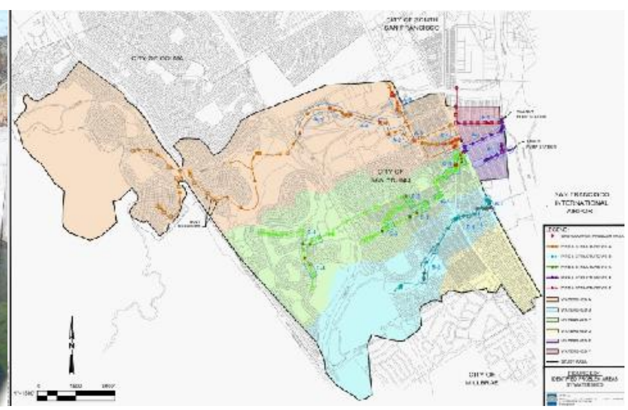
CITY OF SAN BRUNO

FINAL REPORT

STORM DRAIN MASTER PLAN

JUNE 2014



Executive Summary

This Storm Drain Master Plan (Plan) presents the results of technical analyses for the City of San Bruno’s storm water utility. The Plan was prepared by GHD Inc., under contract to and with the support from the City. The purpose of the Plan is to identify the causes of flooding within the storm drain system and develop alternative improvements that address the flooding.

The City owns and operates a storm drain system that covers six main watersheds, which are tracked by alphabetical reference (e.g. Watersheds A through F). The system in general flows from the west of Highway 280 to the east towards the San Bruno Channel. The system has four closed conduit outlets to San Bruno Channel. Two of them are gravity outlets at Pine Street and Cupid Row. The other two are pressure systems via the Walnut Pump Station and the Angus Pump Station constructed and owned by the San Mateo County Flood Control District (SMCFCD). .

GHD prepared a hydrology and hydraulic analysis to evaluate the capacity of the existing system. This analysis included flow monitoring for calibration purposes during four separate storm events from December 2009 to January 2010. The hydraulic analysis was developed utilizing Bentley’s SewerGEMS software. The capacity analysis was based on a 25-year design storm. The capacity evaluation shows that the storm drain system has multiple capacity deficiencies under the design storm. Table ES.1 and Figure ES.1 summarizes the problem areas which occur in the defined Watersheds. Watershed D was not modeled in SewerGEMS because it is essentially all overland flow with no major pipe network. It should also be noted that this watershed was not included in past master plan evaluations, but the known deficiencies are described in Chapter 4.

TABLE ES.1 – Capacity Deficiency Summary for Watersheds A, B, C, E, and F

	Watershed A	Capacity/Max Flow (gpm)	Watershed B	Capacity/Max Flow (gpm)	Watershed C	Capacity/Max Flow (gpm)	Watershed D	Watershed E	Capacity/Max Flow (gpm)	Watershed F	Capacity/Max Flow (gpm)
Problem Area by Locations (Starting From Upstream System to Downstream System)	Earl Avenue at Crosby Court	25.9/301.3	Existing Channel at Crystal Spring Park	unknown/383.9	Madison Avenue	39.6/58.7	San Antonio Avenue	Seventh Avenue	35.0/50.9	San Bruno Avenue East	5.8/21.4
	Northeast of the intersection of Freeways 280 and 380	525.1/532.2	Cupid Avenue	235.9/519.8	Whitman Way	84.7/136.4					
	Cherry Avenue	375.4/689.9	Huntington Avenue	385.8/519.7	Jenevein Avenue	25.8/57.8					
	Commodore Drive	557.8/549.5			Cypress Avenue	15.4/34.5					
	Grundy Lane	336.8/539.7			Angus Avenue	N/A					
	Bayhill Drive	522.4/588.1			Casio's Parking Lot	N/A					
	El Camino Real	12.8/25.0			Huntington Avenue	528.1/843.8					
	Masson Avenue	0/369.4 (negative/0 slope)			Belle Air Boxes	387.3/1231.9					
	Mills Avenue	218.4/370.6									
	Huntington and San Mateo Avenue intersection	528.1/843.8									
	Belle Air Boxes	387.3/1231.9									

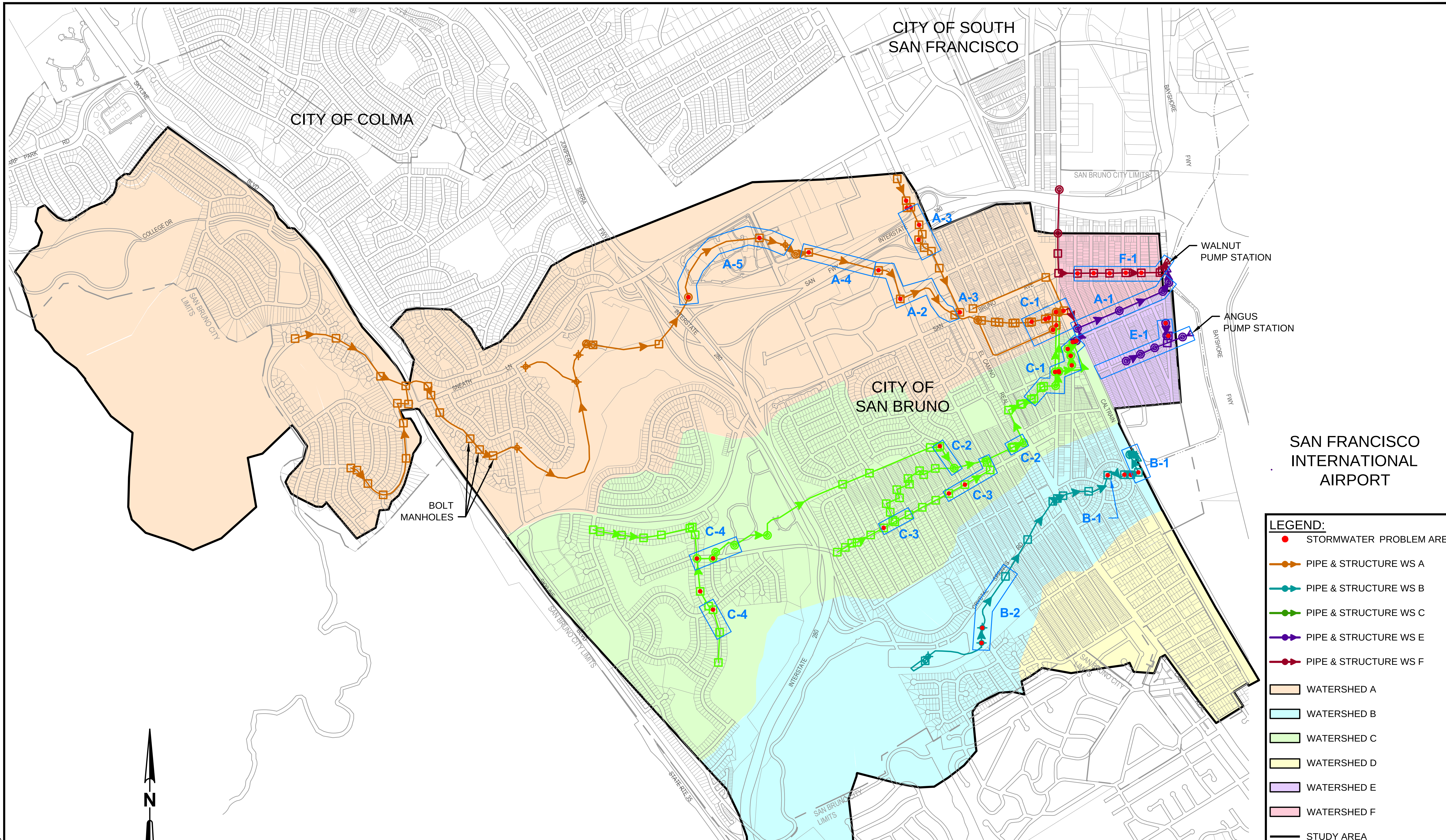


FIGURE ES-1
IDENTIFIED PROBLEM AREAS BY WATERSHED

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG ES-01.dwg
4/28/14 3:46 PM Susan Dove

The hydraulic model was then used to develop alternative improvement projects that would improve the capacity of the system. These alternatives were compared and ranked in order to develop a prioritized Capital Improvement Program (CIP) that addresses the capacity issues in a logical fashion (e.g. downstream improvements are made first) and seeks to prioritize the more severe flooding problems first. Table ES.2 lists the prioritized CIP projects and Chapter 5 provides additional detail on the prioritization process and ranking factors. There are six, Priority 1 projects, including a project for Long Term Trash Control Operation and Maintenance, with a total estimated cost of $ 12,860,000. The total cost of all recommended improvements, which also includes seven Priority 2 projects, is $20,110,000. These project costs do not include San Mateo County Flood Control District (SMCFCD) projects identified in Table ES.3 below.

Table ES.2 – City of San Bruno - Improvements for Collection System

Priority	Project ID	Estimated Cost	Description & Location	Constructed	Problem	Improvements
1.1	**AD-1**	$5,070,000	Belle Air Box : North Side of Pine Street	1900s	Existing RCBs are undersized.	<u>Existing:</u> (2) 5'x9' RCBs. <u>Proposed:</u> adding a third 5'x9' RCB.
1.2	**E**	$1,960,000	Pipeline Improvement: 7th and Angus Avenues adjacent to pump station	1960s	Existing pipes are undersized.	<u>Existing</u>: 30" and 24" diameter pipes <u>Proposed:</u> upsizing to 42" diameter pipes and 3'x3' RCB.
1.3	**CD-1**	$150,000	Bolt Manholes & Install Catch Basin Backflow Preventers in the vicinity of San Mateo, Huntington, Angus and Kains Avenues	1900s	Flat area; existing ground elevations are low; existing pipe has very shallow cover.	<u>Existing:</u> Gravity main trunk collect local runoff <u>Proposed:</u> Pressurized main trunk at peak flow
1.4	**F**	$1,890,000	Pipeline Improvement: San Bruno Avenue East	1960s	Existing pipes are undersized.	<u>Existing:</u> 24" diameter pipes <u>Proposed:</u> upsizing to 30" and 36" pipes.
1.5	**AD-2**	$2,790,000	Detention Basin at Crestmoor Canyon	1970s	Existing pipes undersized, at the east of Crestmoor Canyon at intersection Fwy 280 and 380, Cherry Avenue, Commodore Drive, Grundy Lane, and Bayhill Drive	<u>Existing:</u> A small detention basin that collects a small localized sub-watershed. <u>Proposed:</u> A large scale detention basin to collect the upstream watersheds.
1.6	**Mainten-ance**	$1,000,000	Compliance with MRP- Long Term Trash Control Operation and Maintenance	On-going		
Total Cost of Priority 1 Projects: $12,860,000						
2.1	**CD-2**	$2,240,000	Pipeline Improvement: North of Jenevein Avenue & El Camino Real	1900s	Existing pipes are undersized.	<u>Existing:</u> 3'x10' RCB. <u>Proposed:</u> 4'x10' RCB.

Priority	Project ID	Estimated Cost	Description & Location	Constructed	Problem	Improvements
2.2	**CD-3**	$1,410,000	Pipeline Improvement: Jenevein Avenue between Hazel & Cypress Avenues	1900s	Existing pipes are undersized.	Existing: 30" diameter pipes. Proposed: 42" diameter pipes.
2.3	**AD-3**	$820,000	Pipeline Improvement: El Camino Real at 380 undercrossing	1970s	Existing pipes are undersized.	Existing: 20" and 24" diameter pipes. Proposed: 30" diameter pipes.
2.4	**CD-4**	$1,380,000	Pipeline Improvement: Whitman Way between Madison Avenue & Eastburn Court	1950s	Existing pipes are undersized.	Existing: 21" and 24" diameter pipes. Proposed: 36", 42" and 60" diameter pipes.
2.5	**B-1**	$1,090,000	Pipeline Improvement: Huntington Avenue at Cupid Row	1900s	Existing pipe has insufficient capacity due to flat slope.	Existing: Flat slope pipe at 0.002 ft/ft. Proposed: Increasing the slope to 0.0031 ft/ft
2.6	**B-2**	$90,000	Concrete Channel at City Park: South side of Crystal Spring Avenue	Park	Existing channel is undersized and running into parking lot.	Existing: 1.5'x8' wide channel. Proposed: 1.5'x9' wide channel.
2.7	**D**	$220,000	Catch Basins at San Antonio Ave	1900s	Existing street geometry has insufficient capacity for the overland flow.	Proposed: Add 10 catch basins with gallery
Total Cost of Priority 2 Projects: $7,250,000						
Total Cost of Priority 1 and 2 Projects: $20,110,000						

The City currently has a Stormwater Fund to track the proceeds of its drainage parcel fee. The current fees are $2.0982/1,000 square feet for parcels characterized as Miscellaneous, Agriculture, Vacant and Condominium and $4.1964/1,000 square feet for all other land uses. On average, the Stormwater Fund collects about $500,000 to $600,000 a year which largely supports operational work and allows for the construction of the occasional small improvement project. The annual surplus varies, but on average less than $100,000 a year. The City would need to revise its storm drainage fee structure to fund the proposed CIP.

Municipal Regional Permit

The Municipal Regional Permit (MRP) went into effect on December 1, 2009. As a National Pollutant Discharge Elimination System (NPDES) permit, it has a five-year term and expires on November 30, 2014. The permittees are required to submit an application for reissuance, called a Report of Waste Discharge (ROWD) by June 2014. San Bruno, being one of the permittees for San Mateo County, is required to comply with this deadline.

Reissuance of the permit could include an increase in projects subject to stormwater treatment requirements, more specific trash load reduction requirements geared toward meeting the 2022 deadline for zero impact on receiving waters, continued water quality monitoring requirements, and expansion from existing pilot-scale implementation to full implementation of control measures that must achieve specific reductions in mercury and PCBs at the watershed scale. These new requirements will require significant funds to implement. A CIP project for Long Term Trash Control Operation and Maintenance is included in this master plan as a Priority 1 project in anticipation of the new requirements.

SMCFCD Facilities

The Walnut and Angus pump stations were constructed in 1968 and are owned and operated by the County. In a preliminary design report by Brown and Caldwell dated 2009, it was recommended that the two pump stations be rehabilitated to upgrade the existing mechanical, structural, electrical and instrumentation components.

In addition, the County also owns and maintains the tide gate at the discharge point of San Bruno Creek into the San Francisco Bay. The tide gate is old and in need of rehabilitation to restore full functionality.

Table ES.3 shows the estimated rehabilitation costs for the pumps stations and the tide gate for a total of $2,750,000. It is anticipated that the SMCFCD will secure additional funding via special assessment or bond funding to finance these projects.

Table ES.3 – SMCFCD Pump Stations and Tide Gate Improvement Projects

Priority	Project ID	Improvements	Description
Priority	**Project ID**	**Improvements**	**Description**
1	FC-1	$2,500,000	Rehabilitation of Walnut and Angus Pump Stations
2	FC-2	$250,000	Rehabilitation of San Bruno Creek Tide Gate
Total Cost of County Projects: $2,750,000			

Table of Contents

Table

Figure

Appendices

1. INTRODUCTION

GHD was retained by the City of San Bruno (the City) to prepare the City's storm drain master plan to address potential flooding within the City. The boundary of the study area and its main watersheds are shown in Appendix A, Figure 1A.

The City of San Bruno is located in San Mateo County on the peninsula west of San Francisco Bay. The City is bordered by the San Francisco International Airport to the east, the City of South San Francisco to the north, and the City of Millbrae to the south. The area is within the Mediterranean climate zone, where the hydrological cycles typically consist of dry summers and wet winters. Episodic storms in winter create potential flood hazards.

Based on the topography and storm drain collection system configuration, the City consists of six main watersheds. The City currently owns and maintains the storm drain collection system in the watersheds. The system in general flows from the west of Highway 280 to the east towards the San Bruno Channel. The system has four closed conduit outlets to San Bruno Channel. Two of them are gravity outlets at Cupid Row and San Bruno Avenue. The other two are pressure systems via the Angus and Walnut Pump Station, constructed and owned by the County of San Mateo (the County). The City has a long term agreement with the County to maintain and operate the pump stations.

This master plan is motivated by a number of factors. The City has periodic localized flooding that has raised the concerns from the impacted residents, the most significant being in the vicinity of Seventh Street and Angus Avenue. The master plan update allows the City to study and review the existing storm drain collection system performance, and develop strategies to improve its level of services. In addition, the previous master plan study was developed in the early 1990s, with an update in early 2000s. This current master plan not only updates this important flood control guiding document for the City, it also defines a new Capital Improvement Program (CIP) to address the storm drain system capacity deficiency. Finally, along with the CIP, the City needs to review its current funding mechanism for the storm drain system. To identify funding for the proposed CIP, a storm drain rate study is needed.

For this master plan a hydrologic and hydraulic coupled model of the City's storm drain collection system was developed. Specifically, the City's main trunk collection systems, as shown in Appendix A, Figure 1A were modeled. The purpose of this model is to assess the hydraulic capacity performance of the existing system, and to guide the project team in developing improvement alternatives. The model is checked against selected survey and field observations, and calibrated against flow monitoring data. The outcome of the analysis is a proposed CIP to guide the City in proceeding forward with the required improvements and in developing future funding opportunities.

This report summarizes GHD's efforts including our data gathering and analysis effort, flow monitoring, hydrologic and hydraulic analysis of the study area, existing system capacity evaluation, and CIP development.

2. EXISTING INFORMATION

2.1 Background Data

During the first phase of this master plan preparation, background information pertinent to the project was collected, reviewed, and analyzed. The background information review is required to thoroughly understand the existing storm drain collection system configuration, evaluate the nature and extent of the flooding problem, and to serve as the basis to identify and evaluate improvement options to alleviate the City's storm water routing and flood control level of service.

Relevant documents were obtained and reviewed during the initial phase of work. A list of the existing documents and information collected and reviewed is shown below:

- Bissell & Karn (1988) Crestmoor Canyon Holding Basin
- Bissell & Karn (1991) Storm Drain Master Plan Study, City of San Bruno
- BKF Engineers (2008) Conceptual Hydrology and Hydraulics Pre-Design Report for Storm water Conveyance on San Antonio Ave
- Brian Kangas Foulk (2000) Update of City of San Bruno Storm Drainage Master Plan Analyses, City of San Bruno
- Brown and Caldwell (2003) Storm Drain System Index Mapping, City of San Bruno
- Brown and Caldwell (2009) Walnut and Angus Stormwater Pumping Station Preliminary Design Report
- City of San Bruno (1973) Engvall School 72" Storm Drain
- City of San Bruno Digital Base Map and GIS database in ArcGIS format (electronic file)
- City of San Bruno General Plan (1984)
- City of San Bruno Horizontal and Vertical Control Network Monument Map
- City of San Bruno Initial Infrastructure Construction Map
- City of San Bruno Municipal Codes
- City of San Bruno Storm Drain System Maps (1971)
- Cotton, Shires & Associates (2008) Geologic and Geotechnical Study, Crestmoor Canyon, City of San Bruno
- Profession Land Services (2010) Storm Drain Master Plan, Horizontal and Vertical Control Survey (Manhole Rim Elevation and Locations)
- San Bruno Channel HEC-RAS model (electronic file)
- Smith, Randlett, Foulk & Stock (1992) Topograhic Survey of Crestmoor Canyon, San Bruno
- V&A (2001) Seventh Avenue Trunk Sewer Replacement Project, As-Built
- V&A (2010) Condition Assessment of the Crystal Spring Road Storm Drain Water Box Culvert
- V&A (2010) Condition Assessment of the Pine Street and Cupid Row Stormwater Box Culverts
- Wilsey & Ham (1970) San Bruno Channel Flood Control Project, As-Built
- Wilsey, Ham & Blair (1965) San Bruno Channel Flood Control Zone
- Wilsey, Ham & Blair (1965) San Bruno Channel Zone - Preliminary Plans

2.2 Watershed and Land Use Information

The background topographic mapping used in this study comes from a combination of USGS and San Mateo County and is NGVD 1929 Datum. Based on the topography and storm drain collection system configuration, the City is partitioned into six main watersheds. The combined tributary area encompass the area east of Highway 35, the area south of Sneath Lane from Highway 35 to Cherry Avenue, the area north of Crystal Spring Road, and the area west of Highway 101. An area north of Sneath Lane that is within the City boundary drains to drainage systems outside of the City and has not been incorporated into this or previous master plans. For the purposes of this master plan, the watersheds were divided into the following two tiers of watershed definitions:

First Tier – The first tier consists of six main watersheds identified by letters A, B, C, D, E and F, comprising the entire City of San Bruno. The watershed naming system is consistent with the watershed definition from the previous study.

This first tier of watershed definitions provides a framework to organize the hydrology and hydraulic analysis, report the findings and identify the longitudinal hydraulic relationship between proposed improvement projects.

Second Tier – The second tier consists of 80 sub-watersheds identified by numbers 1, 2, 3, etc., all located within the project area. The second tier watersheds are a subset of the first tier watersheds as follows:

- Watershed A consists of sub-watersheds A0 through A38.
- Watershed B consists of sub-watersheds B0 through B15.
- Watershed C consists of sub-watersheds C0 through C21.
- Watershed D consists of sub-watersheds D0 through D3.
- Watershed E consists of sub-watersheds E0 through E1.
- Watershed F consists of sub-watersheds F0 through F1.

These sub-watersheds were used in the hydrology analysis to estimate the storm water runoff within its tributary. The estimated flow becomes the input to the hydraulic analysis to assess the system capacity performance.

The total area of the six watersheds is 2850 acres, or approximately 4.5 square miles. The area breakdown for each watershed is summarized in Table 2.1.

Table 2.1 – Watershed Summary

Watershed	Area (acres)
Watershed A	1415.8
Watershed B	504.6
Watershed C	648.5
Watershed D	151.5
Watershed E	52.2
Watershed F	76.4
Total	2849.0

The locations of all watersheds are shown in Appendix A, Figure 1A.

Generally stormwater runoff flows from the western hill area to the eastern floodplain area. Except Watershed D, all watersheds discharge to San Bruno Channel. Watershed D overflows across San Antonio Road to an open field and then crosses Highway 101 via a series of culvert pipes. In general the longitudinal topography along the City's watersheds varies from steep hillsides in the upper drainage area at the west of Highway 280, to relatively flat slopes at the east of El Camino Real. Watersheds E and F, located to the east of Caltrain right of way, are in the low laying areas vulnerable to flooding. Due to its low surface elevation, both watersheds require pumping for stormwater discharge to San Bruno Channel.

As indicated in Appendix A, Figure 1B, the City is close to built-out. Other than Crestmoor Canyon located in Watershed A, the City Park located in Watershed B, and pockets of open spaces scattered in the City, the watersheds are mostly urbanized with residential and commercial developments. The City does not anticipate any major land use change or new green-field land development projects within the planning horizon. Most of the new developments will be in-fill developments within the existing urbanized area. Therefore, these in-fill developments would not significantly affect the stormwater runoff due to urban hydro-modification.

