}\left[\ln\left[\frac{H}{r}+\sqrt{\left(\frac{H}{r}\right)^2+1}\right]-\frac{\sqrt{1+\left(\frac{H}{r}\right)^2}}{\frac{H}{r}}+\frac{r}{H}\right]$$

Condition 2:

$$K_s = \frac{Q(\mu_{20}/\mu_T)}{2\pi H^2}\left[\frac{\ln\left(\frac{H}{r}\right)}{\frac{1}{6}+\frac{1}{3}\left(\frac{H}{T_u}\right)^{-1}}\right]$$

Condition 3:

Condition III:

$$k_{20} = \frac{gV}{2\pi h^2}\left[\frac{\ln\left(\frac{h}{r}\right)}{\left(\frac{h}{T_u}\right)^{-1}+\frac{1}{2}\left(\frac{h}{T_u}\right)^{-2}}\right]$$

Temp (C)	Dynamic Viscosity
0	1.787
5	1.519
10	1.307
11	1.2843
12	1.247
13	1.2111
14	1.1766
15	1.1435
16	1.1118
17	1.0815
18	1.0526
19	1.0251
20	1.002
21	0.9743
22	0.951
23	0.9291
24	0.9086
25	0.8895
26	0.8718
27	0.8555
28	0.8406
29	0.8271
30	0.815
31	0.8043
32	0.795

K_s = saturated hydraulic conductivity (infiltration rate, inches/hour)
H = height of water in well (inches)
Q = percolation flow rate from selected time interval (cubic inches/hour)
r = effective radius of well (inches)
μ_T = viscosity of water at water temperature, T
μ_{20} = viscosity of water at 20° C
T_u = unsaturated distance between the water surface and the water table or impervious strata

Temperature - t - (°C)	Dynamic Viscosity - μ - (Pa s, N s/m²) x 10^{-3}	Kinematic Viscosity - ν - (m²/s) x 10^{-6}
0	1.787	1.787
5	1.519	1.519
10	1.307	1.307
20	1.002	1.004
30	0.798	0.801
40	0.653	0.658
50	0.547	0.553
60	0.467	0.475
70	0.404	0.413
80	0.355	0.365
90	0.315	0.326
100	0.282	0.294

u = 0.0007*t^2 - 0.0534*t + 1.7785 R^2 = 0.9993

APPENDIX B

PRELIMINARY DESIGN CALCULATIONS

BOULDER CREEK DIVERSION SPILLWAY

Creek 25-year 24-hour storm flowrate

The creek diversion spillway was designed to convey the 25-year 24-hour storm flowrate from the creek into sedimentation basin 1.

The watershed runoff coefficient, *C*, was calculated as

$$C = 0.95 \cdot imp + C_p(1 - imp) = 0.95(0.37) + 0.12(1 - 0.37) = 0.43$$

where *imp* is the fraction impervious and C_p is the pervious coefficient for the watershed.

The flowrate during the 25-year storm 24-hour storm, Q_{25yr}, was calculated using the rational formula as

$$Q_{25\,yr} = Ci_{25\,yr}A = (0.43)\left(0.286\frac{in}{hr}\right)(1{,}836\ ac) = \mathbf{225\ CFS}$$

where $i_{25\,yr}$ is the 25-year 24-hr storm intensity and *A* is the area of the watershed.

Creek 25-year 24-hour storm depth

Manning's equation was used to iteratively determine the creek depth during the 25-year 24-hour storm. The value of $A_cR^{2/3}$ was calculated as

$$A_cR^{2/3} = \frac{Q_{25\,yr}n}{1.49\sqrt{S}} = \frac{(225\ CFS)(0.035)}{1.49\sqrt{0.0029}} = 98.6$$

where A_c is the creek area, *R* is the hydraulic radius, *n* is the manning roughness coefficient, and *S* is the creek slope.

Using contour information, the value of $A_cR^{2/3}$ at a 2.5 ft depth was calculated as

$$A_cR^{2/3} = (69\ ft^2)\left(\frac{69\ ft^2}{41.7\ ft}\right)^{\frac{2}{3}} = 96.5$$

The value of $A_cR^{2/3}$ at a 2.6 ft depth was calculated as

$$A_cR^{2/3} = (73\ ft^2)\left(\frac{73\ ft^2}{42.4\ ft}\right)^{\frac{2}{3}} = 104.9$$

Using this iterative approach, a **creek depth of 2.5 ft** was determined for the 25-year 24-hour storm.

Diversion spillway width

The minimum diversion spillway width was calculated using the Francis weir equation and the triangular weir equation. The following variables necessary for the weir equation were calculated.

The hydraulic head, *H*, was calculated as

$$H = d - h = 2.5\ ft - 1\ ft = 1.5\ ft$$

where *d* is the depth in the creek and *h* is the weir height.

The coefficient of discharge for the rectangular portion of the weir, C_{d1}, was calculated using the Rehbock formula as

$$C_{d1} = \left(0.6035 + 0.0813\frac{H}{Y} + \frac{0.000295}{Y}\right) \cdot \left(1 + \frac{0.00361}{H}\right)^{3/2}$$
$$= \left(0.6035 + 0.0813\frac{1.5\ ft}{1\ ft} + \frac{0.000295}{1\ ft}\right) \cdot \left(1 + \frac{0.00361}{1.5\ ft}\right)^{\frac{3}{2}} = 0.728$$

where *Y* is the weir height.

The diversion spillway minimum width, *b* was calculated as

$$Q_{spill} = \frac{2}{3}C_{d1}b\sqrt{2g}H^{3/2} + \frac{8}{15}C_{d2}\sqrt{2g} \cdot \tan(\theta) \cdot H^{5/2}$$
$$225\ CFS = \frac{2}{3}(0.728)\boldsymbol{b}\sqrt{2 \cdot 32.2\frac{m}{s^2}} \cdot (1.5\ ft)^{\frac{3}{2}} + \frac{8}{15}(0.53)\sqrt{2 \cdot 32.2\frac{ft}{s^2}} \cdot \tan(1.25)\ (1.5\ ft)^{\frac{5}{2}}$$
$$= \boldsymbol{28.8\ ft}$$

where Q_{spill} is the flowrate, C_{d2} is the coefficient of discharge for the triangular portion, and θ is the angle the spillway sides make with the vertical.

SEDIMENTATION BASINS

Culvert between sedimentation basins

The velocity through the culvert connecting sedimentation basin 1 to sedimentation basin 2 was calculated using the Bernoulli equation. To be conservative, it was assumed that the water elevation in sedimentation basin 1 was equal to the water elevation in the creek (597.5 ft above sea level) and that the water depth in sedimentation basin 2 was zero (594.5 ft above seas level) during the 25-year 24-hour storm. The velocity, *v*, was calculated as

$$v = \sqrt{2zg} = \sqrt{2(3\ ft)(32.2\frac{ft}{s^2})} = 13.9\ ft/s$$

where z is the pressure head in sedimentation basin 1 (i.e., the difference between the creek water elevation and the bottom elevation of sedimentation basin 2 [three feet]) and g is the acceleration of gravity.

The required **box culvert area**, A_b, was calculated as

$$A_b = \frac{Q_{25\,yr}}{v} = \frac{225\ CFS}{13.9\ ft/s} = \mathbf{16.2\ ft^2}$$

Sedimentation basin 2 overflow spillway width

The minimum overflow spillway width was determined by using the Francis weir equation and the triangular weir equation. It was assumed that the spillway must be designed to convey the 25-year 24-hour peak flowrate because the culvert was designed to limit the flow to this value. It was assumed that the water depth within the basin was the full depth (5.5 ft), even though the depth is not expected to reach this height during the 25-year 24-hour storm event. The coefficient of discharge for the rectangular portion of the weir, C_{d1}, was calculated using the Rehbock formula as

$$C_{d1} = \left(0.6035 + 0.0813\frac{H}{Y} + \frac{0.000295}{Y}\right) \cdot \left(1 + \frac{0.00361}{H}\right)^{3/2}$$
$$= \left(0.6035 + 0.0813\frac{1\ ft}{4.5\ ft} + \frac{0.000295}{4.5\ ft}\right) \cdot \left(1 + \frac{0.00361}{1\ ft}\right)^{\frac{3}{2}} = 0.625$$

where Y is the weir height.

The overflow spillway minimum width, b was calculated as

$$Q_{spill,o} = \frac{2}{3}C_{d1}b\sqrt{2g}H^{3/2} + \frac{8}{15}C_{d2}\sqrt{2g} \cdot \tan(\theta) \cdot H^{5/2}$$
$$225\ CFS = \frac{2}{3}(0.625)b\sqrt{2 \cdot 32.2\frac{m}{s^2}} \cdot (1\ ft)^{\frac{3}{2}} + \frac{8}{15}(0.53)\sqrt{2 \cdot 32.2\frac{ft}{s^2}} \cdot \tan(1.25)\ (1\ ft)^{\frac{5}{2}}$$
$$= \mathbf{65.3\ ft}$$

where $Q_{spill,o}$ is the flowrate, C_{d2} is the coefficient of discharge for the triangular portion, and θ is the angle the spillway sides make with the vertical.

BIORETENTION BASIN

The bioretention basin outlet was designed to drain the ponding depth after a storm from the sedimentation and bioretention basins in 72 hours. The capacity of the basins, V, was calculated as

$$V = A_{sed,1}d_{sed,1} + A_{sed,2}d_{sed,2} + A_{bio}d_{bio}$$

$$= (70{,}473\ ft^2)(1\ ft) + (123{,}565\ ft^2)(1.5\ ft) + (105{,}514\ ft^2)(2\ ft)$$

$$= 466{,}847\ ft^3 = 10.7\ ac\ ft$$

where $A_{sed,1}$ is the approximate area of sedimentation basin 1, $A_{sed,2}$ is the approximate area of sedimentation basin 2, A_{bio} is the approximate area of the bioretention basin, $d_{sed,1}$ is the ponding depth after a storm of sedimentation basin 1, $d_{sed,2}$ is the ponding depth after a storm of sedimentation basin 2, and d_{bio} is the ponding depth after a storm of the bioretention basin.

The **outlet flowrate**, Q_{bio}, was calculated as

$$Q_{bio} = \frac{V}{72\ hr} = \frac{466{,}847 ft^3}{72\ h} = \mathbf{1.8\ CFS}$$

WATER QUALITY CAPTURE OF THE 85TH PERCENTILE 24-HOUR STORM

<u>85th percentile 24-hour storm timestep flowrates</u>

The time of concentration, t_c, for the watershed was calculated as

$$t_c = \frac{1.8(1.1 - C)\sqrt{L}}{S^{1/3}} = \frac{1.8(1.1 - 0.43)\sqrt{17{,}619\ ft}}{(1.16\ \%)^{1/3}} = 153\ \text{min} = 2.5\ h$$

where L is the length of the watershed and S is the slope of the watershed.

A 24-hour unit hyetograph was used to calculate the intensity at 30-minute time steps for the 85th percentile 24-hour storm. The 85th percentile 24-hour storm intensity at each time step, $i_{85,j}$, was calculated as

$$i_{85th,j} = i_{u,j}P_{85th}$$

where $i_{u,j}$ is the unit hyetograph storm intensity at each time step and P_{85} is the 85th percentile 24-hour storm depth.

Consecutive 85th percentile 24-hour storm intensities were averaged to determine the average intensity during each 30-minute time step. The intensities over each 2.5-hour period (varied by 30-

minute start times) were averaged to determine the peak flowrate for each time step. For each time step the flowrate was calculated using the Rational Formula as

$$Q_j = Ci_{85,j}A$$

where A is the watershed area.

85th percentile 24-hour storm timestep depths

Manning's equation was used with creek channel geometry to iteratively determine the depth corresponding to the flowrate at each time step. The depth was varied until the left and right sides of the following equation were equal:

$$A_c R^{2/3} = \frac{Q_j n}{1.49\sqrt{S}}$$

where A_c is the creek area and R is the hydraulic radius.

85th percentile 24-hour storm volume treated

The creek flowrates and depths were then used to calculate a water balance. It was assumed that the peak flowrate and depth would occur at the end of each time step and that an average of consecutive time step peak values would produce an average flowrate and depth for the time step. It was assumed that the maximum flow volume into the basins during each time step was

$$V_{\max in,j} = Q_{j,avg}\frac{d_{j,avg} - 1}{d_{j,avg}} \cdot 30\ min$$

where $Q_{j,avg}$ is the average creek flowrate during the time step and $d_{j,avg}$ is the average creek depth during the time step. The actual flow volume into the basins was determined based on the remaining capacity in the basins. The basin capacity varied over the course of the storm because the creek elevation controlled the maximum water depth in the basins. The flow volume out of the basins through the bioretention media was calculated using the design flowrate based on vector control requirements (see Bioretention Basin calculations). The flow volume out of the basins through the diversion spillway was calculated by determining the volume reduction necessary for the basin capacity to reach the maximum capacity for the following time step (this was only necessary during the second half of the storm). For each time step the volume of water contained in the basins was calculated as

$$V_{basin,j} = V_{basin,j-1} + V_{in,j} - V_{out\ bio,j} - V_{out\ spill,j}$$

where $V_{basin,j-1}$ is the volume of water contained in the basins during the previous time step, $V_{in,j}$ is the volume of water that flows into the basins during the time step, $V_{out\ bio,j}$ is the volume of water that flows out through the bioretention media during the time step, and $V_{out\ spill,j}$ is the volume of water that flows out through the diversion spillway during the time step. The total volume of water treated was calculated by summing the water treated during each time step and adding the volume of water remaining in the basins at the end of the 24-hour storm. The total volume treated, $V_{treated}$, was calculated to be

$$V_{85th,treated} = \mathbf{868,432\ ft^3}$$

The total runoff volume of the 85th percentile 24-hour storm was calculated as

$$V_{85th} = CP_{85th}A = (0.43)(0.91\ in)(1{,}836\ ac) = 2{,}602{,}343\ ft^3$$

The percent captured of the 85th percentile 24-hour storm was calculated as

$$Percent\ Captured = \frac{V_{85th,treated}}{V_{85th}} = \frac{868{,}432\ ft^3}{2{,}602{,}343\ ft^3} = \mathbf{33}\%$$