The watershed definition is based on the previous master plan. The watershed boundaries were verified and the second tier sub-watersheds developed by overlaying the watershed map with the City's storm drain base map and topography data. The topography data is based on a combination of USGS topographic map and LIDAR data. The land use information is based on the City's GIS database.

2.3 Storm Drain Collection System

The City's existing storm water collection system consists of underground pipelines and culverts, concrete and earthen channels, and detention basins. Many of the City's existing infrastructure were originally installed in the 1900s, when the eastern portion of the City developed and urbanized. Appendix A, Figure 1B shows the City's progression by the development era in decades. Table 2.2 summarizes the existing storm water conveyance mechanisms and discharge location by watersheds.

Belle Air Boxes are located between Pine Street and San Bruno Avenue. It is a backbone system that collects runoff from both Watersheds A and C from Huntington Avenue to San Bruno Channel.

San Bruno Channel is approximately 8 miles long. The channel is located at the most downstream end of the City storm drain collection system. The channel outfalls to the San Francisco Bay, via the tide gate to the north of the San Francisco International Airport. San Bruno Channel, in its current form, was constructed by the U.S. Army Corp of Engineers as part of the flood control project in the 1960s. In addition to Watersheds A and C, Watershed B also drains to San Bruno Channel via the Cupid Row Canal (also known as Crystal Spring Channel).

Table 2.2 – Existing Storm Drain System Summary

Watershed	Storm Drain System	Discharge Location
A	Underground pipes, boxes, and channels	Belle Air Boxes to San Bruno Channel
B	Detention Basin, underground pipes, boxes, and channels	Cupid Row Canal (Crystal Spring Channel)
C	Underground pipes and boxes	Belle Air Boxes to San Bruno Channel
D	Overland flow	Cupid Row Canal (Crystal Spring Channel)
E	Underground pipes	Angus Pump Station
F	Underground pipes	Walnut Pump Station

Cupid Row Canal is located at the most downstream end of Watershed B. It is a 4 miles long earthen channel that connects to the headwater of the San Bruno Channel.

In addition to the gravity systems, the City storm water collection system also consists of two pump stations, Angus Pump Station and Walnut Pump Station. They were built as part of the San Bruno Channel flood control project in the 1960s by U.S. Army Corps of Engineers with local sponsorship from San Mateo County. Currently the County owns and responsible to operate and maintain the pump stations.

Angus Pump Station is located at the east of Angus Avenue and Seventh Avenue intersection. The pump station collects runoff from Watershed E, and discharges to San Bruno Channel. According to the pump station evaluation in 2010, the current firm capacity with one of the large pumps out of service is 67 cfs.

Walnut Pump Station is located at the northeast corner of San Bruno Avenue and Seventh Avenue intersection. The pump station collects runoff from Watershed F, and discharges to San Bruno Channel. According to the pump station evaluation in 2010, the current firm capacity with one of the large pumps out of service is 55 cfs.

Table 2.3 summarizes pumps and their capacities.

Table 2.3 – Pump Station Capacities

Angus Pump Station	Walnut Pump Station
P-1: 30,000 gpm (66.8 cfs)	P-1: 5,500 gpm (12.3 cfs)
P-2: 30,000 gpm (66.8 cfs)	P-2: 5,500 gpm (12.3 cfs)
	P-3 14,000 gpm (31.2 cfs)
	P-4: 14,000 gpm (31.2 cfs)
FIRM Cap: 30,000 gpm (66.8 cfs)	FIRM Cap: 25,000 gpm (55.7 cfs)

1 Draft Walnut and Angus Stormwater Pumping Station Preliminary Design Report, Nov. 10, 2009, Brown & Caldwell

The storm water collection system is based on the City's system base map. During the data gap analysis, the main trunk system that was included in the modeling analysis was identified and compared it to available City GIS information. This effort identified missing information needed to develop an accurate hydraulic model

In order to supplement identified missing data, the project team, together with the City's staff conducted several site visits and meetings to spot check and verify the existing system condition. The information and observations from the site visits were used to supplement the background documents and survey data.

In addition, the City retained Professional Land Services (PLS) to survey the missing manhole rim elevations, and City's staff measured the manhole depths, and field verified existing pipe and box dimensions and alignments.

The collected information was subsequently imported into the hydrology and hydraulic model to improve the symbolic representation of the existing storm water collection system.

2.4 Flow Monitoring

In order to conduct model calibration the project team subcontracted with V&A to install four flow gages at key locations of the storm water collection system and one rain gage at the Walnut Pump

Station. The gages were installed for one month between December 26, 2009, and January 27, 2010. Figure 2.1 shows the location of the flow and rain gages

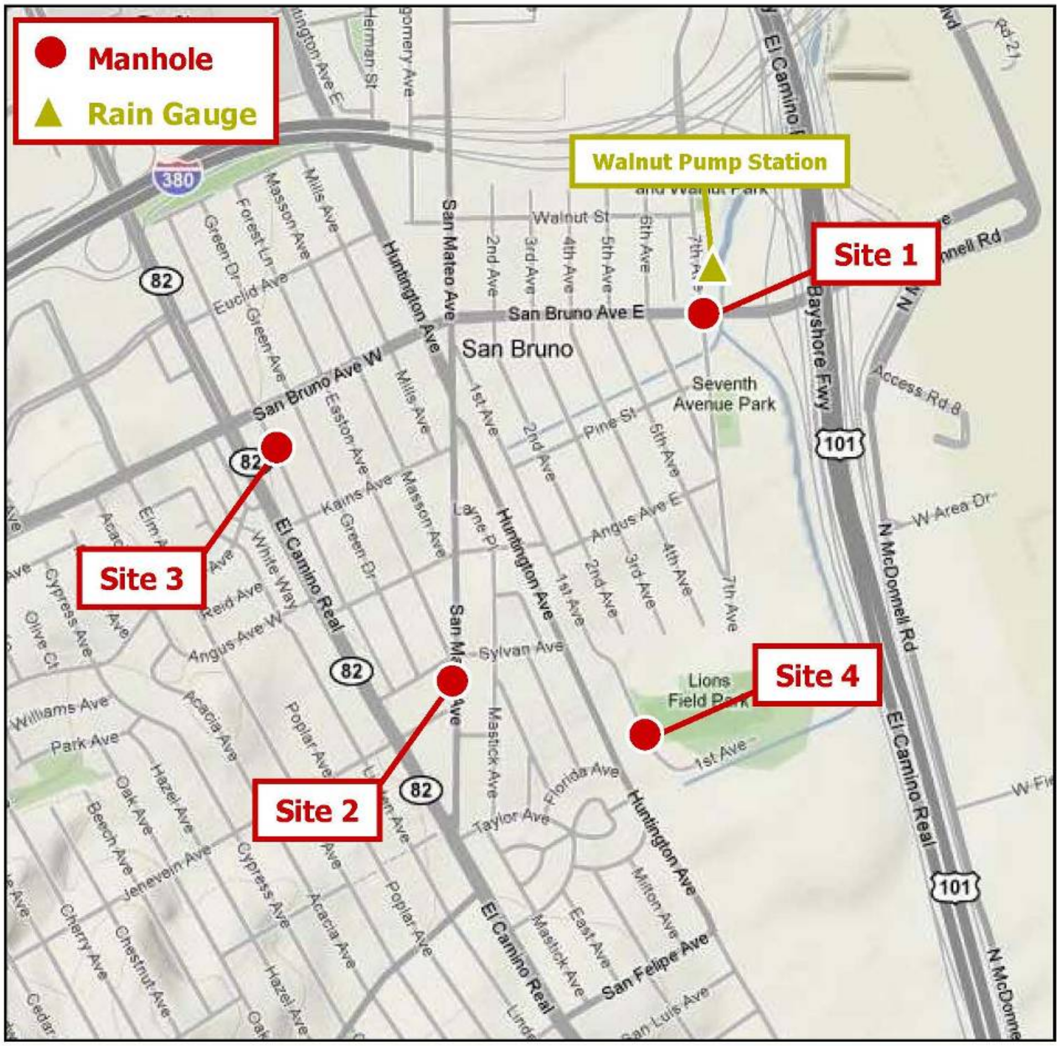


Figure 2-1 - Flow and Rain Gauges Location

The four flow monitoring locations were selected such that runoff from Watersheds A, B, and C could be independently measured. These three watersheds cover 90% of the total tributary area within the study area.

- Site 1 – Measure flow to Walnut Pump Station, from Watershed F
- Site 2 – Measure flow from Watershed C, upstream of Belle Air Box
- Site 3 – Measure flow from Watershed A, upstream of Belle Air Box
- Site 4 – Measure flow from Watershed B, upstream of Cupid Row Canal (Crystal Spring Channel)

During the monitoring period, there were approximately four storm events in the City, with the largest 24-hour storm on January 19 that was approximately equivalent to a 2-year return frequency storm. No flooding was noted during this event which was supported in the model results.

Appendix C contains the flow monitoring report and data used for model analysis calibration.

3. HYDROLOGY AND HYDRAULIC ANALYSIS

3.1 Modeling Software

A hydrologic and hydraulic modeling software was used to estimate the storm water runoff flow and analyze the storm drain collection system conveyance. The software used was capable of modeling both closed conduit and open channel components, and couple both hydrology and hydraulic analysis in a single package. In addition, dynamic time series analysis was needed to study the effects of storm water attenuation and the benefits of storm water detention. Finally, the modeling software has a user-friendly graphic user interface, so it is intuitive to operate by both the City's staff and its consultants for future revisions.

With these criteria in mind, this project utilized SewerGEMS modeling software from Bentley Systems (formally Hasted Method, the developer for StormCAD modeling software).

3.2 Hydrology Analysis

The objective of the hydrology analysis was to estimate the design flow as input to the hydraulic capacity analysis. Neither the City of San Bruno nor the County of San Mateo has a hydrology standard. The previous storm drain master plans referenced to the Western Alameda County Hydrology Manual. Per the manual, since the total watershed area is more than 640 acres, and detention facilities are considered in the hydraulic capacity analysis and improvement alternative analysis, the Soil Conservation Method (SCS method) is used to develop flood hydrograph for each sub-watershed. The SCS Unit Hydrograph Method was used in conjunction with the SCS Type I 24-hour storm distribution. The 24-hour storm duration is a typical design standard for detention pond analysis.

In the SCS Unit Hydrograph Method, the lag time input is based on the time of concentration estimate. The time of concentration for each sub-watershed is estimated based on the sum of an initial time of concentration of 3 minutes, a surface time of concentration, and a storm drain (pipe) time of concentration:

$$T_c(Surface) = 1.8\left(\frac{(1.1-C)L_{overland}^{0.5}}{S^{\frac{1}{3}}}\right)$$ *<Equation 3.1>*

$$T_c(Pipe) = \frac{L_{pipe}}{60V}$$ *<Equation 3.2>*

$$T_c(Total) = 3\ mins. + T_c(Surface) + T_c(Pipe)$$ *<Equation 3.3>*

Where,

Where,	T_c (Surface)	= Overland Flow Time of Concentration, minutes
	C	= Runoff Coefficient
	$L_{overland}$	= Overland Flow Length, feet
	S	= Slope of the Overland Flow Path, feet/feet
	T_c(Pipe)	= Storm Drain Time of Concentration, minutes
	L_{pipe}	= Pipe Length, feet
	V	= Flow Velocity, feet/second
	T_c(Total)	= Total Time of Concentration, minutes

In the SCS Unit Hydrograph Method, the Curve Number (CN) value reflects the underlying soil type, land use and its associated storm water infiltration attribute. The CN value, as shown in Table 3.1, is based on TR-55 from the Natural Resources Conservation Service. Land use data is based on the

City's GIS database. The weighted CN value for each sub-watershed was estimated based on the area per land use type, and the CN value per land use.

Table 3.1 – CN versus Land Use

	Land use														
	U, Unclassified	**P-D, Planned Development**	**R-1, Single Family Residential**	**M, Industrial**	**O, Open Space**	**C-N, Neighborhood Commercial**	**C-M, Community Commercial**	**C, General Commercial**	**R-3, Medium Density Residential**	**R-2, Low Density Residential**	**A-R, Administration & Research**	**C-B-D, Central Business District**	**C-O, Community Office**	**R-4, High Density Residential**	**C-B-D-M, Central Business District**
CN (C Soil)	98	94	78	91	74	94	94	94	86	81	94	94	94	90	94
CN (D Soil)	98	95	83	93	80	95	95	95	89	86	95	95	95	92	95

The total precipitation volume for the design storm is based on NOAA Atlas 14. Due to the range of terrains and elevations throughout the City, multiple total precipitation volumes were used in different parts of the City, to reflect its hydrologic characteristic influenced by topography. Cumulative hydrographs for various intensities for the 25-year storm is shown in Figure 3.1.

The hydrology analysis is performed in SewerGEMS. At each model node location, the runoff hydrograph, peak flow, and peak volume were estimated. Table 3.2 summarizes the total peak flow rate and the total volume contributed by a 25-year storm at each watershed. The 25-year storm is reported since it is the flood return frequency design criteria for the City's storm water collection system.

TABLE 3.2 – Hydrology Analysis Summary

Watershed	Peak 25-Year Storm Flow (cfs)	Peak Flow per Acre	Volume (ac-ft)	Volume per acre
A	1154.3	0.8	317	0.22
B	450.7	0.9	130	0.26
C	572.3	0.9	163	0.25
D	150.6	1.0	44	0.29
E	47	0.9	14	0.27
F	44.9	0.6	13	0.17

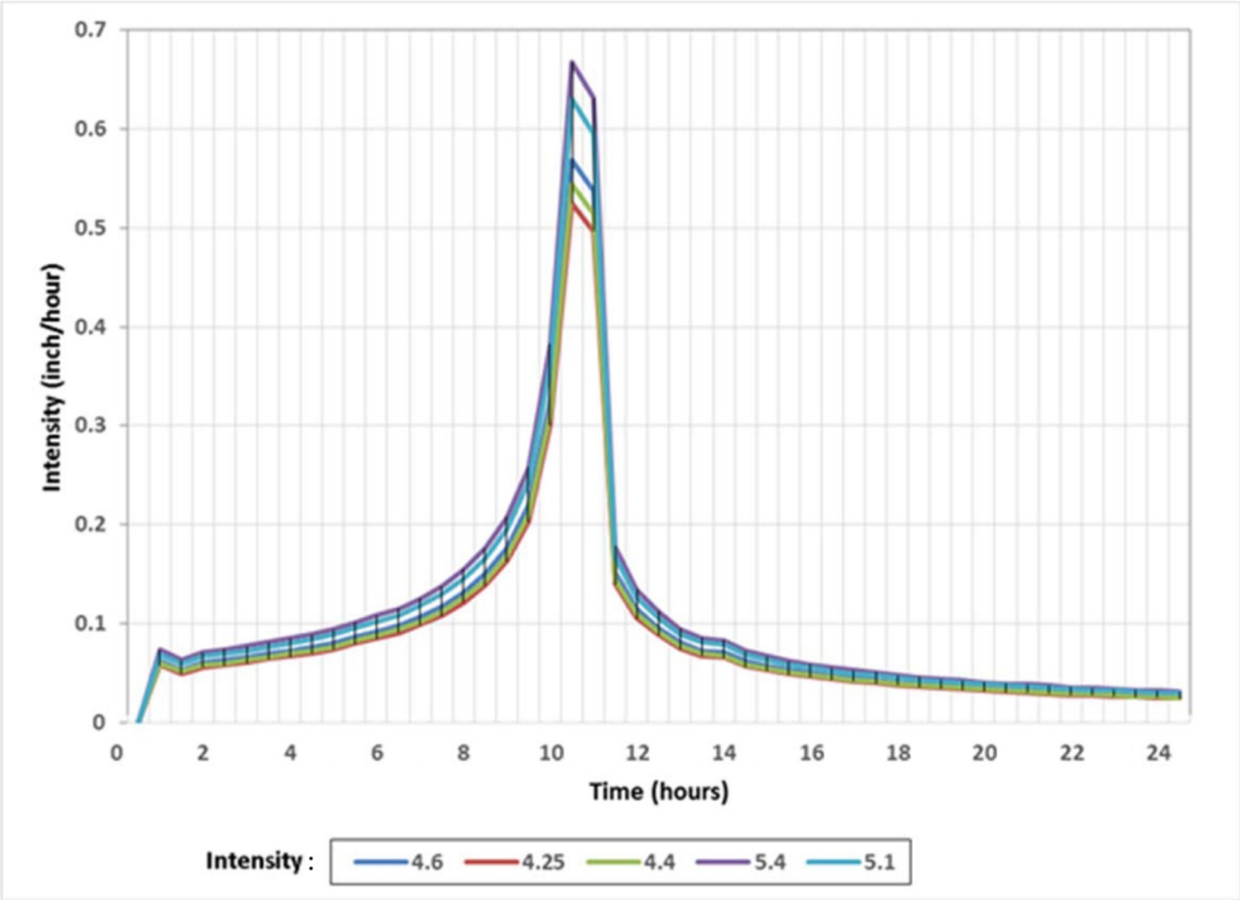


Figure 3-1 – 25-Year Storm Hyetographs

3.3 Hydraulic Analysis

The objective of the hydraulic analysis is to estimate the existing storm water collection system hydraulic capacity, identify potential problem areas, and assess hydraulic performance of the proposed improvement options. The analysis is based on the 25-year design storm, consistent with the City's design criteria for the storm water collection system.

Based on the City's storm drain base map, and subsequent data collected from supplemental survey and field visits, a hydraulic model was developed for Watersheds A, B, C, E, and F. The model included the main trunks in each watershed that form the backbone of the system, (generally storm drains 24-inches or greater). Local storm drain collection pipelines are not included in this analysis. Appendix A, Figure 1A shows the portion of the storm water collection system that is included in the modeling analysis.

The hydraulic model analyzes the hydraulic condition through closed conduits and open channels using Manning's Equation. Specifically, to estimate the hydraulic grade line (HGL) during the surcharge condition, the hydraulic model uses Manning's Equation to estimate the friction slope (Sf) along the storm drain system. The Manning's Equation is represented as follows:

$$Q = \left(\frac{1.49}{n}\right) AR^{2/3}\sqrt{S_f} \qquad \textit{<Equation 3.4>}$$

Where, Q = discharge, cubic feet-per-second

n = Manning roughness coefficient,

A = Cross-section Area of flow, square-feet

S_f = *Friction Slope, feet/feet*
R = Hydraulic Radius, foot
Where, R = A/P *<Equation 3.5>*
A = area of the flow, square-feet
P = Wetted Perimeter, foot

To analyze detention basins, the elevation-area curve method was selected for this analysis with the outlet control at the discharge location. The only detention site analyzed in detail is located at Crestmoor Canyon.

Watersheds A, B, and C discharge to San Bruno Channel and Cupid Row Canal by gravity. Tidal cycles from the San Francisco Bay influence the water surface elevation at both open channels. Therefore, the beginning water surfaces at the downstream boundary of San Bruno Channel are set based on the tide curve in Figure 3.2 shown in NGVD 1929 datum.

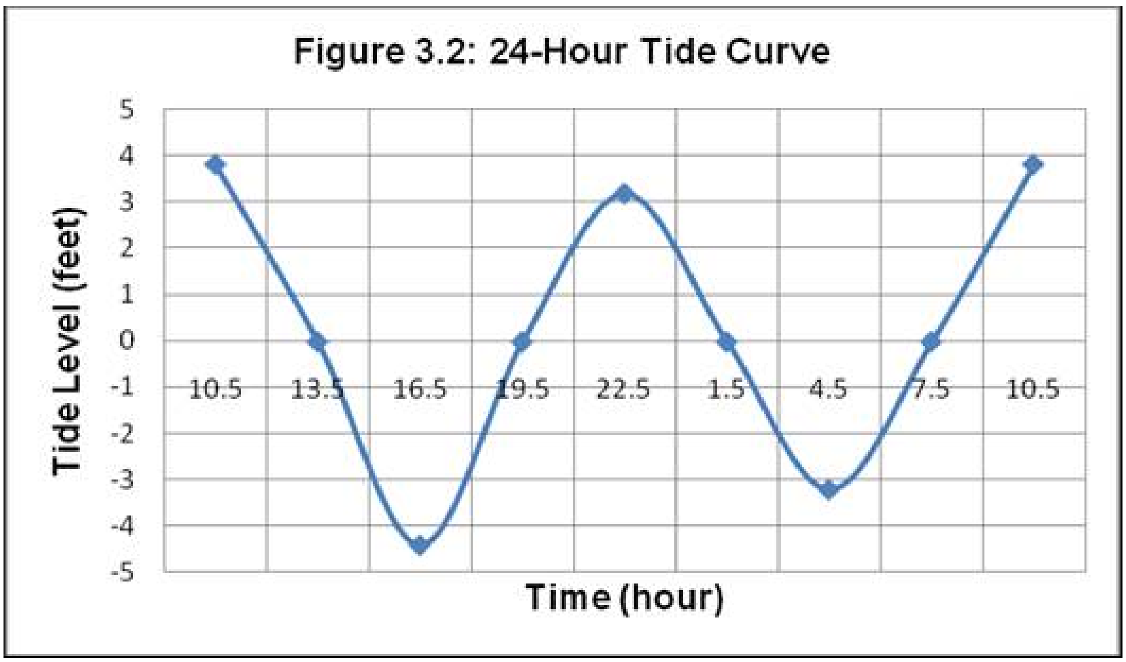


Figure 3-2 – 23 Hour Tide Curve

In the analysis, the tide curve data is input into the City's existing HEC-RAS open channel hydraulic model for San Bruno Channel. Quasi-steady state model runs were prepared to estimate the water surface elevation as a function of time at the outlet of Belle Air Box (Watersheds A/C) and the box culverts at Cupid Row (Watershed B). The estimated water surface elevation curves were set as the downstream boundary conditions of the Watersheds A, B, and C hydraulic model analysis. The peak 25-year storm event was routed to coincide with the HEC-RAS boundary condition occurring at MHHW.

Watersheds E and F discharge to Angus and Walnut Pump Stations. Since the pump stations disconnect Watersheds E and F from tidal influence, the beginning water surfaces at the downstream boundary of both systems are set as normal depth condition. Since the pump stations' capacities are slightly greater than the design storms, for the most part, during the peak of the storm the pumps will be continually running as opposed to cycling on and off so modeling the pumps will have little impact. If the pump settings appear to have an impact on flooding in the watershed, they can be set at a lower pump-on elevation to reduce this threat.

Due to overland flow dominated routing, no detailed hydraulic modeling analysis was performed on Watershed D. Evaluation of Watershed D is based on a combination of reviewing the previous storm water study for the area, field visits to the watershed to identify potential flooding problems, and desktop analysis to estimate any improvement needs.