APPENDIX C

PRELIMINARY DESIGN SHEETS

CITY OF REDDING

SEWER PONDS STORMWATER RETROFIT PRELIMINARY DESIGN

PROJECT LOCATION:
MILL VALLEY PARKWAY AND STINSON LOOP
REDDING, CA 96003

FEBRUARY 2019

LOCATION MAP:
SCALE 1" = 100'

PROJECT TEAM:

APPLICANT:
CITY OF REDDING
777 CYPRESS AVE
REDDING, CA 96001
(530) 224-6068

CIVIL ENGINEER:
GEOSYNTEC CONSULTANTS, INC.
924 ANACAPA ST, SUITE 4A
SANTA BARBARA, CA 93101
(310) 957-6100

PROJECT DESCRIPTION:

CONSTRUCT DIVERSION SPILLWAY, GRADE SEDIMENTATION BASINS, INSTALL CULVERT AND SEDIMENTATION BASIN OUTLET STRUCTURES, CONSTRUCT BIORETENTION BASIN AND OVERFLOW SPILLWAYS.

DRAWING INDEX

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	G-01	TITLE SHEET AND DRAWING INDEX
2	C-01	SITE PLAN
3	C-02	DETAILS

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY
DATE

Geosyntec consultants
engineers | scientists | innovators

CITY OF REDDING CALIFORNIA

MILL VALLEY PARKWAY AND STINSON LOOP, REDDING, CA

CITY OF REDDING SWRP:
SEWER PONDS STORMWATER RETROFIT
PRELIMINARY DESIGN
TITLE SHEET AND DRAWING INDEX

JOB NO. LA0443
DRAWING NO. G-01
SCALE AS SHOWN
SHEET NO. 01 OF 03

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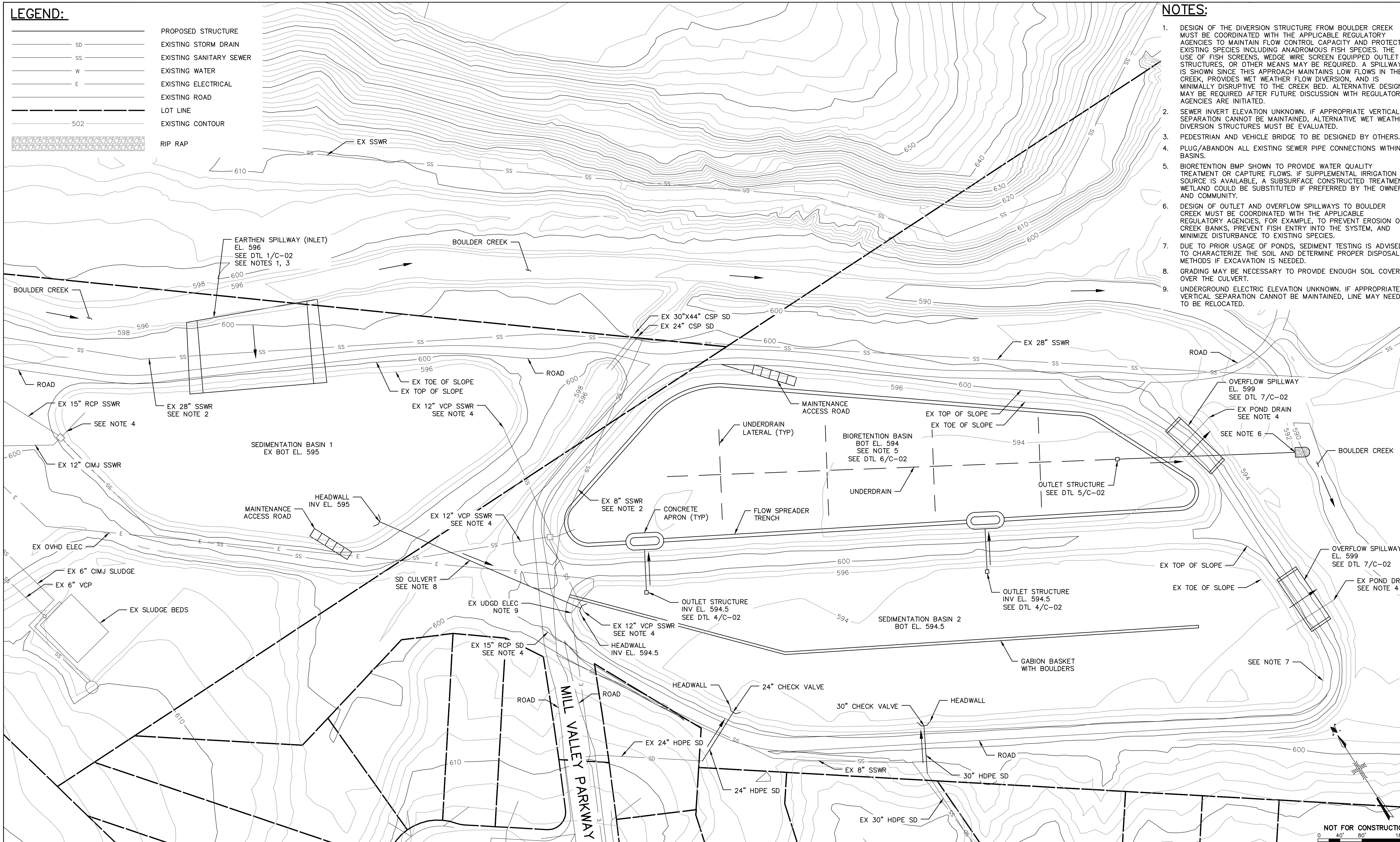
February 07, 2019 - 12:04am AGrayStewart



NOTES:

1. DESIGN OF THE DIVERSION STRUCTURE FROM BOULDER CREEK MUST BE COORDINATED WITH THE APPLICABLE REGULATORY AGENCIES TO MAINTAIN FLOW CONTROL CAPACITY AND PROTECT EXISTING SPECIES INCLUDING ANADROMOUS FISH SPECIES. THE USE OF FISH SCREENS, WEDGE WIRE SCREEN EQUIPPED OUTLET STRUCTURES, OR OTHER MEANS MAY BE REQUIRED. A SPILLWAY IS SHOWN SINCE THIS APPROACH MAINTAINS LOW FLOWS IN THE CREEK, PROVIDES WET WEATHER FLOW DIVERSION, AND IS MINIMALLY DISRUPTIVE TO THE CREEK BED. ALTERNATIVE DESIGNS MAY BE REQUIRED AFTER FUTURE DISCUSSION WITH REGULATORY AGENCIES ARE INITIATED.
2. SEWER INVERT ELEVATION UNKNOWN. IF APPROPRIATE VERTICAL SEPARATION CANNOT BE MAINTAINED, ALTERNATIVE WET WEATHER DIVERSION STRUCTURES MUST BE EVALUATED.
3. PEDESTRIAN AND VEHICLE BRIDGE TO BE DESIGNED BY OTHERS.
4. PLUG/ABANDON ALL EXISTING SEWER PIPE CONNECTIONS WITHIN BASINS.
5. BIORETENTION BMP SHOWN TO PROVIDE WATER QUALITY TREATMENT OR CAPTURE FLOWS. IF SUPPLEMENTAL IRRIGATION SOURCE IS AVAILABLE, A SUBSURFACE CONSTRUCTED TREATMENT WETLAND COULD BE SUBSTITUTED IF PREFERRED BY THE OWNER AND COMMUNITY.
6. DESIGN OF OUTLET AND OVERFLOW SPILLWAYS TO BOULDER CREEK MUST BE COORDINATED WITH THE APPLICABLE REGULATORY AGENCIES, FOR EXAMPLE, TO PREVENT EROSION OF CREEK BANKS, PREVENT FISH ENTRY INTO THE SYSTEM, AND MINIMIZE DISTURBANCE TO EXISTING SPECIES.
7. DUE TO PRIOR USAGE OF PONDS, SEDIMENT TESTING IS ADVISED TO CHARACTERIZE THE SOIL AND DETERMINE PROPER DISPOSAL METHODS IF EXCAVATION IS NEEDED.
8. GRADING MAY BE NECESSARY TO PROVIDE ENOUGH SOIL COVER OVER THE CULVERT.
9. UNDERGROUND ELECTRIC ELEVATION UNKNOWN. IF APPROPRIATE VERTICAL SEPARATION CANNOT BE MAINTAINED, LINE MAY NEED TO BE RELOCATED.

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY
DATE

Geosyntec consultants
engineers | scientists | innovators

CITY OF REDDING CALIFORNIA

MILL VALLEY PARKWAY AND STINSON LOOP, REDDING, CA

CITY OF REDDING SWRP: SEWER PONDS STORMWATER RETROFIT PRELIMINARY DESIGN

SITE PLAN

JOB NO. LA0443
DRAWING NO. C-01
SCALE 1"=80'
SHEET NO. 02 OF 03

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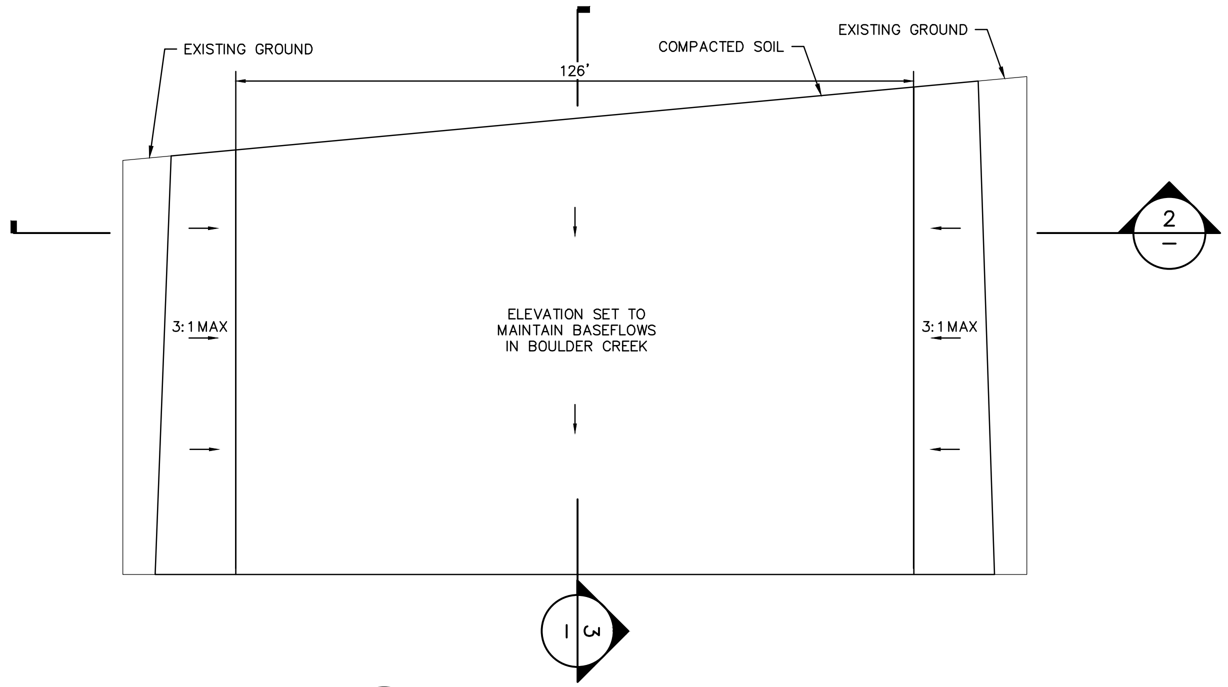
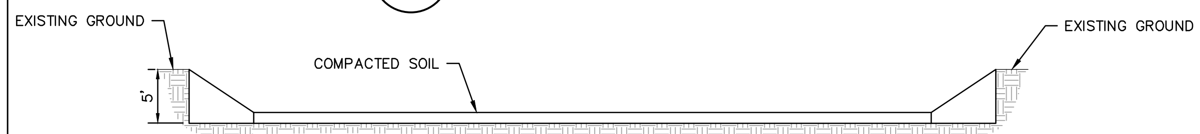


1 / C-01 SPILLWAY (INLET) PLAN VIEW



2 / — SPILLWAY (INLET) SECTION
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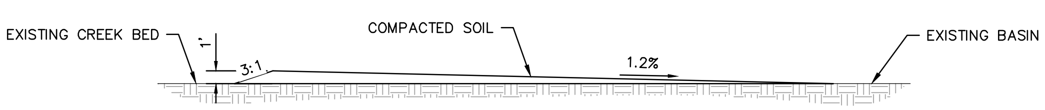