3.4 Calibration

The SewerGEMS hydrology model was calibrated using the largest 24-hour storm event from the flow and rainfall monitoring data obtained from December 26, 2009 to January 27, 2010, which occurred on January 19, 2010. The cumulative rainfall total for the January 19, 2010 event was 2.25 inches within a 24-hour period. No flooding was observed during this storm event and is supported by the model output which also did not indicate any flooding occurring. It should be noted that the calibration storm only approximated a 2-year return frequency event and may not provide good calibration for the 25-year design storm event. However, this was the only calibration data available and provides a model that more accurately represents flooding conditions within the projected boundary.

In the calibration effort, the precipitation data from the January 19, 2010 storm was input to the SewerGEMs hydrology model. The model simulates the stormwater runoff generated from the storm, and routes the runoff along the City's storm water collection system. Based on the simulation, the model estimated the hydrographs at the locations where the flow gages were installed. The objective of the calibration analysis is to match the hydrograph between the model and the flow monitoring data, in terms of peak flow and cumulative volume.

The key variable adjusted during the calibration process was the CN values for each sub-watershed. This parameter was important in the calibration process because the timing of the peak flows was accurate, just the volume of runoff created by the storms needed to be altered.

Table 3.3 summarized the estimated peak flows and volume at the gage locations from the calibrated hydrology model, in comparison to the flow monitoring data.

The calibration analysis indicates that the peak flow estimated from the model match closely with flow monitoring data. The total volumes for Site 3 (Watershed A) and Site 4 (Watershed B) also match closely between model output and flow monitoring data. However, total volumes for Sites 1 and 2 (Watershed F and Watershed C) are significantly overestimated in the model. However it does not necessarily compromise the accuracy of the model as the peak flow is accurately estimated, which is critical for the capacity analysis. Also, a detention option is not considered in Watershed F and Watershed C, so the total volume estimate is not needed for the improvement analysis.

Table 3.3 – January 19, 2010 Flow and Volume

	Peak Flow (cfs)			Total Volume (ft^3)		
Location	Flow Monitoring	Model Output	% Difference	Flow Monitoring	Model Output	% Difference
Site 1	16.8	16.4	-2.1 %	116,932	222,165	90 %
Site 2	169.4	194.4	14.7 %	1,867,534	2,723,436	45.8 %
Site 3	276.2	267.1	-3.3 %	4,341,864	4,312,089	-0.7%
Site 4	160.2	149.9	-6.4%	2,429,739	2,158,848	-11.1%

Graphical comparisons between the calibrated model and flow monitoring data are shown in Figures 3.3 through 3.6.

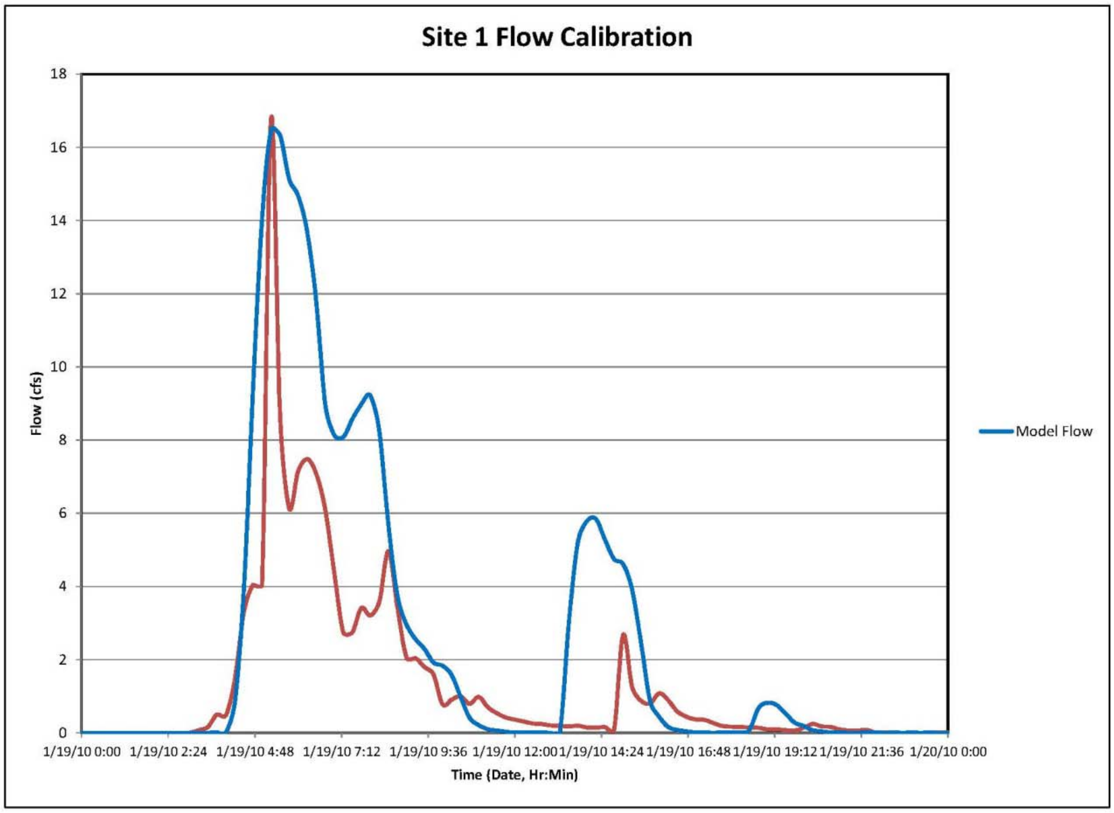


Figure 3.3 – Site 1 Calibrated Flow vs Model Flow Chart

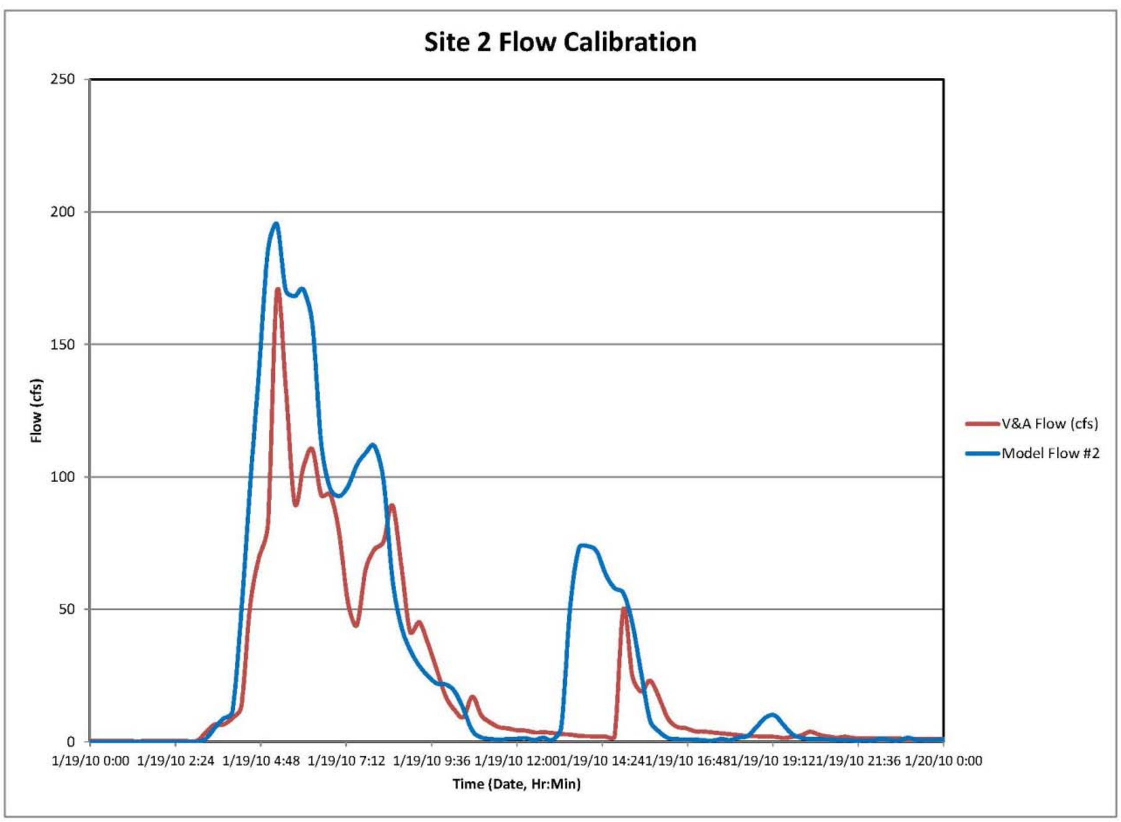


Figure 3.4 – Site 2 Calibrated Flow vs Model Flow Chart

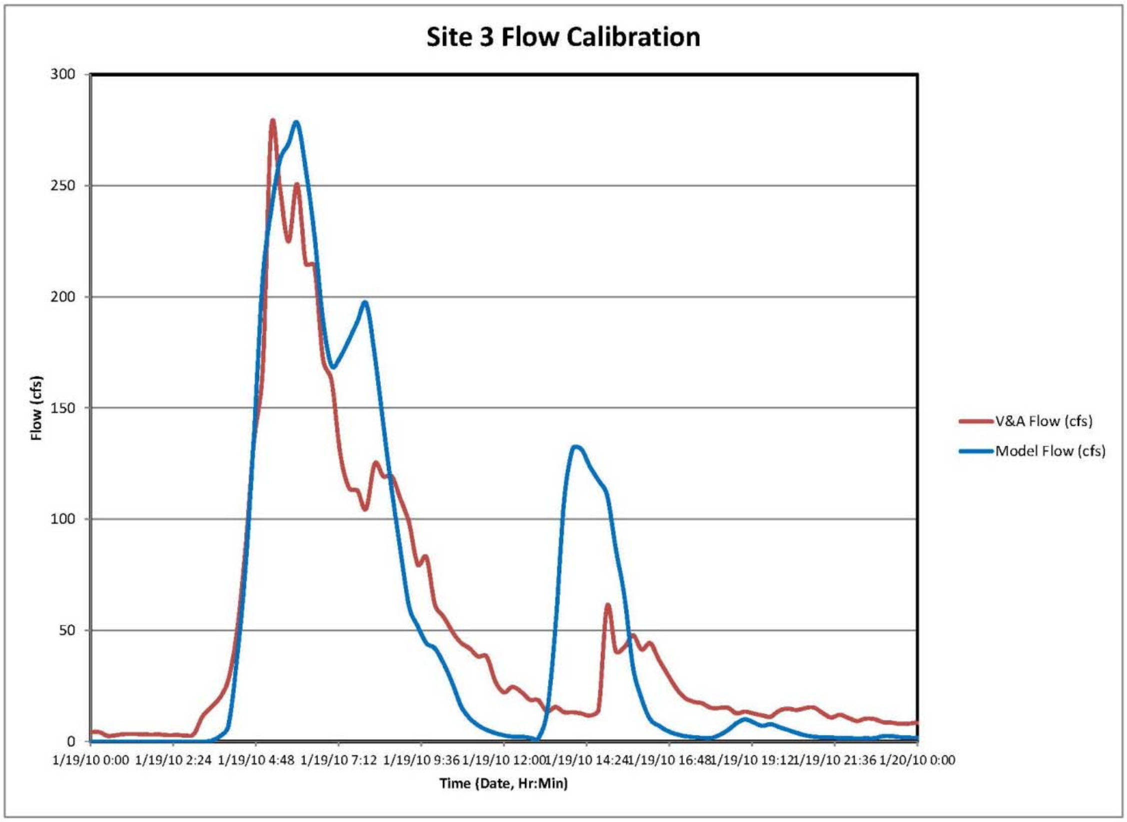


Figure 3.5 – Site 3 Calibrated Flow vs Model Flow Chart

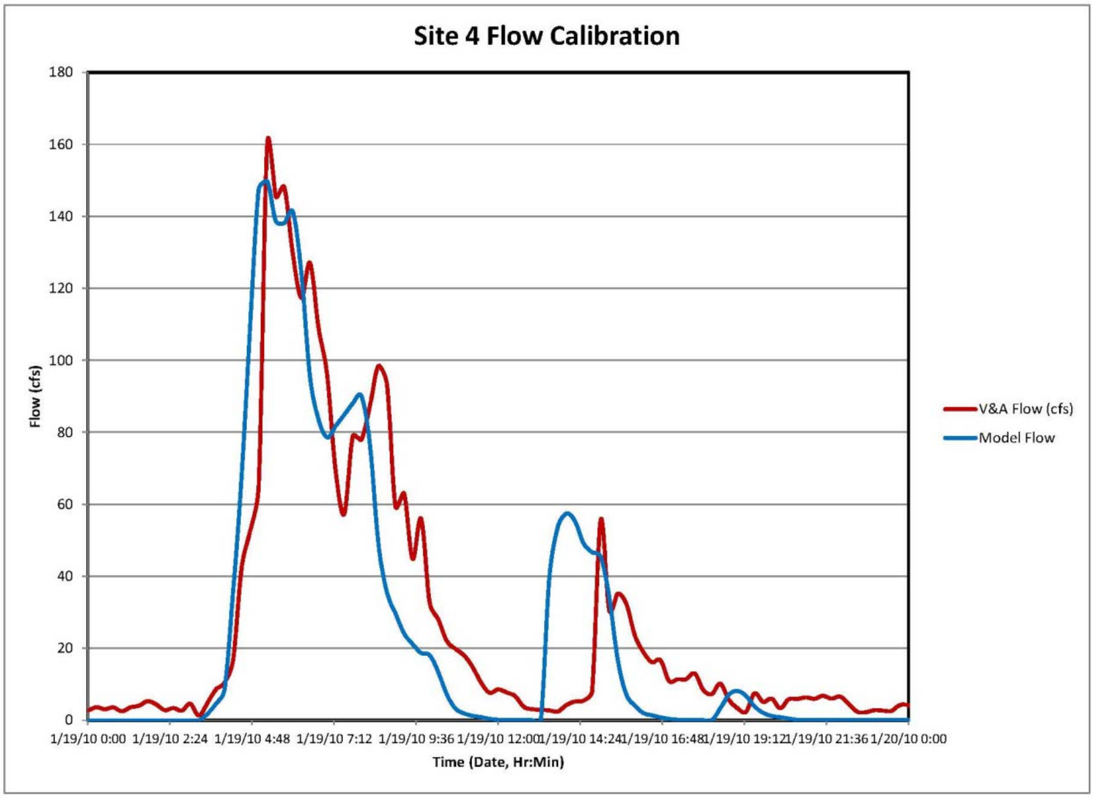


Figure 3.6 – Site 5 Calibrated Flow vs Model Flow Chart

3.5 Design Criteria Summary

Tables 3.4 and 3.5 summarize the hydrology and hydraulic analysis design criteria.

Table 3.4 – Hydrology Analysis Design Criteria Summary

Parameter	Criteria
Analysis Time Step	6 minutes
Storm Pattern	SCS Type 1
Storm Duration	24 hours
Rainfall Precipitation (in)	See Figure 3.1 (based on NOAA Atlas 14)
Hydrograph Method	SCS Unit Hydrograph
Hydrologic Soil Group Definition	C and D (based on NRCS Soil Survey)
Land Use	City of San Bruno GIS Database
Percentage of Impervious Area	City of San Bruno GIS Database
Curve Number (CN)	See Table 3.1 (based on NRCS TR-55)

Table 3.5 – Hydraulic Analysis Design Criteria Summary

Parameter	Criteria
Downstream Boundary Condition to San Bruno Channel or Cupid Row Canal	Tide Curve, See Figure 3.2
Downstream Boundary Condition to Walnut or Angus Pump Stations	Normal Depth
Max HGL Elevation (Pipe/Box)	No greater than the lowest point on a road (flow line)
Max HGL Elevation (Channel)	No greater than the channel's top of berm elevation
Velocity Range in CMP (Full Pipe Flow)	Min 3 ft/s – Max 15 ft/s
Velocity Range in RCP	Min 3 ft/s – No Max Limit
Minimum Slope	To generate min 3 ft/s velocity
Existing Material for Close Conduit	RCP, CMP, Concrete Box Culvert
Proposed Material for Close Conduit	RCP, Concrete Box Culvert
Existing Channel Material	Earth and Concrete-lined
Proposed Channel Material	Match (E) Condition or (N) Natural Channel if possible
Manning's Friction Coefficient (n):	
Reinforced Concrete Pipe (RCP)	0.013
Corrugated Metal Pipe (CMP)	0.024
Earthen Channel	0.045
Concrete Channel	0.013
Detention Basin Hydraulic	Area-Elevation Curve Method
Detention Outlet Control	Orifice Outlet
Orifice Coefficient	0.6

4. CIP DEVELOPMENT

4.1 Capacity Evaluation

The objective of this analysis is to evaluate the existing storm water collection system hydraulic capacity performance, and to estimate the existing flood control level of service.

The capacity evaluation shows that the storm water collection system has multiple capacity deficiencies based on a 25-year design storm. Table 4.1 summarizes the problem areas for the identified Watersheds based on the hydraulic model output. The problem areas are graphically shown in Appendix A, Figure 1A.

TABLE 4.1 – Capacity Deficiency Summary for Watersheds A, B, C, E, and F

	Watershed A	Capacity/Max Flow	Watershed B	Capacity/Max Flow	Watershed C	Capacity/Max Flow	Watershed D	Watershed E	Capacity/Max Flow	Watershed F	Capacity/Max Flow
Problem Area by Locations (Starting From Upstream System to Downstream System)	Earl Avenue at Crosby Court	25.9/301.3	Existing Channel at Crystal Spring Park	unknown/383.9	Madison Avenue	39.6/58.7	San Antonio Avenue	Seventh Avenue	35.0/50.9	San Bruno Avenue East	5.8/21.4
	Northeast of the intersection of Freeways 280 and 380	525.1/532.2	Cupid Avenue	235.9/519.8	Whitman Way	84.7/136.4					
	Cherry Avenue	375.4/689.9	Huntington Avenue	385.8/519.7	Jenevein Avenue	25.8/57.8					
	Commodore Drive	557.8/549.5			Cypress Avenue	15.4/34.5					
	Grundy Lane	336.8/539.7			Angus Avenue	N/A					
	Bayhill Drive	522.4/588.1			Casio's Parking Lot	N/A					
	El Camino Real	12.8/25.0			Huntington Avenue	528.1/843.8					
	Masson Avenue	0/369.4 (negative/0 slope)			Belle Air Boxes	387.3/1231.9					
	Mills Avenue	218.4/370.6									
	Huntington and San Mateo Avenue intersection	528.1/843.8									
	Belle Air Boxes	387.3/1231.9									

Problem areas are defined based on the model report where it indicates the HGL is above the manhole or catch basin rim elevations. Appendix A, Figure 1A shows these locations.

The model report also indicates that high velocities (>15 ft/s) are present in the existing storm drain system. In addition, the model report shows that a few existing pipes have insufficient capacity due to the flat slope (0% slope) or slightly reversed slope. The following table summarizes the existing storm drain system with high velocities, flat slope, or reversed slopes. While these segments do not automatically trigger the need for capital improvements, routine inspection is needed to monitor potential scouring and debris build-up.

Table 4.2 – Summary of High Pipe Velocity, Flat or Reversed Slope Locations

Pipe Channel ID	Dimensions	Material	Slope (ft/ft)	Velocity (ft/s)
		Watershed A		
378	72" Ø	Concrete	0.074	40.21
418	54" Ø	Concrete	0.156	39.77
507	54" Ø	Concrete	0.079	31.09
406	36" Ø	Concrete	0.138	27.05
396	56" Ø	Concrete	0.01	26.44
394	56" Ø	Concrete	0.076	26.39
514	10' W x 7' H	Concrete	0.027	26.28
380	72" Ø	Concrete	0.021	24.22
369	72" Ø	Concrete	0.055	23.84
566	72" Ø	Concrete	-0.008	22.97
408	20" Ø	Concrete	0.084	21.85
424	54" Ø	Concrete	0.028	21.26
363	72" Ø	Concrete	0.015	20.71
508	54" Ø	Concrete	0.004	20.02
367	72" Ø	Concrete	0.017	19.42
402	36" Ø	Concrete	0.053	19.32
365	72" Ø	Concrete	0.006	19.22
376	72" Ø	Concrete	0.015	18.84
733	66" Ø	Concrete	0	18.03
390	60" Ø	Concrete	0	16.22
404	36" Ø	Concrete	0.031	15.95
392	60" Ø	Concrete	0	15.38
341	10' W x 3' H	Concrete	0	13.11
134	10' W x 8' H	Concrete	0	9.52
		Watershed B		
299	6' W x 4' W	Concrete	0.034	21.2
305	6' W x 4' W	Concrete	0.023	21.15
577	30" Ø	CMP	0.007	17.87

Pipe Channel ID	Dimensions	Material	Slope (ft/ft)	Velocity (ft/s)
303	6' W x 4' W	Concrete	0.012	16.73
301	6' W x 4' W	Concrete	0.004	15.66
CH-15	V-Ditch: 8' Top Width x 1.5' Deep	Concrete Lined	0.022	32.16
CH-13	V-Ditch: 8' Top Width x 1.5' Deep	Concrete Lined	0.016	27.41
CH-14	V-Ditch: 8' Top Width x 1.5' Deep	Concrete Lined	0.011	23.33
Watershed C				
258	30" Ø	Concrete	0.113	29.95
560	60" Ø	Concrete	0.072	29.21
248	60" Ø	Concrete	0.042	26.25
166	30" Ø	Concrete	0.093	24.73
254	36" Ø	Concrete	0.047	23.93
168	30" Ø	Concrete	0.077	23.03
156	30" Ø	Concrete	0.093	22.86
260	30" Ø	Concrete	0.058	22.65
262	27" Ø	Concrete	0.048	22.54
194	10' W x 3' H	Concrete	0.026	20.83
555	10' W x 3' H	Concrete	0.021	19.23
256	36" Ø	Concrete	0.016	18.99
553	10' W x 3' H	Concrete	0.018	18.97
278	24" Ø	Concrete	0.031	18.43
246	60" Ø	Concrete	0.016	18.34
176	30" Ø	Concrete	0.037	17.78
202	10' W x 3' H	Concrete	0.005	15.84
158	30" Ø	Concrete	0.065	15.66
240	60" Ø	Concrete	0.008	15.21
200	10' W x 3' H	Concrete	-0.001	14.29
170	30" Ø	Concrete	-0.001	7.27

Refer to Appendix A, Figures 2 series for the pipe and channel ID locations.

Watershed D

No detailed hydrologic/hydraulic modeling analysis was performed on Watershed D. Review of previous analysis as well as field site visits indicate that there are four sub-watersheds, all bounded on the west by El Camino Real draining eastward to San Antonio Avenue. The four sub-watersheds drain to low points in the San Antonio grade routing to independent discharges onto undeveloped property between San Antonio and the Caltrain right-of-way.