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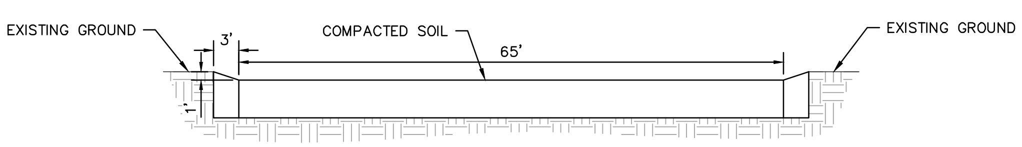

7 / C-01 OVERFLOW SPILLWAY SECTION
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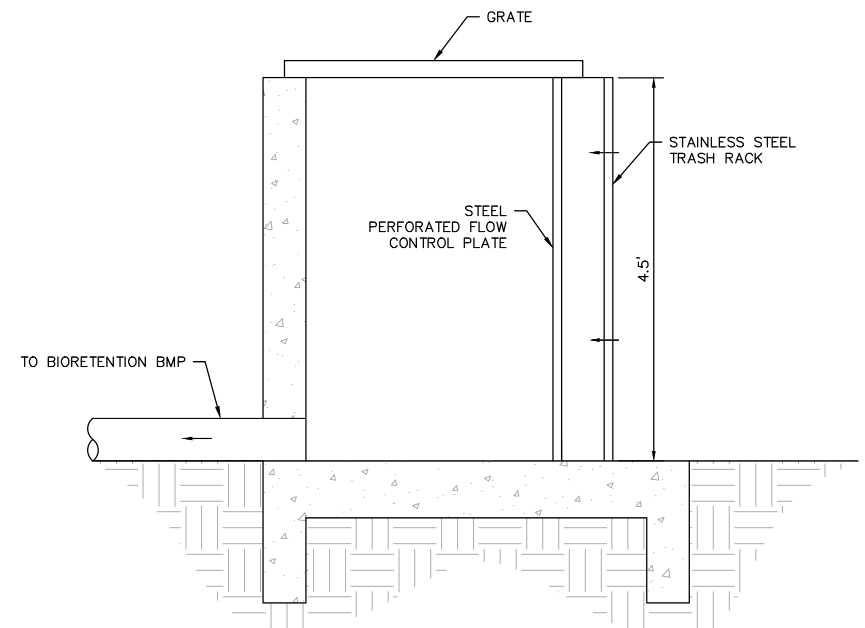

4 / C-01 SEDIMENTATION BASIN OUTLET SECTION
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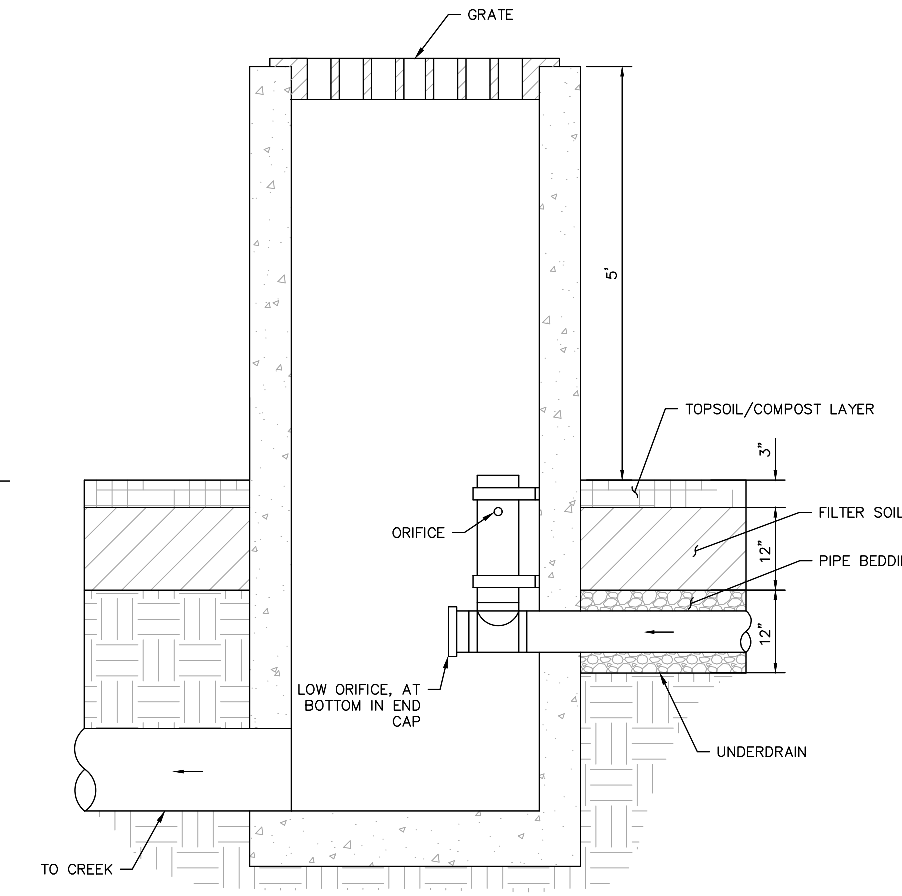
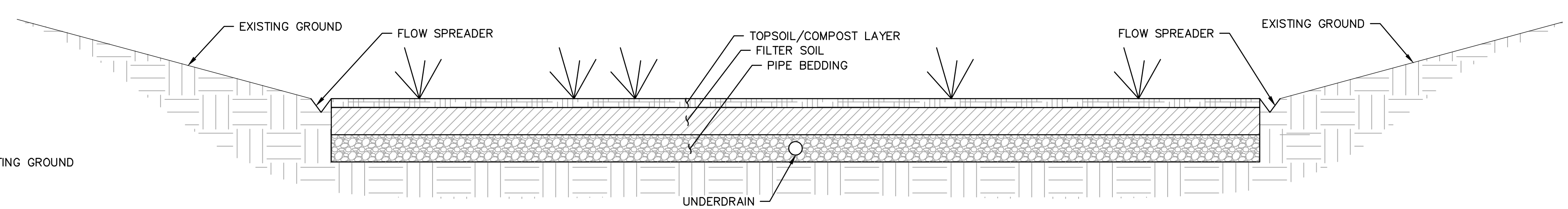


5 / C-01 BIORETENTION BASIN OUTLET SECTION
NOT TO SCALE



6 / C-01 BIORETENTION SECTION
NOT TO SCALE

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CITY OF REDDING CALIFORNIA

MILL VALLEY PARKWAY AND
STINSON LOOP, REDDING, CA

CITY OF REDDING SWRP:
SEWER PONDS STORMWATER RETROFIT
PRELIMINARY DESIGN
DETAILS

JOB NO. LA0443
DRAWING NO. C-02
SCALE NOT TO SCALE
SHEET NO. 03 OF 03

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February 07, 2019 - 10:33am AGrayStewart

APPENDIX D

PRELIMINARY DESIGN WORK PLAN, COST ESTIMATE,
AND SCHEDULE

Geosyntec consultants

924 Anacapa Street, Suite 4A
Santa Barbara, California 93101
PH 805.897.3800
FAX 805.899.8689
www.geosyntec.com

Memorandum

Date:	28 March 2019
To:	Mieke Sheffield; City of Redding
From:	Avery Blackwell, PE, Brandon Steets, PE, and Adam Questad, PE, Geosyntec Consultants
Subject:	Sewer Ponds Stormwater Retrofit Work Plan, Cost Estimate, and Schedule Geosyntec Project: LA0443
Attachments:	Attachment A – Preliminary Cost Estimate Attachment B – Preliminary Schedule

INTRODUCTION AND BACKGROUND

The City of Redding (City) identified an opportunity to retrofit the former City sewer ponds to capture, treat, and infiltrate stormwater from Boulder Creek (Creek)and provide some peak flood flow attenuation ("Project"). The former sewer ponds are adjacent to the Creek and are currently abandoned and unused but were previously used as a wastewater application and disposal site. As part of the Project, the existing ponds will be reengineered as sedimentation and bioretention basins and a portion of the flow from the Creek will be diverted through these basins to provide treatment and infiltration. At the point of diversion, the Creek collects runoff from an approximately 1,800-acre drainage area consisting mostly of residential, industrial, and open space land uses and the Project overlies the Enterprise groundwater basin, which is designated for municipal supply use, and will provide recharge benefit via infiltration to this basin.

This memorandum describes the preliminary project work plan, cost estimate, and schedule developed for the Project, in a format consistent with the Proposition 1 Stormwater Grant Program (SWGP) Implementation Grant Proposal Templates[1].

[1] https://www.waterboards.ca.gov/water_issues/programs/grants_loans/swgp/prop1/

PRELIMINARY PROJECT WORK PLAN

Task 1. Project Administration

The Project will be managed by the City, who will oversee all aspects of the Project, including but not limited to planning, permitting, design, construction, bid and award, monitoring, coordination with other entities, and project maintenance, to ensure that all tasks are completed on time and within budget. The following tasks are included under Project Administration and will be executed by the City:

- **Project Management:** To keep the Project on schedule and within budgetary limitations, this subtask includes overall project management to coordinate consultants and subcontractors, track schedule and progression of the Project, track expenditures and budget status, and time for internal City communication and meetings to discuss the Project with other departments.

- **Invoicing:** As required by the final agreement, this subtask includes time to develop invoices and the required backup and supporting information from all subconsultants and consultants.

- **Reporting:** This subtask includes time to develop quarterly and annual reports and other more frequent communication with the grant manager (if the Project receives grant funding).

Task 2. Planning/Design/Engineering/Environmental

The City will oversee the selection of an engineering consultant to develop 100% Construction design drawings and specifications based on the current preliminary designs and feedback from community stakeholders and regulatory agencies. A preliminary site investigation and design for the Project have been completed and are described in subsequent sections of the work plan. To develop the final design for the Project, the following subtasks will be completed by the City, engineering consultant, or subcontractor[2]:

- **Survey and Geotechnical Investigation:** To revise the current base plan shown in the preliminary design, a topographical survey will be executed to capture detailed elevation

[2] The City may consider an alternative to the design-bid-build approach and instead establish a design-build contract with one consultant team. The design-build approach is typically lower cost due to the construction contractor being involved during final design and the removal of the construction bidding process. In addition, design-build contracts promote a partnership where all parties work together and are committed to the same goals, which can result in a more successful project and higher likelihood of achieving the Project's goals within the budget allotment.

information of existing conditions and potential aboveground constraints. This subtask will also include utility investigation and potholing to identify shallow utilities that may impact the proposed design, including the sewer line running through the proposed diversion spillway.

Geotechnical investigations will be executed including soil sampling from the existing abandoned sewer ponds to characterize the soil and determine if any historical contamination will impact its disposal. This investigation will include additional infiltration testing and soil characterization to determine drawdown rate and the depth to groundwater, to support future design modifications (e.g., underdrains) as needed.

- **Hydrologic and Hydraulic Analysis:** Additional calculations and modeling will be performed to finalize the final elevations, size, and material of the Project's required infrastructure. This analysis will be conducted to determine the fluctuation of Creek flow depths in order to more accurately quantify water available for diversion under different hydrologic scenarios. Based on this information and the constraints provided during regulatory agency coordination (e.g., minimum diversion invert elevation and outlet construction requirements), this analysis will then allow for the hydraulic design to be solidified. This task should also include Creek water depth measurements and calibration of the hydrologic model to improve volume capture and peak flow estimates. Additionally, HEC-RAS modeling will be performed to satisfy the City's plan check requirements.

- **CEQA and Permitting:** The City, with the assistance of a consultant, will prepare the required CEQA documentation and develop the material required to obtain the applicable permits, which may include encroachment permits, building permits, grading permits, construction stormwater permits, and additional environmental permits as required by applicable regulators (e.g., California Department of Fish and Wildlife (CDFW), Army Corps of Engineers (ACOE), Regional Water Quality Control Board, etc.). Coordination with key regulators, including CDFW and ACOE, will be initiated at the outset of this Project to determine what constraints (e.g., fish passage protection and instream flow preservation) are applicable and what associated design modifications are needed.

- **Final Design:** Based on the preliminary design and information gathered in the previous subtasks, a consultant will then advance the design and prepare a 100% construction plan set and technical specifications outlining the Project's components with sufficient detail for the contractor to construct the Project. This task will include additional structural calculations to design the diversion and overflow spillways and other culverts and stormdrains. This task will also include a revised cost estimate and schedule based on the final design's alignment and components as well as landscaping and operation and maintenance plans.

- **Vector Control Plan:** Based on the final design, a vector control plan will be developed for areas where standing water may persist (sedimentation basins, bioretention ponding area, outlet structures). This vector control plan may include establishing maintenance and observation procedures or specify the application of specific products to prevent vector introduction or proliferation within the areas identified above.

- **Bid Documents and Construction Award:** Upon completion of the final design, the City or a consultant will prepare the construction bid package and solicit competitive construction bids from qualified contractors unless a design-build approach is selected. The City will then award the Project to a qualified contractor and provide notice to proceed once all contract documents are in place.

Task 3. Construction/Implementation
The following subtasks are included for the administrative management of construction:

- **Contract Administration:** The City will serve as Project Manager throughout construction and the Engineer of Record or qualified engineering consultant(s) will be contracted by the City to provide engineering support during all phases of construction. The City and consultant(s) will coordinate activities with the contractor, review and approve contractor submittals, and make project decisions as required when conflicts or discrepancies are identified in the field. The City will be responsible for all external reporting requirements as necessary to fulfill the needs of any applicable grants.