Previous studies indicate the following summary for the four sub-watersheds from north to south:

- San Felipe outfall is the northern most watershed that drains approximately 10.5 acres to dual 24-inch CMPs. The estimated 25-year flows are 12 cfs.
- The San Marco outfall is the second largest of the sub-watersheds and drains approximately 63 acres to dual 36-inch HDPE culverts and dual 42-inch CMP culverts near San Marco Avenue. The estimated 25-year flows are 150 cfs.
- The Santa Clara outfall is the largest sub-watershed and drains approximately 63.7 acres to dual 36-inch HDPE culverts and a single 24-inch CMP culvert near Santa Clara Avenue. The estimated 25-year flows are 66 cfs.
- The Santa Helena-Lomita School outfall is the southern-most sub-watershed and drains approximately 10.7 acres to an unknown sized pipe. The estimated 25-year flows are 11 cfs.

As mentioned above, each sub-watershed drains to a low point on San Antonio Avenue, causing flooding of the street due to capacity limitations. Much of the problem is that the inlet capacities to the storm water collection system are inadequate to carry these flows.

Angus and Walnut Pump Stations

Angus and Walnut Pump Stations are the only discharge points for Watershed E and F. The analysis shows that the current pump station design capacity can match the 25-year design storm demand (Q25) for the watersheds:

- Angus Pump Station Firm Capacity = 56 – 72 cfs > Watershed E Q25 = 60.6 cfs
- Walnut Pump Station Firm Capacity = 56 cfs > Watershed F Q25 = 44.9 cfs

Note that the Watershed E Q25 included the overland flow from Huntington Ave crossing the railroad along Angus Ave.

In addition, concerning the pump station reliability, a worst case scenario analysis is prepared. In this analysis, the pump stations are assumed to be offline during the entire duration of a 25-year storm. Appendix A, Figure 3 shows the extent of the floodwater ponding in Watersheds E and F under this worst case scenario.

4.2 Improvement Alternatives

Six watersheds have been identified contributing runoff in the City of San Bruno. Refer to Appendix A, Figure 1A. The hydraulic model indicates that flooding occurs in all six watersheds during the 25-year design storm event. Two different options were considered in developing alternatives to address the flooding:

- Upsizing of storm drainage pipes
- Detention in the watersheds to reduce downstream peak flows

Appendix A, Figures 2A.1 through 2A.3 and 2B.1 through 2B.3 identify projects that address the 25-year flooding within the watersheds. The Figure 2A series identifies alternatives based on the upsizing of pipes options while the Figure 2B series identifies alternatives based on detention alternatives. It should be noted that some of the identified alternatives for the two options are identical where detention options had no impact on these alternatives. If a pipe system was undersized, the alternative is to replace that pipe with a larger pipe and parallel systems are generally not considered. This is a somewhat conservative approach but at a master plan level only the typical size pipe is considered to convey the design storm. During the design phase for any improvements, a more detailed analysis of alternatives should be considered in developing a cost effective design.

Watershed A

Significant backwater occurs in the lower reaches of Watershed A, in part due to backwater in the San Bruno Channel which is tidally influenced. This backwater, when combined with peak storm discharge, causes significant flooding that can only be partially addressed by upsizing of the storm drain pipe network. Five pipe upgrade projects (identified as A-projects) are identified in Watershed A to reduce flooding. The most significant project is Project A-1 which requires upsizing of the Belle Air storm drain by adding a third 9' x 5' Reinforced Concrete Box (RCB). This project is required both for the pipe option and detention option. The remaining four projects are required due to localized sections of pipe being undersized for the 25-year design flow. A potential minor flooding issue may occur on Earl Avenue where manholes 35, 36 and 37 could potentially surcharge. These manholes could be bolted shut to reduce the threat of overtopping. It is assumed that this work could be completed by City maintenance staff and is not included as a project.

In addition to the proposed projects, the lower reaches of the storm drain system at the vicinity of San Mateo Avenue and Huntington Avenue need to be pressurized during the 25-year storm. This requires bolted manholes (water-proofing) in certain locations as indicated on Appendix A, Figures 2A.2 and 2B.2. The bolted manholes separate the local drainage from the main trunk storm drain system. Therefore, bolting down manholes will require the construction of a local system described in more detail under Watershed C.

The detention option identifies three projects (identified as AD-projects) including Project AD-1 which is the Belle Air culvert upsizing project described above. Project AD-2 is a 64.5 acre-foot detention basin located in the Crestmoor Canyon area. This alternative deletes the need for pipe alternatives A-2, A-4 and A-5. However, project AD-3 (identical to project A-3) is still required.

Watershed B

Watershed B has a pipe and a detention option. The pipe option requires the following two projects:

- Realigning and widening of the open channel in the City Park, such that the channel does not flow along the parking spaces.
- Upsizing of the storm drain just upstream from its discharge to Cupid Row Channel near Huntington Avenue.

The detention option includes constructing a 25 acre-foot detention basin in the upper watershed near the City Park, as well as a realignment of the channel in the park, away from the parking spaces.

Watershed C

Watershed C alternatives are the same for either the pipe or the detention option, as no viable detention sites have been identified in Watershed C. Watershed C ties into Watershed A at the Belle Air Box and is impacted by the Watershed A backwater. Four projects have been identified to address flooding in Watershed C. Projects C-2 to C-4 addressing upstream storm water pipeline capacity deficiencies. Project C-1 is to address flooding at Huntington Ave area. The flooding at Huntington Avenue area is caused by the backwater effects in the main trunk storm drain system leading to Belle Air Box. To alleviate storm water backflow into the street, this project will bolt the manholes in the lower drainage system and install catch basin backflow preventers at the vicinity of San Mateo, Huntington, Angus and Kains Avenues. The improvements hydraulically separate the local drainage from the pressurized main trunk storm drain system. With this improvement, during the peak of a storm, local runoff cannot drain to the main trunk. As a result, a new localized storm water conveyance system is needed to collect and route storm water runoff at the Huntington Avenue area. The estimated local 25-year runoff is 108 cfs.

A number of potential improvement alternatives were considered. One alternative could be a local drainage collection system with a storm water pump station pumping into the pressurized Belle Air Box. The required pump station is relatively large as compared to the proposed sump pump station at the adjacent Grade Separation Project (GSP). Therefore, instead of routing the flow to the GSP sump pump station, a new separated pump station is needed. It is anticipated that the entire pump station will be underground, except for a small building housing the pump controls and electrical equipment. The two identified locations for this facility are:

- The private parking lot at the intersection of Angus Avenue and Huntington Avenue
- The City parking lot at the intersection of Angus Avenue and Easton Avenue

Use of the private parking lot site provides the opportunity for a more streamlined system design, but the site would require negotiations with the property owner. On the other hand, while the City parking lot site does not have the easement issue, it required construction of an additional pipeline to route the flow to the pump station and then discharge to Belle Air Box. Due to potential right-of-way issues, the City parking lot site was selected as the preferred pump station alternative. The preliminary analysis for the project cost is approximately $5.1 million.

Based on discussions with City staff, the pump station alternative is not economically feasible to prevent what is considered localized flooding. Another improvement option to reduce the localized flooding was explored. This option proposes a new gravity storm drain along Huntington Avenue to divert storm water runoff to Cupids Row, discharging directly to the Cupid Row Canal (Crystal Spring Channel). The estimated street overland flow capacity (curb to curb) on Huntington Ave is approximately 12 cfs. Therefore 96 cfs out of 108 cfs total runoff needs to be routed by a new storm drain. A system consisting of a 5-foot by 4-foot RCB routed from Cupid Row Canal north on Huntington Avenue to the intersection with Angus Avenue, with a 48-inch reinforced concrete pipe (RCP) extending upstream to the low point on Huntington Avenue, 450 feet north of the Angus Ave intersection was modeled . Due to the downstream tail water elevation, the pipe slope restriction, and the existing topography, this option will not eliminate flooding at the local point on Huntington Avenue. The resultant localized ponding is shown in Appendix A, Figure 4. Due to the potential utility conflicts along the proposed new pipe alignment on Huntington Ave, and preliminary estimates of cost at $3.9 million, this option is also considered as unfeasible to pursue.

If there is no local flood protection project, previous analysis indicates that the low point on Huntington Ave (450 feet north of the Angus Ave intersection) will receive approximately 33 acre-feet of runoff, at 22 cfs peak flow. The low point has only 1.5 acre feet of available storage before storm water would overtop at the high point of elevation 16.8’ at Angus Ave. Based on the proposed Grade Separation Project (GSP) design surface grade, the 22 cfs overflow would route east along Angus Avenue to the Angus Pump Station. Since Angus Avenue at the east of Huntington Ave has street capacity of approximately 49 cfs, the 22 cfs overflow from Huntington Ave will not cause flooding along Angus Ave, but there may be minor flooding at Seventh Ave if the storm water collection system to the pump station is not adequately sized. The pump station itself has a maximum capacity of approximately 72 cfs. The watershed peak flow is estimated at 61 cfs. With an additional 22 cfs added to the system a maximum peak flow arriving at the pump station, if additive, is estimated at 82 cfs. However the timing of the peak for the local Angus Pump Station watershed should peak significantly earlier than the peak overtopping flows from Huntington.

With 22 cfs flow to Angus Ave, the remaining 86 cfs flow (108 cfs – 22 cfs) would flow along Huntington Avenue towards Cupid Row. Since Huntington Ave only has street capacity of approximately 12 cfs, without a new storm drain on Huntington Ave to carry excess flows, around one foot of flooding could occur along Huntington Ave. Additional catch basins and/or an overflow system would be needed at Cupid Row intersection to route the street surface flow directly into Cupid Row Canal (Crystal Spring Channel).

The recommended project is to bolt down the manholes as described above and install additional catch basins at the Cupid Row intersection. This alternative will mitigate the flooding on Huntington as indicated in Appendix A, Figure 4. The flows diverted down Angus Avenue to the pump station will be addressed by recommended improvements in Watershed E described below.

Watershed D

Watershed D is a stand-alone watershed that was not modeled. Localized flooding along San Antonio Avenue at low points in the street occurs due to sheet flow down the various tie-in streets from San Felipe Avenue south to Santa Maria Avenue. Additional catch basins at the low points are recommended to allow street runoff to more quickly migrate to the roadside ditch at the open space along the east side of San Antonio Avenue. Refer to Appendix A, Figure 5. The approximate maximum capacity of two catch basins in series is approximately 14 cfs at a curb depth of 0.6 feet. Thus dual catch basins should provide adequate capacity for San Felipe and Santa Helena. The two larger sheds will be difficult to capture full flow without curb depths of close to 1 foot which would actually overtop curbs. Two catch basins staged side by side have a maximum capacity of approximately 30 cfs at a gutter depth of 0.9 feet. With an added 14 foot long curb opening, the overall capacity would be approximately 60 cfs.

Watershed E

Watershed E is a small local watershed located on the east side of the Caltrain right-of-way that drains to the Angus Pump Station. A project is recommended to upsize an existing storm drain on Seventh Avenue and along Angus Ave. The pipeline improvement on Angus Ave is sized not only to capture the local runoff from Watershed E, but also the overflow across the Caltrain rail track from Huntington Ave.

In addition, to alleviate periodic local ponding observed at the intersection of Seventh Avenue and Angus Avenue, local storm drain inlets improvements are recommended as shown on Appendix A, Figure 6.

Watershed F

Watershed F is a small local watershed located on the east side of the Caltrain right-of-way that drains to the Walnut Pump Station. A project is recommended to upsize an existing storm drain on San Bruno Avenue.

SMCFCD Facilities

In addition to the gravity systems, the City storm water collection system also consists of two pump stations, Angus Pump Station and Walnut Pump Station, and the tide gate at the discharge point of the Colma Creek to the San Francisco Bay. These facilities were built as part of the San Bruno Channel Flood Control Project in the 1960s, by U.S. Army Corps of Engineers with local sponsorship from San Mateo County. Currently the SMCFCD owns and is responsible for the operation and maintenance of the pump stations and tide gate.

In a preliminary design report by Brown and Caldwell dated 2009, it was recommended that the two pump stations be rehabilitated to upgrade the existing mechanical, structural, electrical and instrumentation components. The estimated rehabilitation costs were approximately $1 million for the Walnut Pump Station and $1.5 million for the Angus Pump Station. In addition, the tide gate is old and in need of rehabilitation to restore functionality at an estimated cost of $250,000. The projects are identified on Appendix A, Figure 7.

4.3 Alternative Evaluation

Table 4.3 summarizes estimated costs for the identified alternatives (excluding the SMCFCD projects). Costs were developed based on review of previous Master Plan Study and Update and RS Means Building Construction Cost Data, 2011 and include a 30% contingency, 5% Pre-Design, 11% Design (contract documents), 4% Construction Management Administrative Support and 14% Construction Management Field Support. The costs were then escalated to March 2013 utilizing the ENR cost index (10,368.09). This increase from October 2011 to March 2013 is 1.66%. As described above, only Watersheds A and B have detention options different than pipe options.

A detention basin in Watershed A would be less costly and would delete the need for significant pipe projects that would have numerous adverse construction impacts to the public. For these reasons, the detention option would certainly be the preferred option, unless there are unknown environmental or other project limitations that may come to light.

Based on discussions with City staff, the Watershed B detention option would likely not be feasible in its present location and no other site has been identified for a detention basin site. Based on this finding as well as the higher associated costs for the detention option, the pipe option is the preferred option for Watershed B.

All other alternatives identified in the various watersheds as well as the SMCFCD projects have been developed as projects to address flooding within the City.

Table 4.3 – Estimate of Probable Project Cost (incl. Engineering & CM)

City of San Bruno - Improvements for Collection System		
Project ID	**Pipe Improvement Option**	**Detention Option**
A-1	$5,070,000	$5,070,000
A-2	$2,670,000	-
A-3	$820,000	$820,000
A-4	$2,720,000	-
A-5	$4,670,000	$2,790,000
B-1	$1,090,000	$1,890,000
B-2	$90,000	-
C-1	$150,000	$150,000
C-2	$2,240,000	$2,240,000
C-3	$1,410,000	$1,410,000
C-4	$1,380,000	$1,380,000
D	$220,000	$220,000
E	$1,960,000	$1,960,000
F	$1,890,000	$1,890,000
Total	**$26,380,000**	**$19,820,000**

5. RECOMMENDED CIP

5.1 Recommended CIP

Recommended alternatives have been identified in Section 4.3. This section sets forth a CIP that prioritizes the identified alternatives. Generally it makes sense to complete downstream improvements prior to upstream improvements. This helps ensure that any increased flows from upstream improvements can be accommodated by the downstream system. The exception is the construction of detention anywhere in the watershed, which can be accomplished independent of other improvements.

In discussions with City Staff, it is clear that flooding in Watersheds E and F in the vicinity of the Angus Pump Station and Walnut Pump Station is a priority, and the project costs are comparatively inexpensive when compared with the most of the other identified priorities. These projects should rank high on the priority list as it is likely something that can be completed in the near future.

Watersheds A and C make up the largest portion of the City and comprise the majority of identified projects. The Belle Air Box Improvement Project (Project A-1/AD-1) is an obvious high priority project as the backwater caused by the undersized system impacts much of the lower City watersheds. As mentioned above, the detention in watershed A (Project AD-2) would benefit both watersheds A and C and should be done as soon as funds are available.

The remaining projects in Watersheds A, B, C, D and F have less overall flooding impacts to the community and would be considered as lower priority projects. Improvements to the pump stations, while important are really not in the City jurisdiction and will require coordination with the County.

Tables 5.1 and 5.2 set forth a proposed CIP priority table for addressing flooding within the City. The proposed CIP are organized for the collection system components (Table 5.1) and SMCFCD components (Table 5.2). In each component, there are two tier groups. The first priority tier group contains the projects recommended to the City for implementation as soon as feasible. This first tier includes a project for Long Term Trash Control Operation and Maintenance. The second priority tier group contains the remaining projects that are needed to address the City's flood issues based on 25-year design storm. However, these projects maybe deferred to the future when City funding and resources become available.

Table 5.1 – City of San Bruno - Improvements for Collection System

Priority	Project ID	Estimated Cost	Description & Location	Constructed	Problem	Improvements
1.1	**AD-1**	$5,070,000	Belle Air Box : North Side of Pine Street	1900s	Existing RCBs are undersized.	Existing: (2) 5'x9' RCBs. Proposed: adding a third 5'x9' RCB.
1.2	**E**	$1,960,000	Pipeline Improvement: 7th and Angus Avenues adjacent to pump station	1960s	Existing pipes are undersized.	Existing: 30" and 24" diameter pipes Proposed: upsizing to 42" diameter pipes and 3'x3' RCB.

Priority	Project ID	Estimated Cost	Description & Location	Constructed	Problem	Improvements
1.3	**CD-1**	$150,000	Bolt Manholes & Install Catch Basin Backflow Preventers in the vicinity of San Mateo, Huntington, Angus and Kains Avenues	1900s	Flat area; existing ground elevations are low; existing pipe has very shallow cover.	Existing: Gravity main trunk collect local runoff Proposed: Pressurized main trunk at peak flow
1.4	**F**	$1,890,000	Pipeline Improvement: San Bruno Avenue East	1960s	Existing pipes are undersized.	Existing: 24" diameter pipes Proposed: upsizing to 30" and 36" pipes.
1.5	**AD-2**	$2,790,000	Detention Basin at Crestmoor Canyon	1970s	Existing pipes undersized, at the east of Crestmoor Canyon at intersection Fwy 280 and 380, Cherry Avenue, Commodore Drive, Grundy Lane, and Bayhill Drive	Existing: A small detention basin that collects a small localized sub-watershed. Proposed: A large scale detention basin to collect the upstream watersheds.
1.6	**Mainten-ance**	$1,000,000	Compliance with MRP- Long Term Trash Control Operation and Maintenance	On-going		
Total Cost of Priority 1 Projects: $12,860,000						
2.1	**CD-2**	$2,240,000	Pipeline Improvement: North of Jenevein Avenue & El Camino Real	1900s	Existing pipes are undersized.	Existing: 3'x10' RCB. Proposed: 4'x10' RCB.
2.2	**CD-3**	$1,410,000	Pipeline Improvement: Jenevein Avenue between Hazel & Cypress Avenues	1900s	Existing pipes are undersized.	Existing: 30" diameter pipes. Proposed: 42" diameter pipes.
2.3	**AD-3**	$820,000	Pipeline Improvement: El Camino Real at 380 undercrossing	1970s	Existing pipes are undersized.	Existing: 20" and 24" diameter pipes. Proposed: 30" diameter pipes.

Priority	Project ID	Estimated Cost	Description & Location	Constructed	Problem	Improvements
2.4	**CD-4**	$1,380,000	Pipeline Improvement: Whitman Way between Madison Avenue & Eastburn Court	1950s	Existing pipes are undersized.	Existing: 21" and 24" diameter pipes. Proposed: 36", 42" and 60" diameter pipes.
2.5	**B-1**	$1,090,000	Pipeline Improvement: Huntington Avenue at Cupid Row	1900s	Existing pipe has insufficient capacity due to flat slope.	Existing: Flat slope pipe at 0.002 ft/ft. Proposed: Increasing the slope to 0.0031 ft/ft
2.6	**B-2**	$90,000	Concrete Channel at City Park: South side of Crystal Spring Avenue	Park	Existing channel is undersized and running into parking lot.	Existing: 1.5'x8' wide channel. Proposed: 1.5'x9' wide channel.
2.7	**D**	$220,000	Catch Basins at San Antonio Ave	1900s	Existing street geometry has insufficient capacity for the overland flow.	Proposed: Add 10 catch basins with gallery
Total Cost of Priority 2 Projects: $7,250,000						
Total Cost of Priority 1 and 2 Projects: $20,110,000						

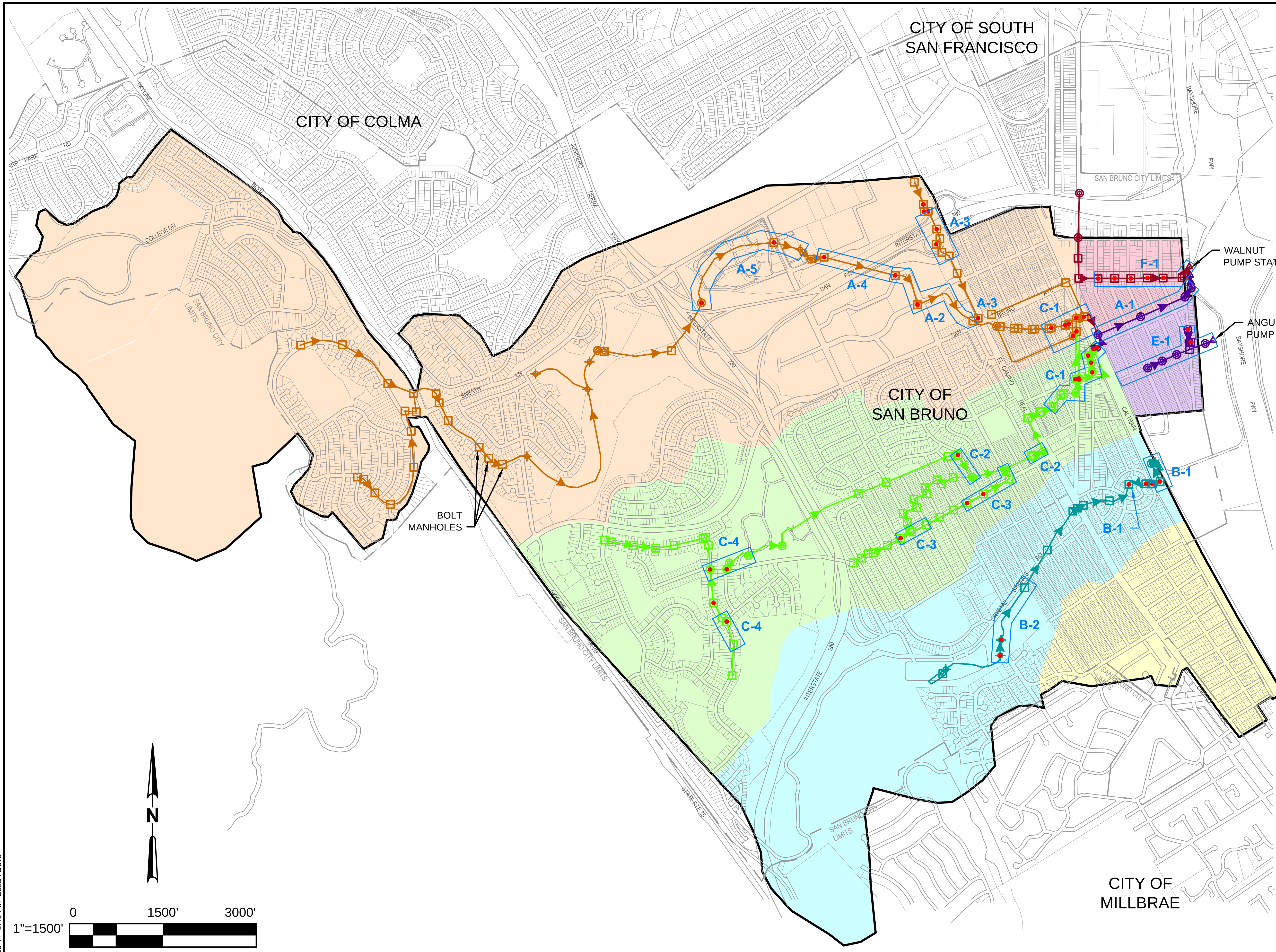
Table 5.2 shows the estimated rehabilitation costs for the pumps stations and the tide gate for a total of $2,750,000. It is anticipated that the SMCFCD will secure additional funding via special assessment or bond funding to finance these projects.