- **Construction Management:** The City will contract a qualified construction manager to oversee construction activities and contractor coordination including conducting tailgate meetings, reviewing the contractor's execution of tasks, communication of progress and concerns to the City or consultant through daily and/or weekly reporting, and performing other general construction management responsibilities.

The following subtasks are expected to be executed by the construction subcontractor as part of this Project although the following tasks may be revised after the final design is complete:

- **Contractor mobilization** – After the contractor is provided with the notice to proceed, they will begin mobilization to the site, which may include establishing cost tracking tools and metrics, ordering material and assembling their crews, establishing a staging area if not provided by the City, and equipment rentals.

- **Clearing and grubbing –** The area within and surrounding the proposed diversion spillway and within the existing ponds will be cleared of vegetation and other debris after mobilization is complete. Care will be taken to preserve the existing trees in place, but depending on the final design, this task may also include tree removal and/or replacement.

- **Excavation and Utility Relocation –** Over excavation will be executed within the diversion spillway, overflow spillways, and bioretention outlet pipe trench to prepare for installation of the Project's components. In addition, trenches will be excavated in preparation for stormdrain connections and culverts. If during initial investigations it is determined that the existing sewer line's invert elevation will interfere with the diversion spillway or the existing electric line's invert elevation will interfere with the culvert, these lines will be relocated as part of this task according to the final design plans. Excavated material will be stockpiled as needed and hauled offsite for proper disposal.

- **Sedimentation Basins, Bioretention Basin, and Spillways Construction –** After completion of excavation and utility relocation, the sedimentation basins, bioretention basin (topsoil, planting media, gravel layer, and underdrain), diversion spillway, overflow spillways, stormdrain and culvert connections, and outlet structures will be installed according to the final design plans and specifications. All trenches and excavated areas will then be backfilled and surface grading will be provided as needed and according to the plans. The bioretention basin will be landscaped with plants to promote evapotranspiration, soil aeration, aesthetics, and pollutant removal. Walking paths and pedestrian bridges will be replaced or installed according to the design plans and structures affected by project construction will be replaced. Finally, permanent educational signage will be installed to educate the public about the Project's multiple benefits.

- **Punch list completion –** Throughout construction, the engineer of record, City, or construction manager will maintain a punch list of items that need to be corrected by the contractor. After completion of the subtasks above, the contractor will be required to address all punch list items before a certificate of occupancy can be issued by the inspector.

- **Demobilization –** After construction is complete the contractor will remove any equipment or facilities used specifically for this Project and clean up the site as needed.

Task 4. Monitoring/Performance

To assess the Project's performance the following monitoring/performance subtasks will be implemented:

- **Monitoring Plan and Quality Assurance Project Plan (QAPP):** A consultant will develop a detailed monitoring plan to outline the required monitoring procedures and methods for collecting baseline and post-construction data and evaluating data collected to determine the effectiveness of the Project and whether the multiple benefit goals have been achieved. In addition, this plan will include a QAPP outlining the quality assurance, quality control requirements to prevent sample contamination and produce reliable results.

- **Dry and Wet Weather monitoring (Pre-Project):** Prior to beginning construction, a consultant will adhere to the monitoring plan developed and collect dry and wet weather samples and measurements for the Project. This baseline monitoring will be conducted in the Creek upstream and downstream of the Project area and within the existing basins during two wet weather and two dry weather runoff events (weather permitting). The purpose of this monitoring will be to collect depth and drawdown measurements to calibrate the hydrologic models, which is used to establish volume capture performance of the proposed project.

- **Dry and Wet Weather monitoring (Post-construction):** After completion of construction, a consultant will adhere to the monitoring plan and collect dry and wet weather samples and measurements for the Project. It is anticipated that the consultant will collect influent, midpoint (between sedimentation and bioretention basins), and effluent grab samples, along with water depth measurements above the diversion spillway and within the sedimentation basins and the bioretention basin during dry and wet weather events (a total of four wet weather and two dry weather events will be targeted). If possible, multiple depth measurements will be collected above the diversion spillway throughout the storm or a pressure transducer will be installed to continuously measure depth and quantify the amount of water diverted through the Project. Water quality samples will be analyzed by a lab subcontracted by the City. If any equipment other than sample bottles are required to collect samples, an equipment blank will be collected for 20% of the samples.

Task 5. Education/Outreach

Three public outreach meetings were held in 2018 during the project selection phase and additional education/outreach subtasks will include:

- **Public Communication:** During all stages of the Project, the public will be notified of the Project’s progression through e-mail communication and possibly through an established website. In addition, temporary signage will be placed during construction to educate the public on the importance of the Project and the expected goals. After construction, a permanent sign will be installed to describe the Project and the multiple benefits it provides including reduced pollutant loading to the Creek, reduced flooding downstream, and improved aesthetics and community benefits.

- **Public Meetings:** Two (2) public meetings are planned during the duration of the Project. After kickoff of the final design subtask, a public meeting will be held to discuss the preliminary design concepts and solicit additional feedback from the community. The feedback will be incorporated into the final design as feasible. Prior to construction, an additional public meeting will be held to present the final design and provide information regarding impacts expected during construction.

PRELIMINARY PROJECT COST ESTIMATE

The Project's preliminary cost estimate (Attachment A) has been assembled to match the five major tasks described above. Each task has a number of subtasks which represent various deliverables or stages of the project. The following is a summary of each category and task:

Project Administration: These costs are associated with grant administration and reporting labor and miscellaneous expenses (e.g., communication, photo copies, etc.) necessary to manage and operate a successful grant project.

Planning/Design/Engineering/Environmental: These costs were developed based on similar costs incurred during previous consultant stormwater improvement projects. Subtasks include deliverables necessary to analyze, design and produce engineering documents that are used in the permitting, bidding, construction and completion of the Project.

Construction/Implementation: The construction costs were developed according to the size and material of infrastructure outlined in the preliminary design layout for the Project. The construction cost is estimated to be $840,000 USD. These costs are based on recent 2018 regional stormwater improvement projects, professional experience and judgment, and construction cost indexes (BNi cost books, R. S. Means). Assumptions used to develop the construction costs include:

- Excavated materials from the project area are considered clean and do not require special sampling, waste handling or disposal. The disposal costs assume that the material will be transported to a nearby facility within 15 miles of the project.
- Stormwater Pollution Prevention Plan monitoring requirements are not included since the Project is not expected to disturb more than one acre of land.

- Landscape vegetation will include low maintenance natives that require initial irrigation to establish the plants during the first one to three years.

Monitoring/Performance: These costs are based on developing and implementing a plan to evaluate the performance of the Project. The costs were determined based on previous experience with monitoring programs developed under Proposition 1 and 84 grant projects.

Education/Outreach: The costs associated with these tasks include providing community, direct and web-based outreach and education to support the Project based on education/outreach experience during past projects.

PRELIMINARY PROJECT SCHEDULE

The Project's preliminary schedule (Attachment B) includes tasks consistent with those described in the preliminary project work plan. Task durations were established based on prior experience with design and construction of similar projects and are expected to be sufficient for completion of each task. Timely completion of these tasks will be facilitated by the Project being managed solely by the City, who will coordinate all aspects of the Project. Based on the preliminary analyses performed, the only identified obstacle that may delay project tasks are unanticipated environmental permitting requirements. These requirements will be established during communication with regulators at the outset and therefore the Project's schedule will be revised early on if needed.

The design drawings for the Project have been developed to approximately the 30% level, with the concept fully described including locations of all key infrastructure, and project effectiveness evaluated through both hydrologic calculations and a geotechnical investigation to estimate site-specific infiltration rates, expected infiltration volumes, and resulting pollutant load reductions. The first phase in the Project includes additional surveying, geotechnical investigations, and hydrologic and hydraulic analysis to confirm the proposed layout is feasible or if modifications are required to avoid environmental, grading, or utility constraints in order to meet the stormwater diversion goals of the Project. This phase is expected to last approximately four (4) months.

The next phase will include the development of the design to the 100% level, as well as submittal of applications for appropriate local permits (grading, etc.), and is expected to last approximately six (6) months. Development of a monitoring plan (to include both baseline and performance monitoring) will be completed concurrently with the final designs, with baseline monitoring kicking off once the monitoring plan has been completed.

During the last month of design and permitting, the construction contractor selection process will be initiated, and is expected to be completed within four (4) months. As soon as the construction contractor has been selected, construction of the project will commence. Construction is expected to be complete within seven (7) months. Once construction is complete, performance monitoring will be conducted, in accordance with the monitoring plan that was developed at the start of the Project.

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ATTACHMENT A

SEWER PONDS STORMWATER RETROFIT

PRELIMINARY COST ESTIMATE

Prop 1 STORMWATER GRANT PROGRAM - BUDGET DETAIL

Applicant: City of Redding **FAAST PIN:**

Project: Sewer Ponds Stormwater Retrofit

Budget Category	Percent of Cost	Labor Costs			Consulting/Materials/Equipment				TOTALS
		Rate	# of Hours	Total Labor	Unit Cost	Units	# of Units	Total Cost	
1. Project Administration	**4.5%**								**$54,800**
Project Management		$100.00	232	$23,200				$0	$23,200
Invoicing		$100.00	116	$11,600				$0	$11,600
Reporting		$100.00	200	$20,000				$0	$20,000
2. Planning/Design/Engineering/Environmental	**18.5%**								**$225,000**
Design Survey				$0	$15,000	LS	1	$15,000	$15,000
Geotechnical Investigation				$0	$15,000	LS	1	$15,000	$15,000
Hydrology & Hydraulics				$0	$20,000	LS	1	$20,000	$20,000
Preliminary Design Report				$0	$15,000	LS	1	$15,000	$15,000
Construction Documents				$0	$60,000	LS	1	$60,000	$60,000
Environmental Approvals/Construction Permits				$0	$100,000	LS	1	$100,000	$100,000
3. Construction/Implementation	**68.9%**								**$837,760**
General Conditions/General Requirements				$0	$100,000	LS	1	$100,000	$100,000
Construct maintenance access road				$0	$15,000	EA	2	$30,000	$30,000
Clearing and grubbing				$0	$15,000	LS	1	$15,000	$15,000
Grading				$0	$20,000	LS	1	$20,000	$20,000
Install underdrain pipe				$0	$60	LF	1081	$64,860	$64,860
Construction of headwall				$0	$20,000	EA	4	$80,000	$80,000
Construction of earthen spillway				$0	$15,000	LS	1	$15,000	$15,000
Construction of overflow spillways				$0	$10,000	EA	2	$20,000	$20,000
Construction of outlet structures				$0	$8,000	EA	3	$24,000	$24,000
Install stormdrain culvert				$0	$145	LF	380	$55,100	$55,100
Construct concrete apron				$0	$5,000	EA	2	$10,000	$10,000
Install gabion baskets				$0	$100	LF	1120	$112,000	$112,000
Flow spreader trench				$0	$50	LF	2340	$117,000	$117,000
Check valve				$0	$45,000	EA	2	$90,000	$90,000
Outlet pipe				$0	$145	LF	240	$34,800	$34,800
Landscaping				$0	$50,000	LS	1	$50,000	$50,000
4. Monitoring/Performance	**6.6%**								**$80,000**
Monitoring Plan and Quality Assurance Project Plan				$0	$15,000	LS	1	$15,000	$15,000
Dry and Wet Weather Monitoring (Baseline)				$0	$25,000	LS	1	$25,000	$25,000
Dry and Wet Weather Monitoring (Post-Construction)				$0	$40,000	LS	1	$40,000	$40,000
5. Education/Outreach	**1.6%**								**$19,000**
Public Communication		$100.00	80	$8,000	$1,000	EA	2	$2,000	$10,000
Public Meeting #1		$100.00	20	$2,000	$2,500	EA	1	$2,500	$4,500
Public Meeting #2		$100.00	20	$2,000	$2,500	EA	1	$2,500	$4,500
Grand Total:	**100%**								**$1,216,560**

ATTACHMENT B

SEWER PONDS STORMWATER RETROFIT

PRELIMINARY SCHEDULE

Sewer Ponds Stormwater Retrofit

City of Redding

Legend: Admin | Engineering | Monitoring | Construction | Public Outreach

Work Tasks	Start (month)	Duration (months)
Task 1. Project Administration		
Project Management	1	32
Invoicing	1	32
Reporting	1	32
Task 2. Planning/Design/Engineering/Environmental		
Survey and Geotechnical Investigation	1	2
Hydrologic and Hydraulic Analysis	2	3
CEQA and Permitting	1	9
Final Design	4	6
Vector Control Plan	9	1
Bid Documents and Construction Award	9	4
Task 3. Construction/Implementation		
Contract Administration	12	8
Construction Management	13	7
Mobilization	13	1
Clearing and Grubbing	13	1
Excavation and Utility Relocation	14	1
Sedimentation Basin, Bioretention Basin, and Spillway Construction	15	3
Complete punch list	18	1
Demobilization	19	0.25
Task 4. Monitoring/Performance		
Monitoring Plan and Quality Assurance Project Plan	4	3
Dry and Wet Weather Monitoring (Baseline)	7	5
Dry and Wet Weather Monitoring (Post-Construction)	20	13
Task 5. Public Education and Outreach		
Public communication	1	32.00
Public meeting #1	2	0.25
Public meeting #2	12	0.25