Table 5.2 – SMCFCD Pump Stations and Tide Gate Improvement Projects

Priority	Project ID	Improvements	Description
1	FC-1	$2,500,000	Rehabilitation of Walnut and Angus Pump Stations
2	FC-2	$250,000	Rehabilitation of San Bruno Creek Tide Gate
Total Cost of County Projects: $2,750,000			

Appendices

Appendix A – Figures



LEGEND:

- STORMWATER PROBLEM AREA
- PIPE & STRUCTURE WS A
- PIPE & STRUCTURE WS B
- PIPE & STRUCTURE WS C
- PIPE & STRUCTURE WS E
- PIPE & STRUCTURE WS F
- WATERSHED A
- WATERSHED B
- WATERSHED C
- WATERSHED D
- WATERSHED E
- WATERSHED F
- STUDY AREA

FIGURE ES-1
IDENTIFIED PROBLEM AREAS
BY WATERSHED

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG ES-01.dwg
4/28/14 3:46 PM Susan Dove

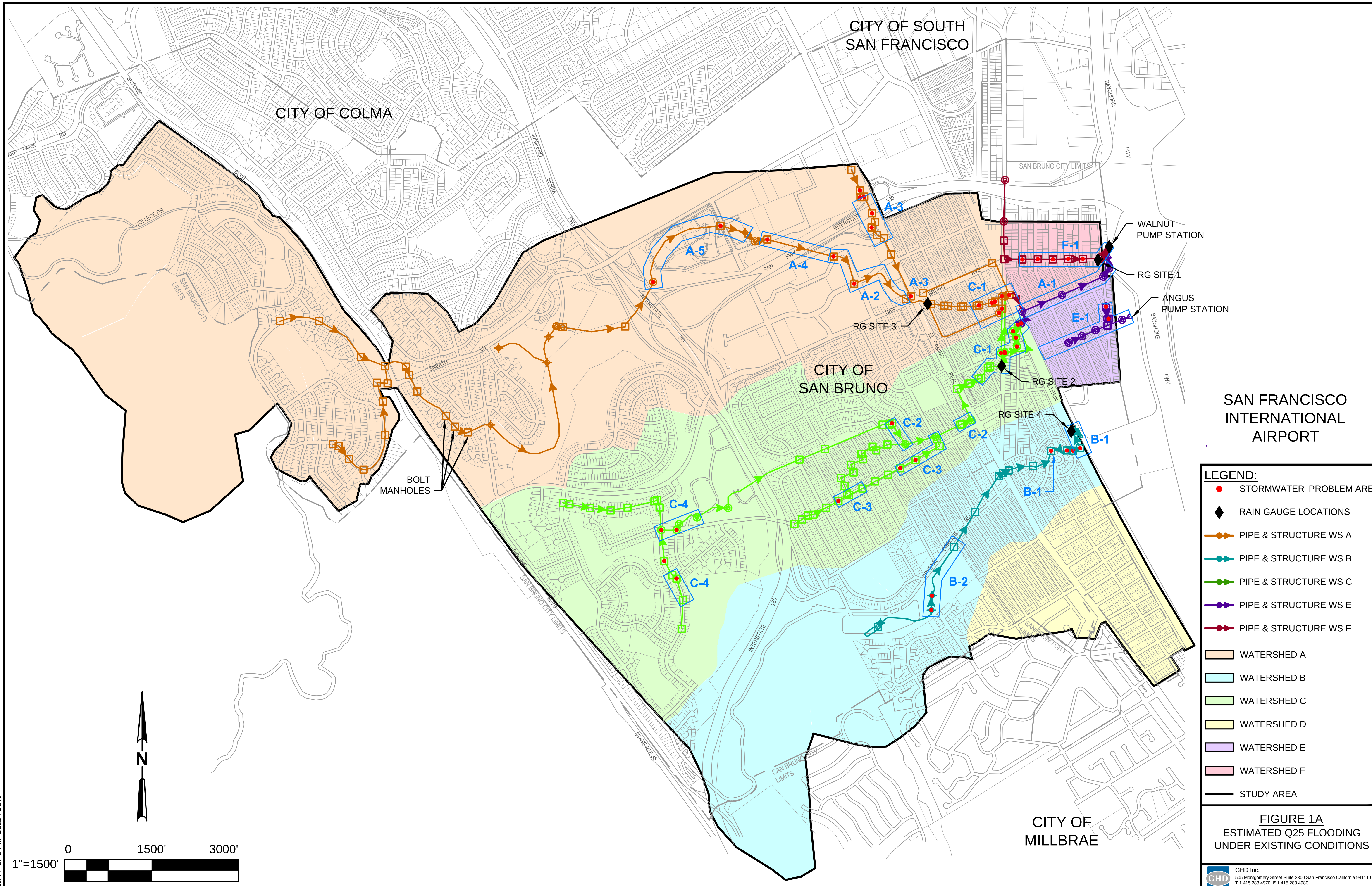
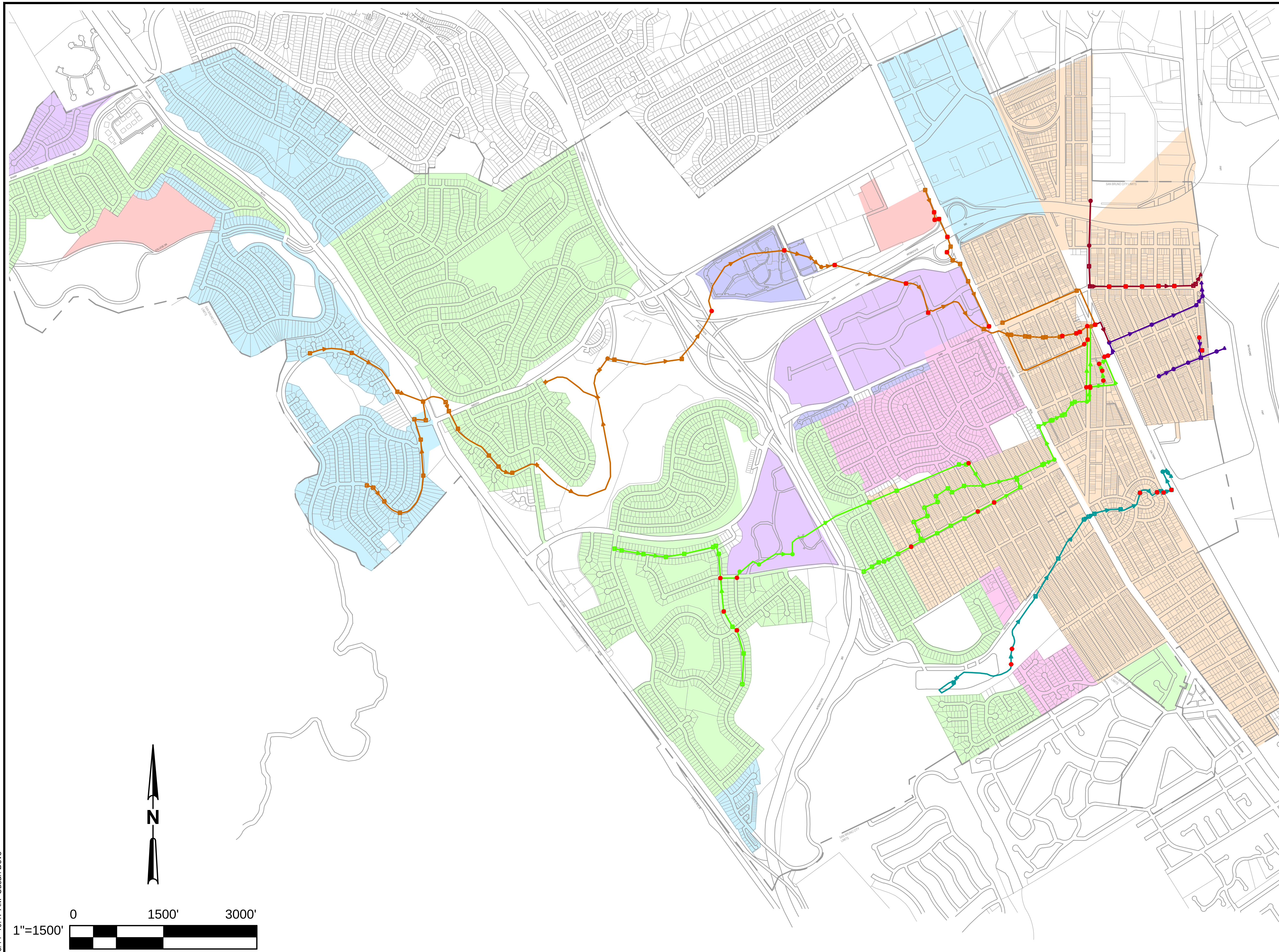


FIGURE 1A
ESTIMATED Q25 FLOODING UNDER EXISTING CONDITIONS

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 01A to 02B.dwg
4/28/14 3:45 PM Susan Dove



LEGEND:

- STORMWATER PROBLEM AREA
- PIPE & STRUCTURE WS A
- PIPE & STRUCTURE WS B
- PIPE & STRUCTURE WS C
- PIPE & STRUCTURE WS E
- PIPE & STRUCTURE WS F
- CONSTRUCTED PRIOR TO 1900's
- CONSTRUCTED PRIOR TO 1940's
- CONSTRUCTED PRIOR TO 1950's
- CONSTRUCTED PRIOR TO 1960's
- CONSTRUCTED PRIOR TO 1970's
- CONSTRUCTED PRIOR TO 1980's
- CONSTRUCTED PRIOR TO 2000's

FIGURE 1B
STORM DRAIN
PIPE/DEVELOPMENT AGE
AND EXISTING CONDITION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

OPTION A - PIPE OPTION

WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culvert	Proposed Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	linear feet
A	132	1664.8	2 Barrels	3	-	5	9	176
	363	986.5	72" Dia, 1 Barrel	2	72	-	-	1,137
	365	919.3	72" Dia, 1 Barrel	2	72	-	-	664
	367	903.9	72" Dia, 1 barrel	2	72	-	-	1,182
	376	752.5	72" Dia	1	84	-	-	1,786
	380	661.6	72" Dia	1	-	6	7	1,207
	435	52.0	18" Dia, 1 Barrel	2	30	-	-	93
	441	38.4	24" Dia	1	30	-	-	131
	443	38.4	24" Dia	1	30	-	-	159
	445	38.4	24" Dia	1	30	-	-	107
	447	38.4	20" Dia	1	30	-	-	164
	449	0.1	20" Dia	1	30	-	-	316
	526	1664.9	2 Barrels	3	-	5	9	742
	529	1664.8	2 Barrels	3	-	5	9	780
	566	869.4	72" Dia	1	84	-	-	438
B	285	462.0	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	62
	287	461.9	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	323
	CH-14	275.4	1.5'H x 8' W	-	-	1.5	9	249
	CH-15	328.9	1.5'H x 8' W	-	-	1.5	9	973
C	160	56.3	(1) 30" Dia	1	36	-	-	210
	162	62.1	(1) 30" Dia	1	36	-	-	257
	170	62.1	(1) 30" Dia	1	42	-	-	304
	172	62.3	(1) 30" Dia	1	42	-	-	475
	174	88.2	(1) 30" Dia	1	42	-	-	139
	176	88.2	(1) 30" Dia	1	42	-	-	34
	184	492.3	(1) 3' H x 10' W	1	-	4	10	30
	240	355.4	(1) 60" Dia	1	-	4	6	430
	254	222.8	(1) 36" Dia	1	66	-	-	107
	256	165.7	(1) 36" Dia	1	42	-	-	266
	278	78.5	(1) 24" Dia	1	36	-	-	92
	280	0.0	(1) 21" Dia	1	36	-	-	386
	482	222.8	(1) 60" Dia	1	66	-	-	386
	552	492.3	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166

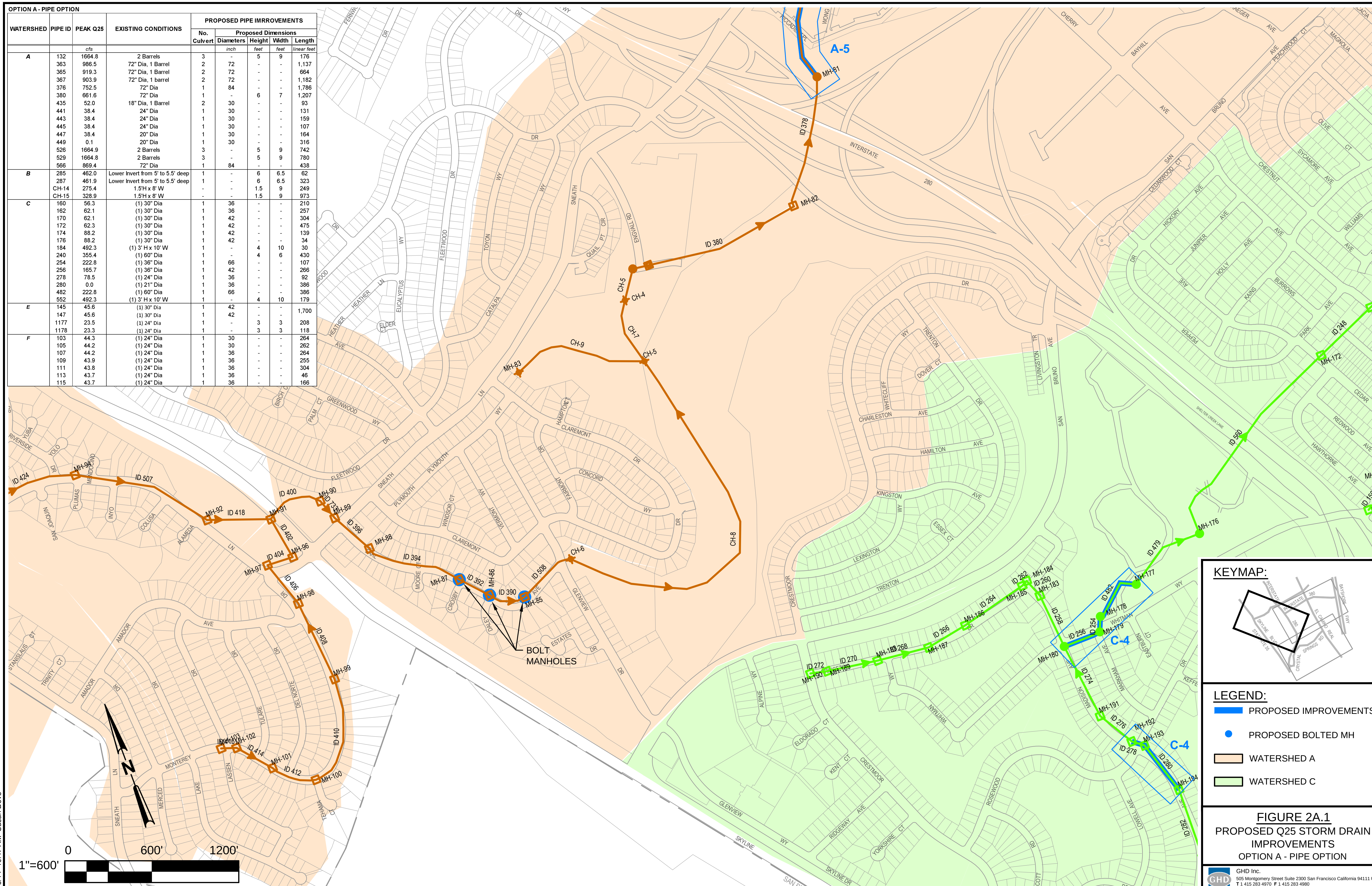


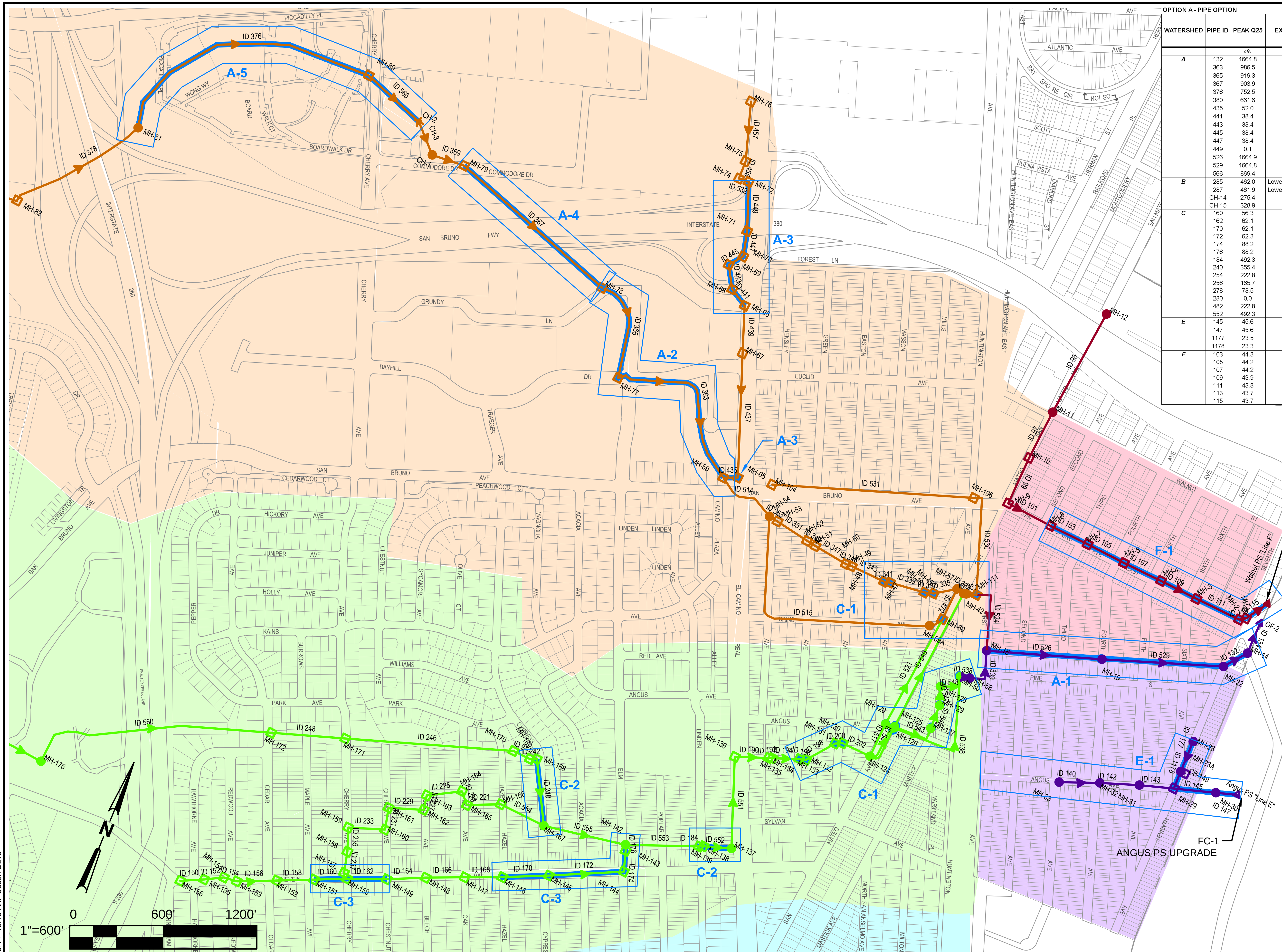
FIGURE 2A.1
PROPOSED Q25 STORM DRAIN IMPROVEMENTS
OPTION A - PIPE OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

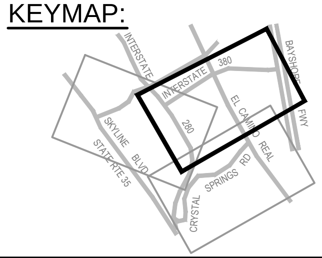
N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 01A to 02B.dwg
4/16/14 10:47 AM Susan Dove

OPTION A - PIPE OPTION

WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culvert	Proposed Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	linear feet
A	132	1664.8	2 Barrels	3	-	5	9	176
	363	986.5	72" Dia, 1 Barrel	2	72	-	-	1,137
	365	919.3	72" Dia, 1 Barrel	2	72	-	-	664
	367	903.9	72" Dia, 1 barrel	2	72	-	-	1,182
	376	752.5	72" Dia	1	84	-	-	1,786
	380	661.6	72" Dia	1	-	6	7	1,207
	435	52.0	18" Dia, 1 Barrel	2	30	-	-	93
	441	38.4	24" Dia	1	30	-	-	131
	443	38.4	24" Dia	1	30	-	-	159
	445	38.4	24" Dia	1	30	-	-	107
	447	38.4	20" Dia	1	30	-	-	164
	449	0.1	20" Dia	1	30	-	-	316
	526	1664.9	2 Barrels	3	-	5	9	742
	529	1664.8	2 Barrels	3	-	5	9	780
	566	869.4	72" Dia	1	84	-	-	438
B	285	462.0	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	62
	287	461.9	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	323
	CH-14	275.4	1.5'H x 8' W	-	-	1.5	9	249
	CH-15	328.9	1.5'H x 8' W	-	-	1.5	9	973
C	160	56.3	(1) 30" Dia	1	36	-	-	210
	162	62.1	(1) 30" Dia	1	36	-	-	257
	170	62.1	(1) 30" Dia	1	42	-	-	304
	172	62.3	(1) 30" Dia	1	42	-	-	475
	174	88.2	(1) 30" Dia	1	42	-	-	139
	176	88.2	(1) 30" Dia	1	42	-	-	34
	184	492.3	(1) 3' H x 10' W	1	-	4	10	30
	240	355.4	(1) 60" Dia	1	-	4	6	430
	254	222.8	(1) 36" Dia	1	66	-	-	107
	256	165.7	(1) 36" Dia	1	42	-	-	266
	278	78.5	(1) 24" Dia	1	36	-	-	92
	280	0.0	(1) 21" Dia	1	36	-	-	386
	482	222.8	(1) 60" Dia	1	66	-	-	386
	552	492.3	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166



KEYMAP:



LEGEND:

- PROPOSED IMPROVEMENTS
- PROPOSED BOLTED MH
- WATERSHED A
- WATERSHED C
- WATERSHED E
- WATERSHED F

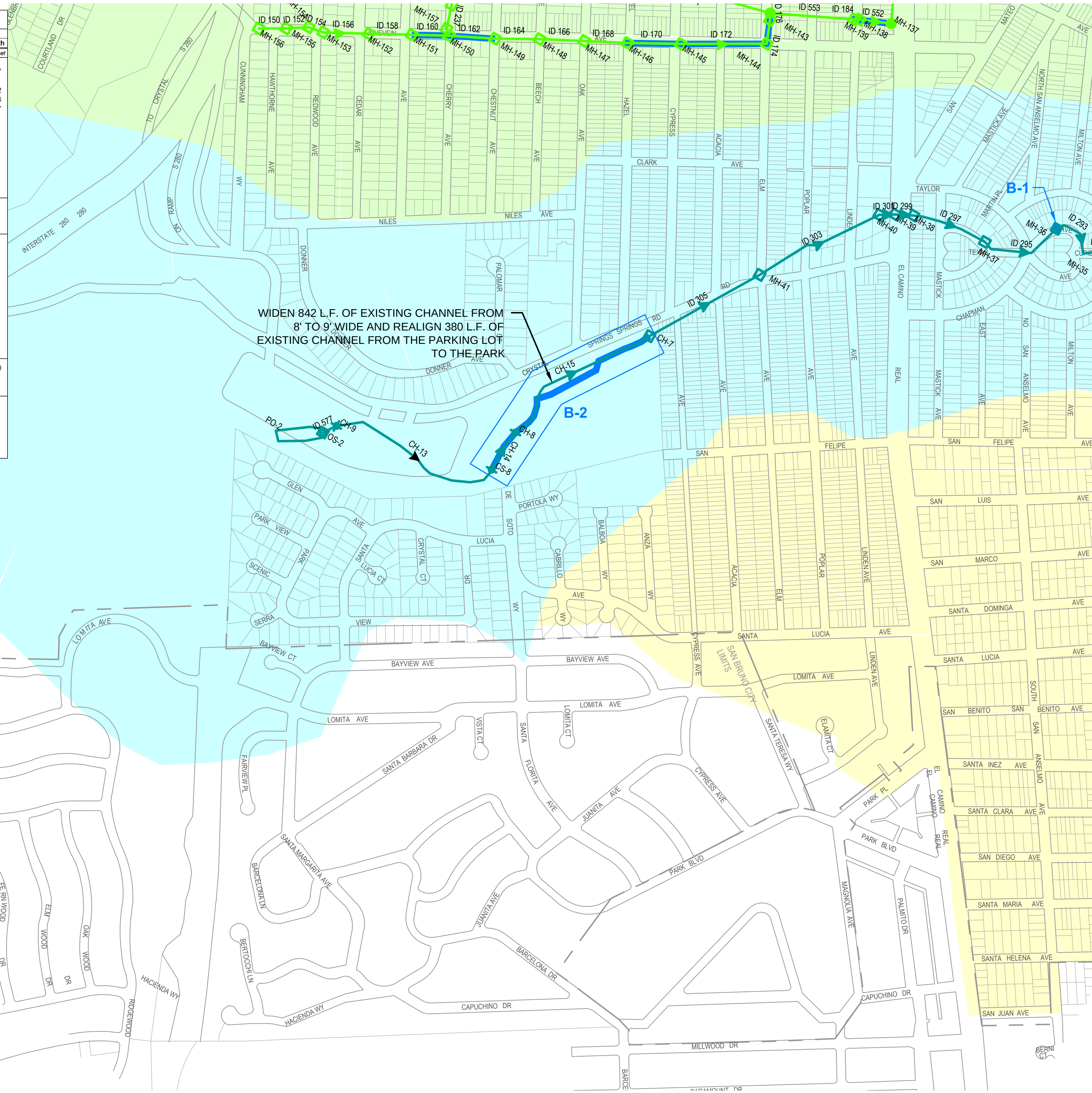
FIGURE 2A.2
PROPOSED Q25 STORM DRAIN IMPROVEMENTS
OPTION A - PIPE OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 01A to 02B.dwg
4/16/14 10:48 AM Susan Dove

OPTION A - PIPE OPTION

WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culvert	Proposed Dimensions: Diameters	Height	Width	Length
		cfs			inch	feet	feet	linear feet
A	132	1664.8	2 Barrels	3	-	5	9	176
	363	986.5	72" Dia, 1 Barrel	2	72	-	-	1,137
	365	919.3	72" Dia, 1 Barrel	2	72	-	-	664
	367	903.9	72" Dia, 1 barrel	2	72	-	-	1,182
	376	752.5	72" Dia	1	84	-	-	1,786
	380	661.6	72" Dia	1	-	6	7	1,207
	435	52.0	18" Dia, 1 Barrel	2	30	-	-	93
	441	38.4	24" Dia	1	30	-	-	131
	443	38.4	24" Dia	1	30	-	-	159
	445	38.4	24" Dia	1	30	-	-	107
	447	38.4	20" Dia	1	30	-	-	164
	449	0.1	20" Dia	1	30	-	-	316
	526	1664.9	2 Barrels	3	-	5	9	742
	529	1664.8	2 Barrels	3	-	5	9	780
	566	869.4	72" Dia	1	84	-	-	438
B	285	462.0	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	62
	287	461.9	Lower Invert from 5' to 5.5' deep	1	-	6	6.5	323
	CH-14	275.4	1.5'H x 8' W	-	-	1.5	9	249
	CH-15	328.9	1.5'H x 8' W	-	-	1.5	9	973
C	160	56.3	(1) 30" Dia	1	36	-	-	210
	162	62.1	(1) 30" Dia	1	36	-	-	257
	170	62.1	(1) 30" Dia	1	42	-	-	304
	172	62.3	(1) 30" Dia	1	42	-	-	475
	174	88.2	(1) 30" Dia	1	42	-	-	139
	176	88.2	(1) 30" Dia	1	42	-	-	34
	184	492.3	(1) 3' H x 10' W	1	-	4	10	30
	240	355.4	(1) 60" Dia	1	-	4	6	430
	254	222.8	(1) 36" Dia	1	66	-	-	107
	256	165.7	(1) 36" Dia	1	42	-	-	266
	278	78.5	(1) 24" Dia	1	36	-	-	92
	280	0.0	(1) 21" Dia	1	36	-	-	386
	482	222.8	(1) 60" Dia	1	66	-	-	386
	552	492.3	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166



KEYMAP:

LEGEND:

PROPOSED IMPROVEMENTS

PROPOSED BOLTED MH

WATERSHED B

WATERSHED D

FIGURE 2A.3

PROPOSED Q25 STORM DRAIN IMPROVEMENTS

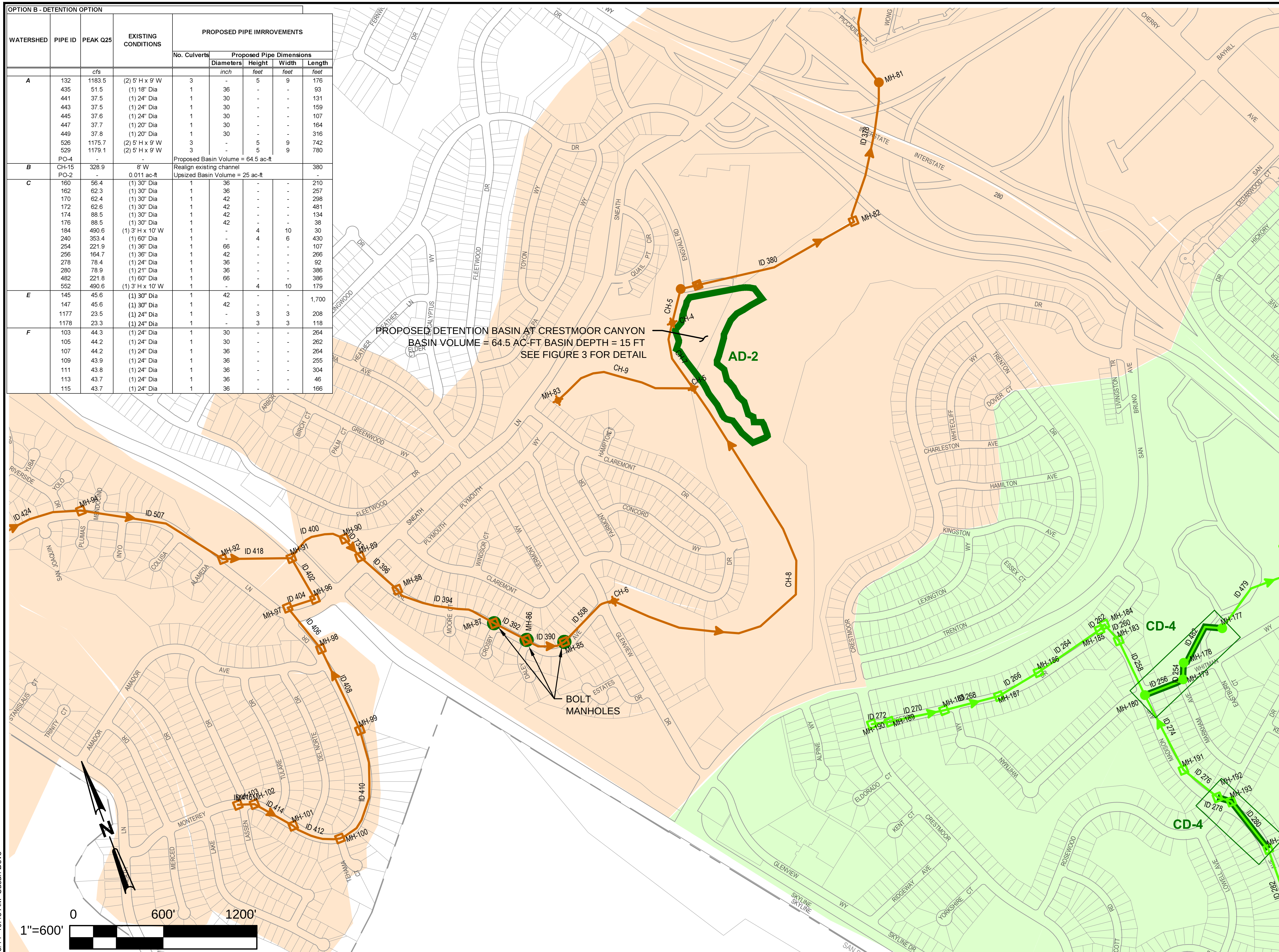
OPTION A - PIPE OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 01A to 02B.dwg
4/16/14 10:48 AM Susan Dove

OPTION B - DETENTION OPTION

WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culverts	Proposed Pipe Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	feet
A	132	1183.5	(2) 5' H x 9' W	3	-	5	9	176
	435	51.5	(1) 18" Dia	1	36	-	-	93
	441	37.5	(1) 24" Dia	1	30	-	-	131
	443	37.5	(1) 24" Dia	1	30	-	-	159
	445	37.6	(1) 24" Dia	1	30	-	-	107
	447	37.7	(1) 20" Dia	1	30	-	-	164
	449	37.8	(1) 20" Dia	1	30	-	-	316
	526	1175.7	(2) 5' H x 9' W	3	-	5	9	742
	529	1179.1	(2) 5' H x 9' W	3	-	5	9	780
	PO-4	-	-	Proposed Basin Volume = 64.5 ac-ft				
B	CH-15	328.9	8' W	Realign existing channel				380
	PO-2	-	0.011 ac-ft	Upsized Basin Volume = 25 ac-ft				-
C	160	56.4	(1) 30" Dia	1	36	-	-	210
	162	62.3	(1) 30" Dia	1	36	-	-	257
	170	62.4	(1) 30" Dia	1	42	-	-	298
	172	62.6	(1) 30" Dia	1	42	-	-	481
	174	88.5	(1) 30" Dia	1	42	-	-	134
	176	88.5	(1) 30" Dia	1	42	-	-	38
	184	490.6	(1) 3' H x 10' W	1	-	4	10	30
	240	353.4	(1) 60" Dia	1	-	4	6	430
	254	221.9	(1) 36" Dia	1	66	-	-	107
	256	164.7	(1) 36" Dia	1	42	-	-	266
	278	78.4	(1) 24" Dia	1	36	-	-	92
	280	78.9	(1) 21" Dia	1	36	-	-	386
	482	221.8	(1) 60" Dia	1	66	-	-	386
	552	490.6	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166



KEYMAP:

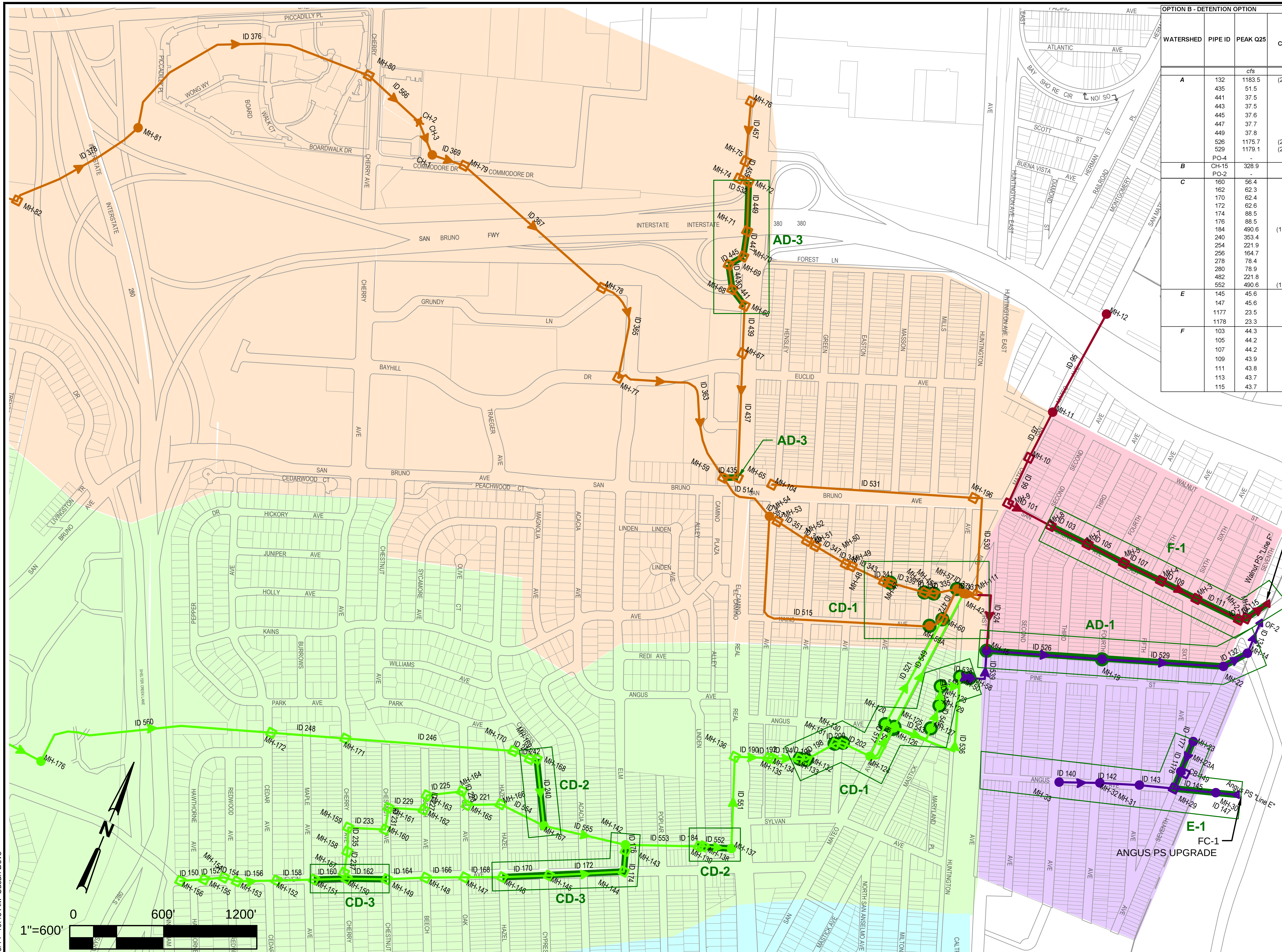
LEGEND:

- PROPOSED IMPROVEMENTS
- PROPOSED BOLTED MH
- WATERSHED A
- WATERSHED C

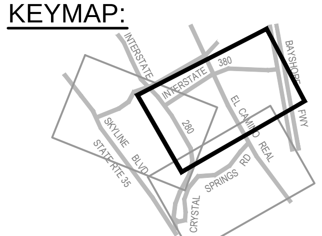
FIGURE 2B.1
PROPOSED Q25 STORM DRAIN IMPROVEMENTS
OPTION B - DETENTION OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

OPTION B - DETENTION OPTION								
WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culverts	Proposed Pipe Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	feet
A	132	1183.5	(2) 5' H x 9' W	3	-	5	9	176
	435	51.5	(1) 18" Dia	1	36	-	-	93
	441	37.5	(1) 24" Dia	1	30	-	-	131
	443	37.5	(1) 24" Dia	1	30	-	-	159
	445	37.6	(1) 24" Dia	1	30	-	-	107
	447	37.7	(1) 20" Dia	1	30	-	-	164
	449	37.8	(1) 20" Dia	1	30	-	-	316
	526	1175.7	(2) 5' H x 9' W	3	-	5	9	742
	529	1179.1	(2) 5' H x 9' W	3	-	5	9	780
	PO-4	-	-	Proposed Basin Volume = 64.5 ac-ft				
B	CH-15	328.9	8' W	Realign existing channel				380
	PO-2	-	0.011 ac-ft	Upsized Basin Volume = 25 ac-ft				-
C	160	56.4	(1) 30" Dia	1	36	-	-	210
	162	62.3	(1) 30" Dia	1	36	-	-	257
	170	62.4	(1) 30" Dia	1	42	-	-	298
	172	62.6	(1) 30" Dia	1	42	-	-	481
	174	88.5	(1) 30" Dia	1	42	-	-	134
	176	88.5	(1) 30" Dia	1	42	-	-	38
	184	490.6	(1) 3' H x 10' W	1	-	4	10	30
	240	353.4	(1) 60" Dia	1	-	4	6	430
	254	221.9	(1) 36" Dia	1	66	-	-	107
	256	164.7	(1) 36" Dia	1	42	-	-	266
	278	78.4	(1) 24" Dia	1	36	-	-	92
	280	78.9	(1) 21" Dia	1	36	-	-	386
	482	221.8	(1) 60" Dia	1	66	-	-	386
	552	490.6	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166



KEYMAP:



LEGEND:

- PROPOSED IMPROVEMENTS
- PROPOSED BOLTED MH
- WATERSHED A
- WATERSHED C
- WATERSHED E
- WATERSHED F

FIGURE 2B.2

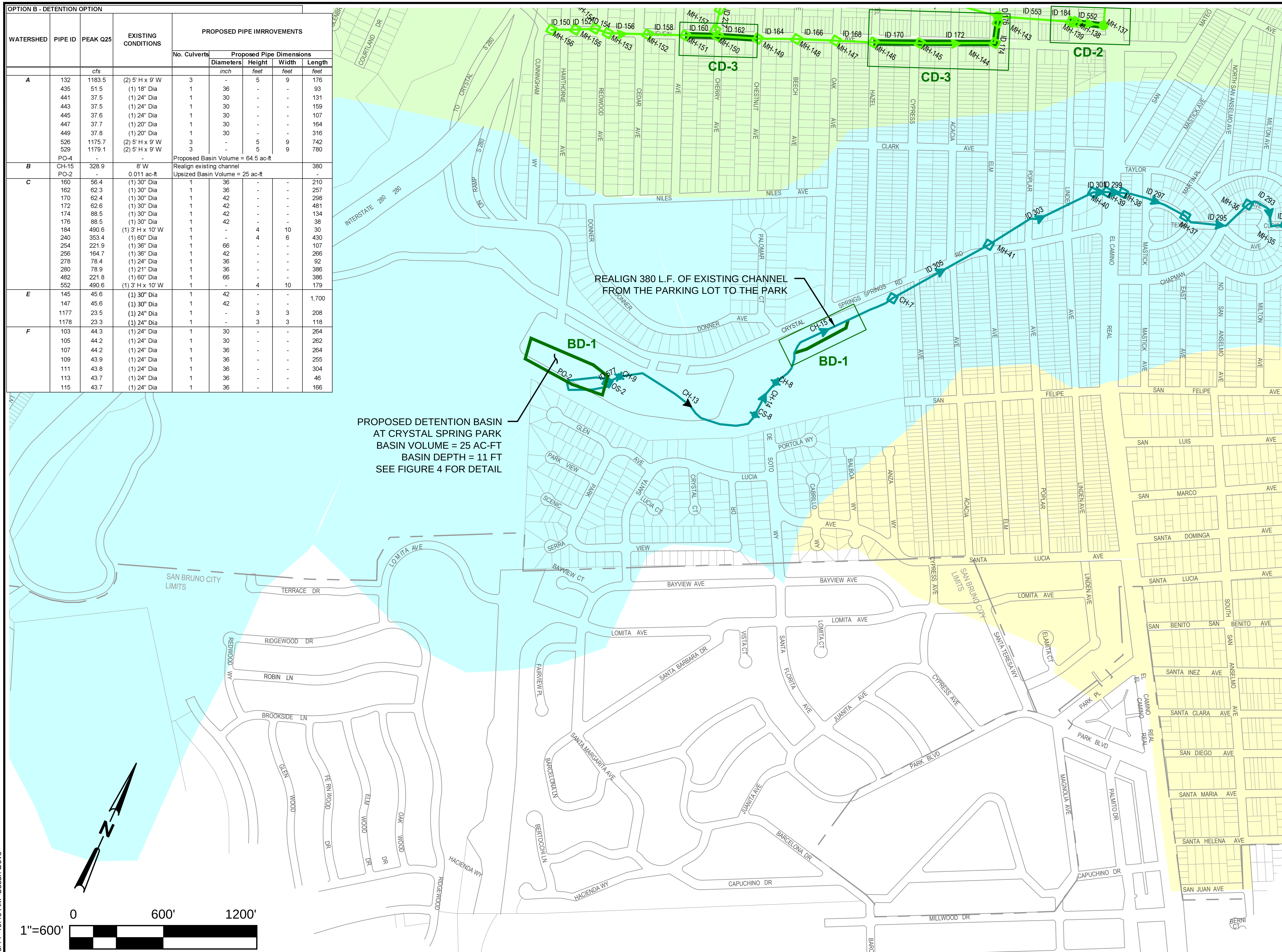
PROPOSED Q25 STORM DRAIN IMPROVEMENTS

OPTION B - DETENTION OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\02487080001 FIG 01A to 02B.dwg
4/16/14 10:48 AM Susan Dove

OPTION B - DETENTION OPTION								
WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culverts	Proposed Pipe Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	feet
A	132	1183.5	(2) 5' H x 9' W	3	-	5	9	176
	435	51.5	(1) 18" Dia	1	36	-	-	93
	441	37.5	(1) 24" Dia	1	30	-	-	131
	443	37.5	(1) 24" Dia	1	30	-	-	159
	445	37.6	(1) 24" Dia	1	30	-	-	107
	447	37.7	(1) 20" Dia	1	30	-	-	164
	449	37.8	(1) 20" Dia	1	30	-	-	316
	526	1175.7	(2) 5' H x 9' W	3	-	5	9	742
	529	1179.1	(2) 5' H x 9' W	3	-	5	9	780
	PO-4	-	-	Proposed Basin Volume = 64.5 ac-ft				
B	CH-15	328.9	8' W	Realign existing channel				380
	PO-2	-	0.011 ac-ft	Upsized Basin Volume = 25 ac-ft				-
C	160	56.4	(1) 30" Dia	1	36	-	-	210
	162	62.3	(1) 30" Dia	1	36	-	-	257
	170	62.4	(1) 30" Dia	1	42	-	-	298
	172	62.6	(1) 30" Dia	1	42	-	-	481
	174	88.5	(1) 30" Dia	1	42	-	-	134
	176	88.5	(1) 30" Dia	1	42	-	-	38
	184	490.6	(1) 3' H x 10' W	1	-	4	10	30
	240	353.4	(1) 60" Dia	1	-	4	6	430
	254	221.9	(1) 36" Dia	1	66	-	-	107
	256	164.7	(1) 36" Dia	1	42	-	-	266
	278	78.4	(1) 24" Dia	1	36	-	-	92
	280	78.9	(1) 21" Dia	1	36	-	-	386
	482	221.8	(1) 60" Dia	1	66	-	-	386
	552	490.6	(1) 3' H x 10' W	1	-	4	10	179
E	145	45.6	(1) 30" Dia	1	42	-	-	1,700
	147	45.6	(1) 30" Dia	1	42	-	-	
	1177	23.5	(1) 24" Dia	1	-	3	3	208
	1178	23.3	(1) 24" Dia	1	-	3	3	118
F	103	44.3	(1) 24" Dia	1	30	-	-	264
	105	44.2	(1) 24" Dia	1	30	-	-	262
	107	44.2	(1) 24" Dia	1	36	-	-	264
	109	43.9	(1) 24" Dia	1	36	-	-	255
	111	43.8	(1) 24" Dia	1	36	-	-	304
	113	43.7	(1) 24" Dia	1	36	-	-	46
	115	43.7	(1) 24" Dia	1	36	-	-	166



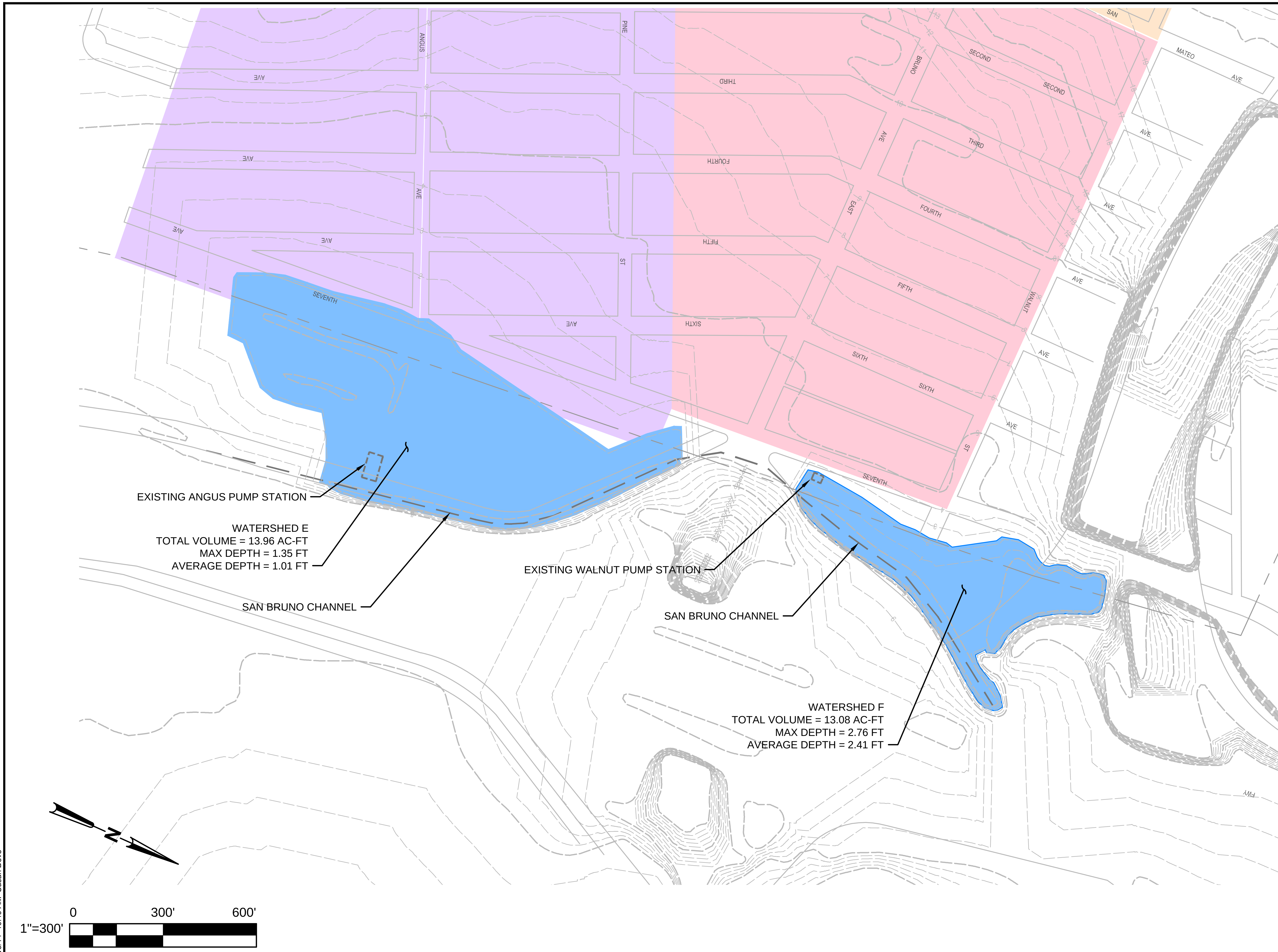
KEYMAP:

LEGEND:
PROPOSED IMPROVEMENTS
PROPOSED BOLTED MH
WATERSHED B
WATERSHED D

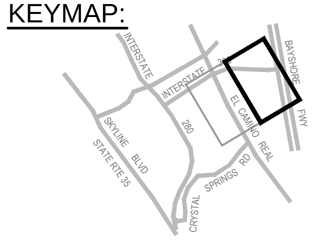
FIGURE 2B.3
PROPOSED Q25 STORM DRAIN IMPROVEMENTS
OPTION B - DETENTION OPTION

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 01A to 02B.dwg
4/16/14 10:49 AM Susan Dove



KEYMAP:



LEGEND:

WATERSHED E

WATERSHED F

APRPOXIMATE PONDING AREA (PS OFFLINE)

FIGURE 3

WATERSHEDS E & F Q25 PONDING (PS OFFLINE)

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 03 to 04.dwg
4/16/14 10:49 AM Susan Dove

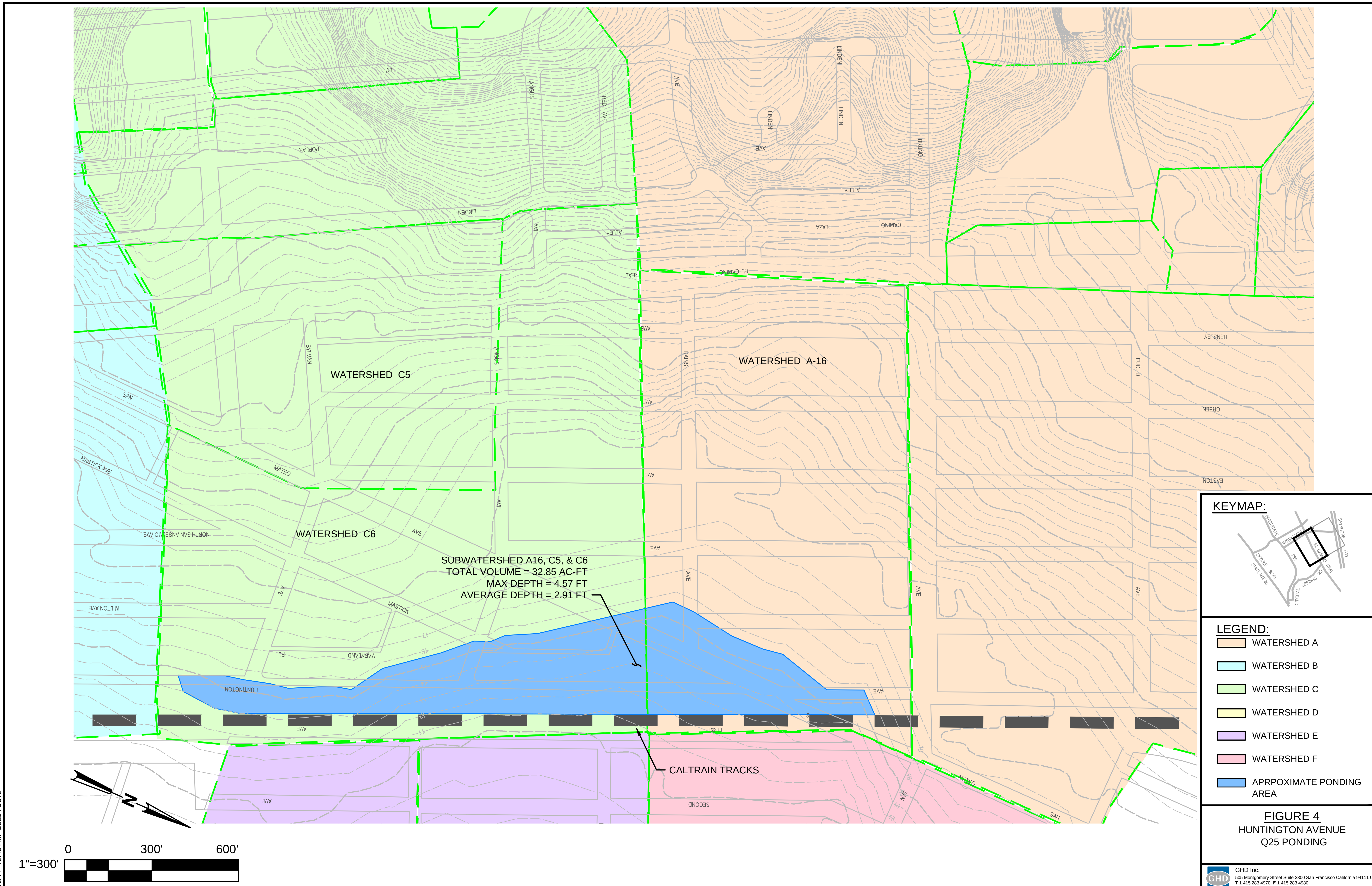
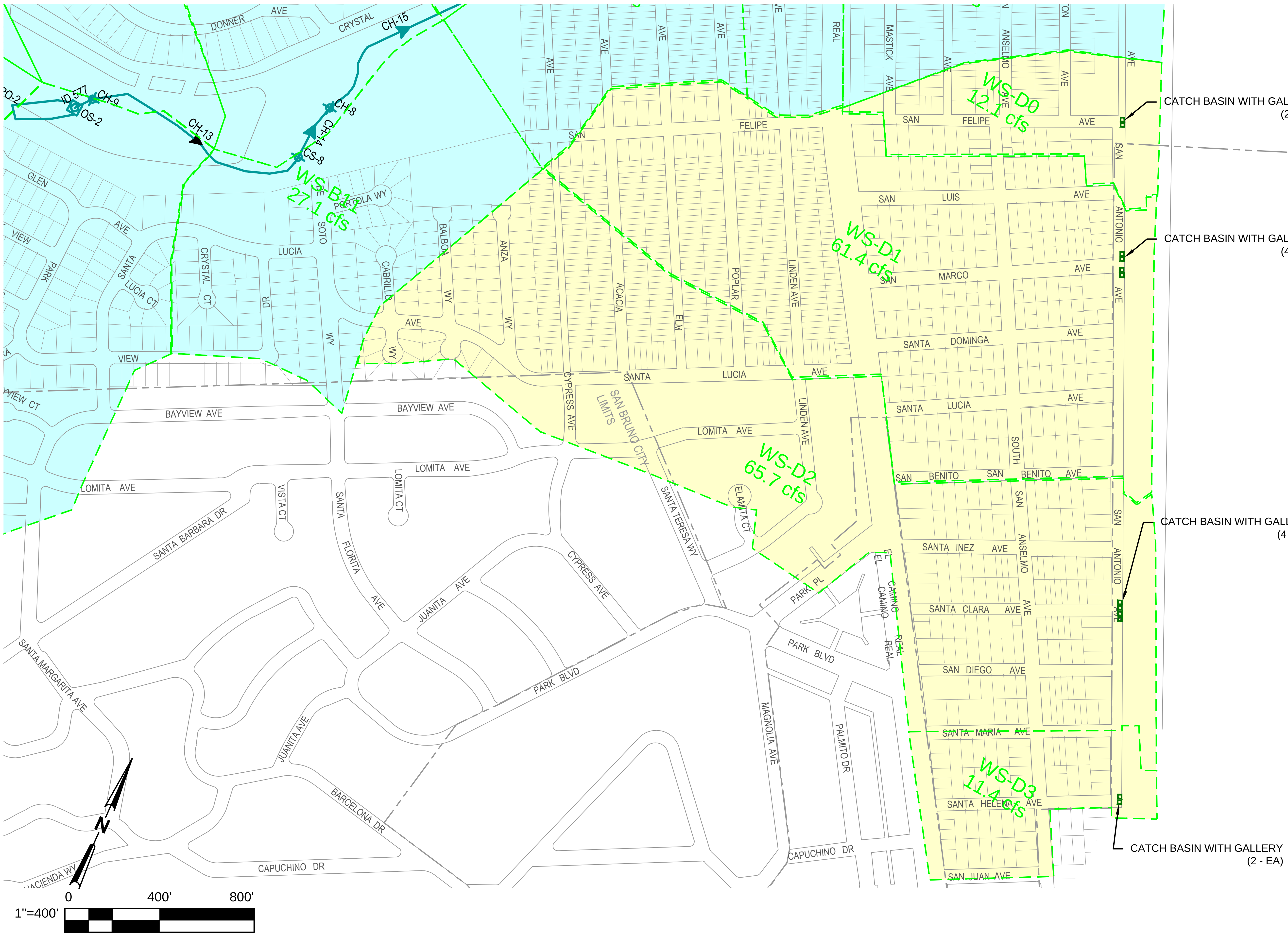
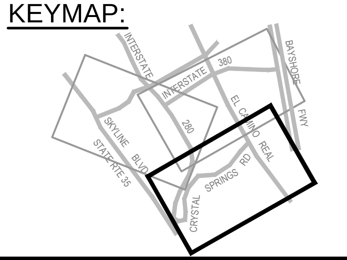


FIGURE 4
HUNTINGTON AVENUE
Q25 PONDING

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\02487080001 FIG 03 to 04.dwg
4/16/14 10:49 AM Susan Dove



KEYMAP:



LEGEND:

PROPOSED IMPROVEMENTS

WATERSHED D

FIGURE 5

PROPOSED Q25 STORM DRAIN IMPROVEMENTS WATERSHED D

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 F 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\02487080001 FIG 05.dwg
4/16/14 10:50 AM Susan Dove

FIGURE 6
CONCEPT DESIGN FOR DRAINAGE INLET IMPROVEMENTS AT 7TH ST AND ANGUS AVE

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 **F** 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 06.dwg
4/16/14 10:50 AM Susan Dove

FIGURE 7
SMCFCD IDENTIFIED PROJECTS

GHD Inc.
505 Montgomery Street Suite 2300 San Francisco California 94111 USA
T 1 415 283 4970 **F** 1 415 283 4980
W www.ghd.com

N:\US\San Francisco\Projects\02487 City of San Bruno\02487-08-001 Storm Drain Master Plan Update & Rate Study\CAD\0248708001 FIG 07.dwg
4/17/14 10:48 AM Susan Dove

Appendix B – Flow Monitoring Report



STORM SEWER FLOW MONITORING AND INFLOW / INFILTRATION STUDY

City of San Bruno

April 2010

V&A

STORM SEWER FLOW MONITORING

City Of SAN BRUNO

Prepared for

WINZLER & KELLY
CONSULTING ENGINEERS

Prepared by

V&A

April 2010

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX

EXECUTIVE SUMMARY

V&A completed storm sewer flow and rainfall monitoring within the City of San Bruno (City). Flow and rainfall monitoring occurred over a 1-month period from December 26, 2009 to January 27, 2010 at four open channel storm sewer sites and one rainfall monitoring site.

Table 1 summarizes the storm sewer flow monitoring results for the flow monitoring sites.

Table 1.
Flow Monitoring Results Summary

Site	Peak Flow (mgd)	Peak Level (inches)	Percent Full (%)	Totalized Flow January 16-26, 2010 (gallons)
Site 1	10.85	38.2	159%	3,186,000
Site 2	109.5	29.2	75%	49,539,000
Site 3	178.5	42.5	133%	136,465,000
Site 4	103.5	38.4	48%	80,423,000

Table 2 summarizes the projected flows through each of the storm sewer sites for a 10-year, 24-hour design storm.

Table 2.
10-Year, 24-Hour Design Storm Data Summary

Site	Peak Flow (mgd)	Totalized Flow (gallons)
Site 1	12.28	1,784,000
Site 2	144.3	32,078,000
Site 3	257.9	73,888,000
Site 4	180.8	44,328,000

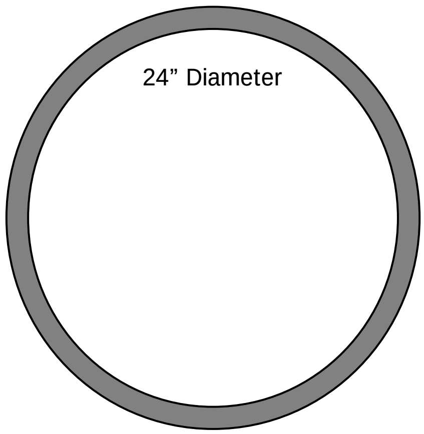
INTRODUCTION

V&A has completed storm sewer flow monitoring and rainfall monitoring within the City of San Bruno (City). Flow and rainfall monitoring occurred over a 1-month period from December 26, 2009 to January 27, 2010 at four open channel storm sewer sites and one rain gauge location. The storm sewer monitoring sites and rain gauge site are illustrated in Figure 1.

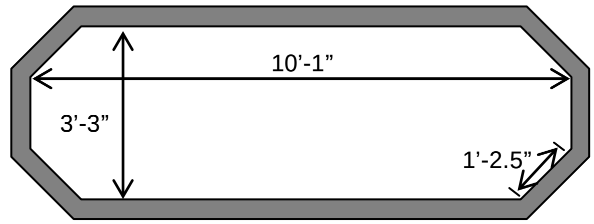
Detailed descriptions of the individual flow monitoring sites, including photographs, are included in *Appendix A*.

Figure 1. City of San Bruno Storm Flow and Rain Monitoring Locations

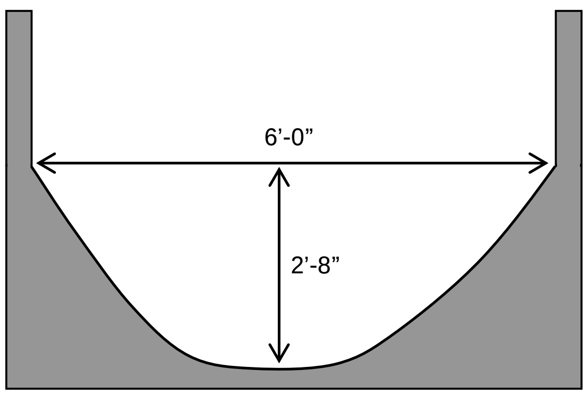
The dimensions of the storm sewer pipes were measured in the field by V&A. Figure 2 illustrates the shapes and dimensions of the cross sections of the pipes.



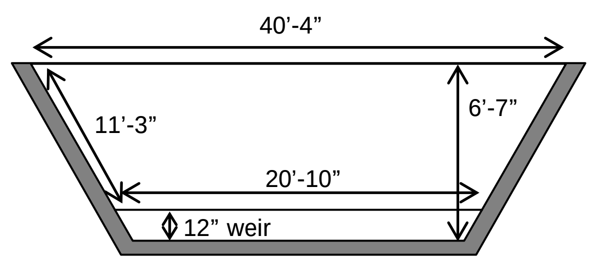
Site 1: 24-inch Circular Pipe



Site 2: 10-foot by 3-foot Octagonal Channel



Site 3: U-Shaped Channel



Site 4: 40-foot by 6.5-foot Trapezoidal Channel

Figure 2. Cross-Sections of San Bruno Storm Sewer Monitoring Locations

METHODS AND PROCEDURES

Confined Space Entry

A confined space (Photo 1) is defined as any space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. Title 8, Section 5158 of the California Code of Regulations provides the guidelines and rules for working in these environments. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5 to 23.0%), and the absence of Hydrogen Sulfide (H_2S) gas, Carbon Monoxide (CO) gas and LEL levels. A typical confined space entry crew has at least three members: the entrant, the attendant and the supervisor. The entrant is the individual performing the work. He/she is equipped with the necessary personal protective equipment needed to perform the job safely, including a personal 4-gas monitor (Photo 2). If it is not possible to maintain line-of-sight with the entrant, then more entrants are required until line-of-sight can be maintained. The attendant is responsible for maintaining contact with the entrant(s) to monitor the atmosphere on another 4-gas monitor and maintaining records of all entrants, if there is more than one.

Photo 1. Confined Space Entry

Photo 2. Typical Personal 4-Gas Monitor

Flow Meter Installation

Four Isco 2150 flow meters were installed by V&A in the storm sewer lines shown in Figure 1. Isco meters use a pressure transducer to collect depth readings and ultrasonic Doppler sensors on the probe to determine the average fluid velocity. Figure 3 shows a sketch of a typical flow meter installation.

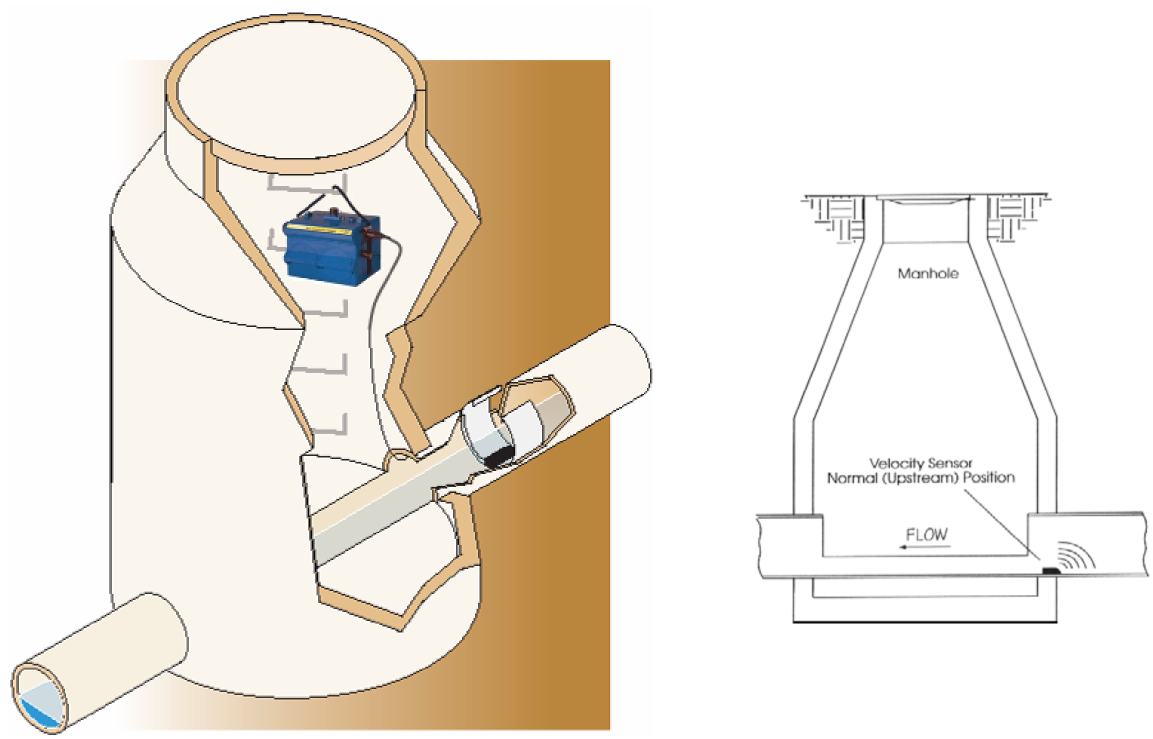


Figure 3. Typical Flow Meter Installation

Continuous depth and velocity readings were recorded by the flow meters in 15-minute increments and downloaded into a computer spreadsheet program where the data could be analyzed and made report ready. Manual level and velocity readings were taken in the field during the flow meter installation and again when the flow meters were removed. These readings were compared to the readings of the flow meters to ensure proper calibration and accuracy.

RAINFALL RESULTS

One rain gauge was stationed at the Walnut Pump Station, located at San Bruno Avenue and Seventh Avenue in San Bruno, to capture rainfall events. The main rainfall event used for analysis in this study occurred from January 16 to January 26, 2010. Figure 4 graphically displays the rainfall events recorded over the flow monitoring period.

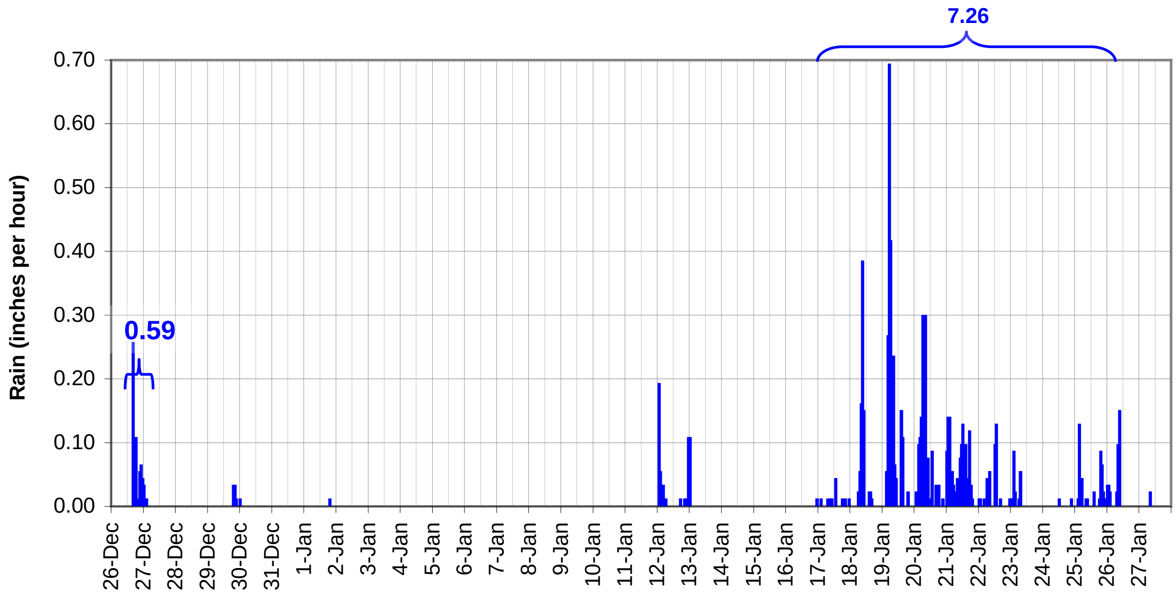


Figure 4. Rainfall Activity over Flow Monitoring Period

Figure 5 shows the rain accumulation plot of the rain gauge, as well as the historical average rainfalls in San Bruno during this project duration.

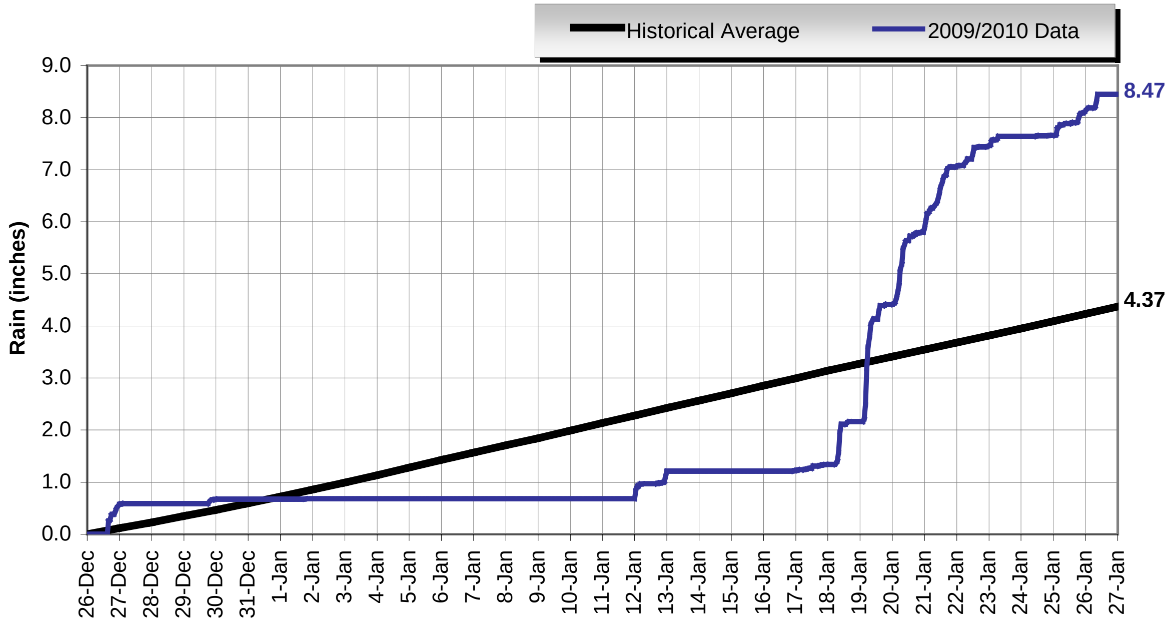


Figure 5. Rainfall Accumulation Plots

The historical average rainfall is shown for comparison to the rainfall that occurred over the course of the flow monitoring period. The historical data was taken from the WRCC[1] at Station 047769 at San Francisco WSO, California. Rainfall data from the years 1970 through 2000 were used to determine these averages. It is estimated that generally for the region, rainfall totals were approximately 94% above normal levels during this period of the wet weather season.

[1] Rainfall data for the site can be viewed at the following website location: http://www.wrcc.dri.edu/summary/climsmnca.html

STORM EVENT CLASSIFICATION

It is important to classify the relative size of the major storm event that occurs over the course of a flow monitoring period. Storm events are classified by intensity and duration. Based on historical data, frequency contour maps for given intensity and duration storm events have been developed by the National Oceanic and Atmospheric Administration (NOAA) for all areas within the continental United States. For example, the NOAA Rainfall Frequency Atlas[2] classifies a 10-year, 24-hour storm event in San Bruno as 4.28 inches (Figure 6). This means that in any given year, there is a 10% chance that 4.28 inches of rain will fall in any 24-hour period.

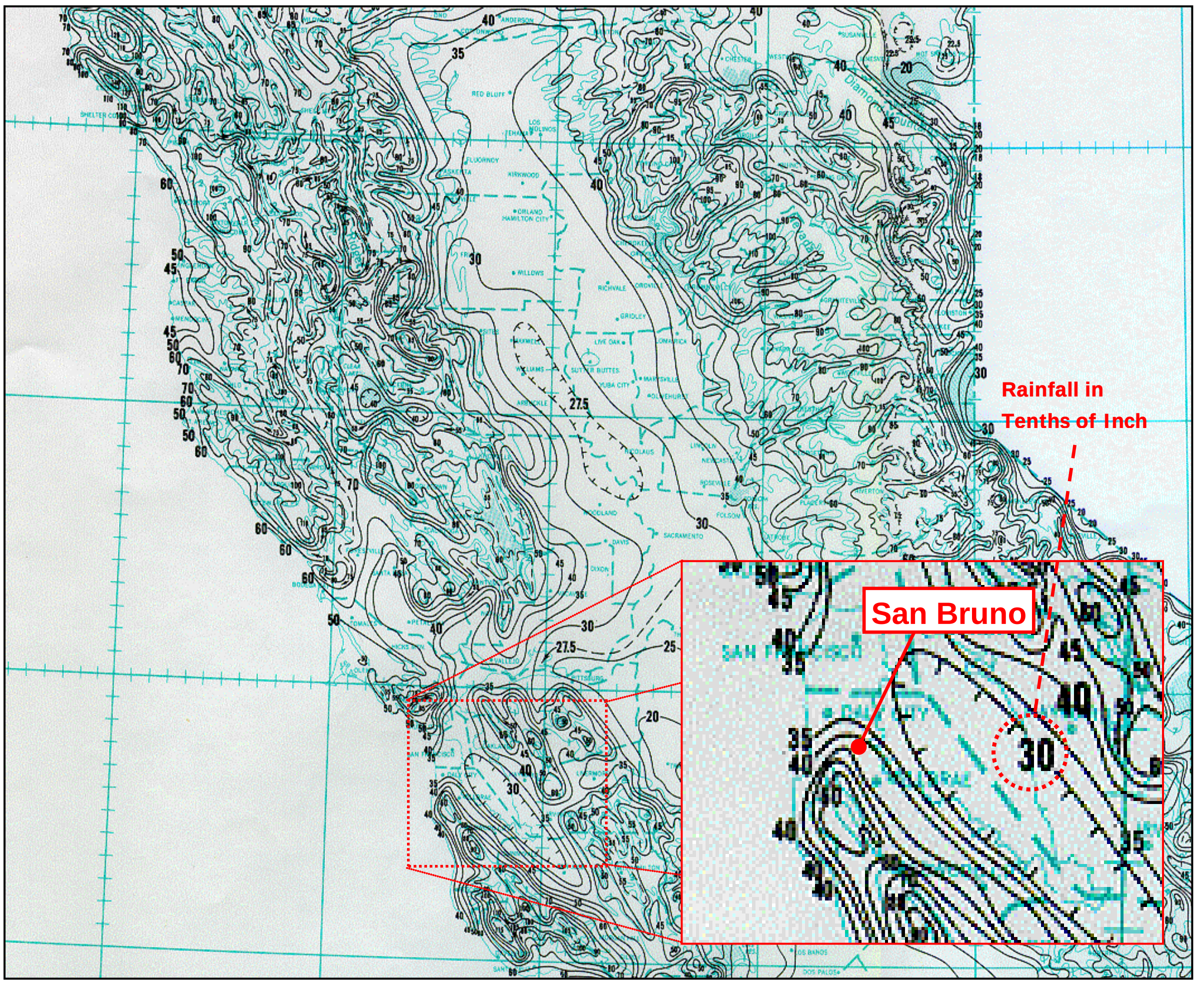


Figure 6. NOAA Northern California Rainfall Frequency Map

From the NOAA frequency maps, the rainfall totals for 1-hour, 6-hour and 24-hour period durations, and 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year period intensities, were plotted to develop a rain event frequency chart specific to the City of San Bruno, as shown in Figure 7.

[2] NOAA Western U.S. Precipitation Frequency Maps Atlas 2, 1973 <http://www.wrcc.dri.edu/pcpnfreq.html>.

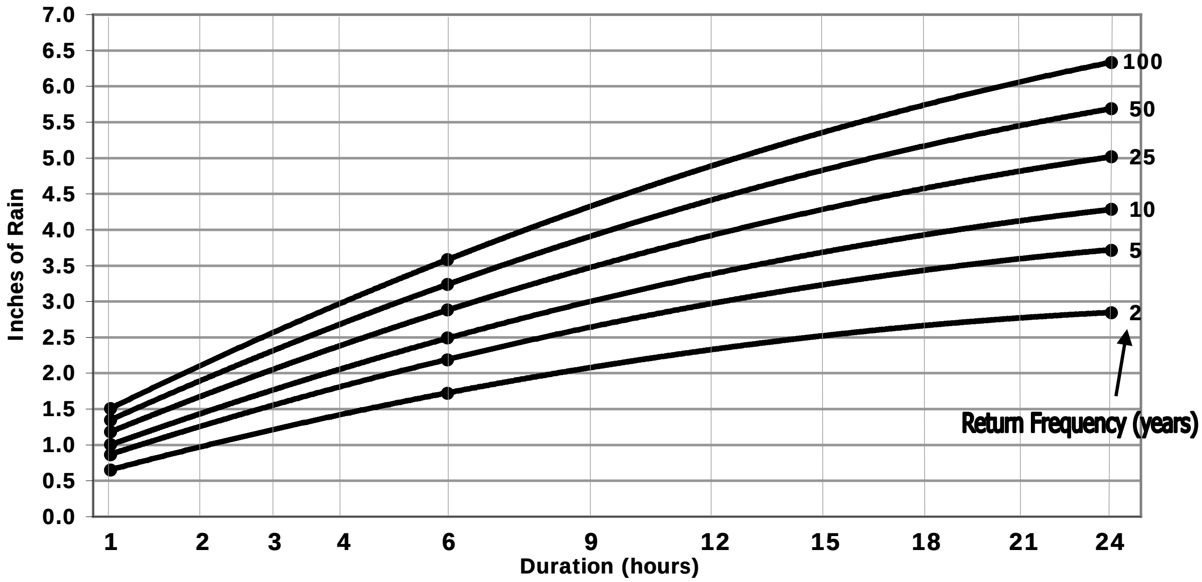


Figure 7. San Bruno Rainfall Frequency Return Chart

For the rain gauge stationed at the Walnut Pump Station, the highest rainfall in a 1-hour period was 0.69 inches, in any consecutive 6-hour period was 1.88 inches, and for any consecutive 12-hour period was 2.17 inches. Peak measured densities per hourly periods were calculated as summarized in Table 3. Superimposing the peak measured densities for the storm events on the Rainfall Storm Event Classification Chart determines the classification of each storm event, as shown in Figure 8.

Table 3.
Peak Measured Rainfall Densities per Hourly Period

Rainfall Duration	Event 1 Rainfall Density (inches)
1 hr	0.69
3 hr	1.37
6 hr	1.88
12 hr	2.17
18 hr	2.25
24 hr	2.45

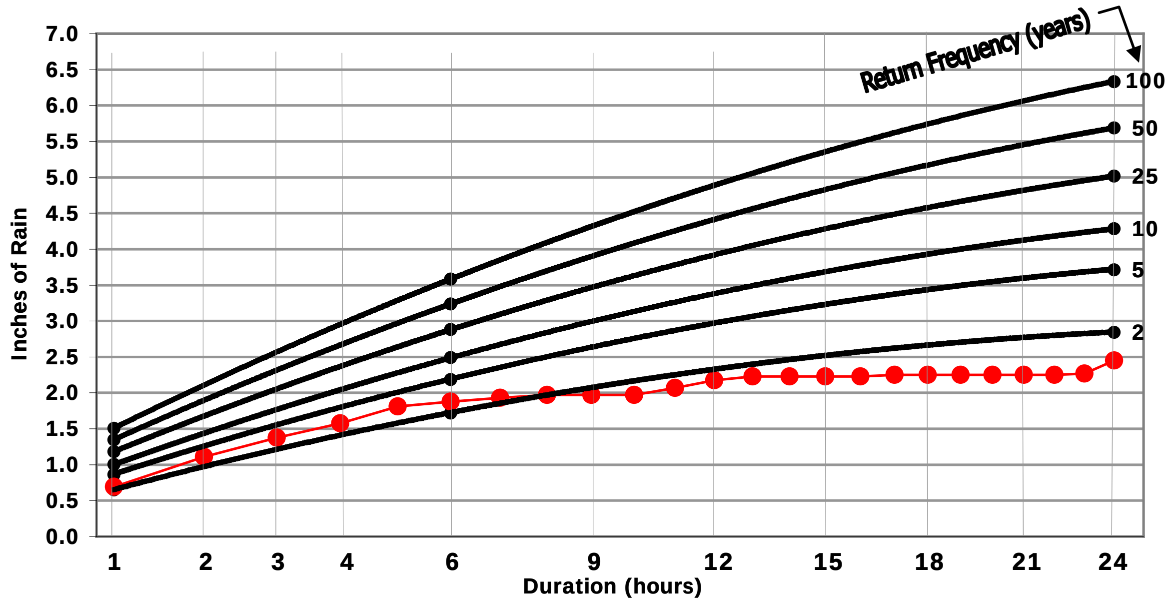


Figure 8. San Bruno Storm Event Classification

The rainfall that occurred between January 16 and 26, 2010, can be classified as between a 3-year and 4-year event between the 2-hour and 4-hour durations.

FLOW MONITORING RESULTS

Storm Sewer Flows

Table 4 summarizes the flow monitoring data recorded for this study.

Table 4.
Flow Summary

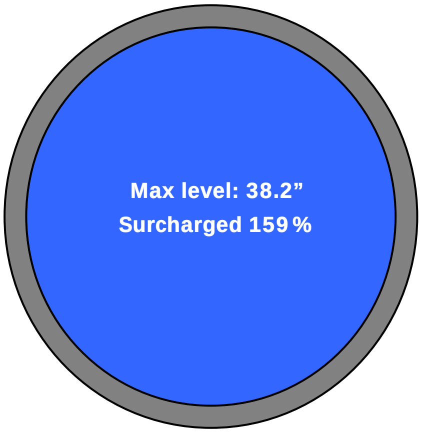
Site	Peak Flow (mgd)	Totalized Flow January 16-26, 2010 (gallons)
Site 1	10.85	3,186,000
Site 2	109.5	49,539,000
Site 3	178.5	136,465,000
Site 4	103.5	80,423,000

Pipe Channel Capacity Analysis

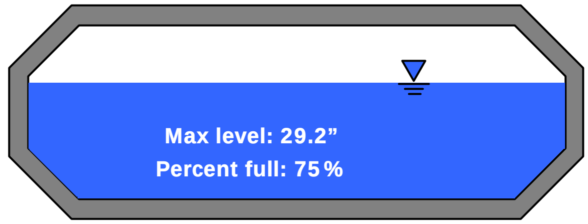
Percent Full: This is the peak measured depth of flow divided by level depth of the pipe channel. Note: this calculation does not consider the total available volume of the pipe channel, as various channel shapes may allow for more or less capacity at higher flow levels. Table 5 summarizes the Percent Full measurements for this study. Figure 9 illustrates the percent full measurements on the pipe and channel cross sections.

Table 5.
Capacity Analysis Summary

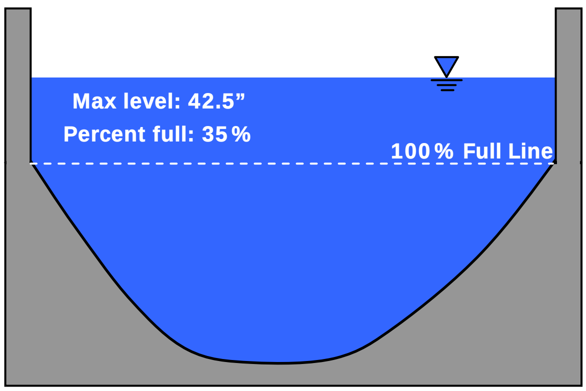
Site	Peak Level (inches)	Percent Full (%)
Site 1	38.2	159%
Site 2	29.2	75%
Site 3	42.5	133%
Site 4	38.4	48%



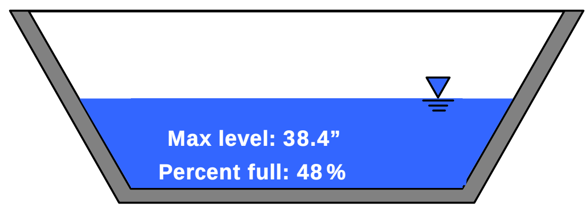
Site 1: 24-inch Circular Pipe



Site 2: 10-foot by 3-foot Octagonal Channel



Site 3: U-Shaped Channel



Site 4: 40-foot by 6.5-foot Trapezoidal Channel

Figure 9. Illustrations of Percent Full on Cross Sections

SYNTHETIC HYDROGRAPHS

In order to model design storms, synthetic hydrographs were developed to approximate the actual RDI/I hydrograph shape in terms of parameters representing time to the peak and the recession coefficient. The actual RDI/I hydrograph was best matched with a synthetic hydrograph by separating the synthetic hydrograph into seven volume components (R1, R2, R3, R4, R5, R6, R7). The seven components represent different response times to the rainfall event and, therefore, different infiltration or inflow paths into the sewer system. R1 is characterized by a short response time and is assumed to consist of mainly inflow. R7 represents slower response and longer recession times and consists of mostly infiltration. Levels of soil saturation are also considered. Using synthetic hydrograph analysis, appropriate time and recession parameters were estimated by a trial-and-error procedure until a good match was obtained. A sample synthetic hydrograph and its component hydrographs for the period of January 18, 2010 through January 25, 2010 for Site 2 is shown in Figure 10.

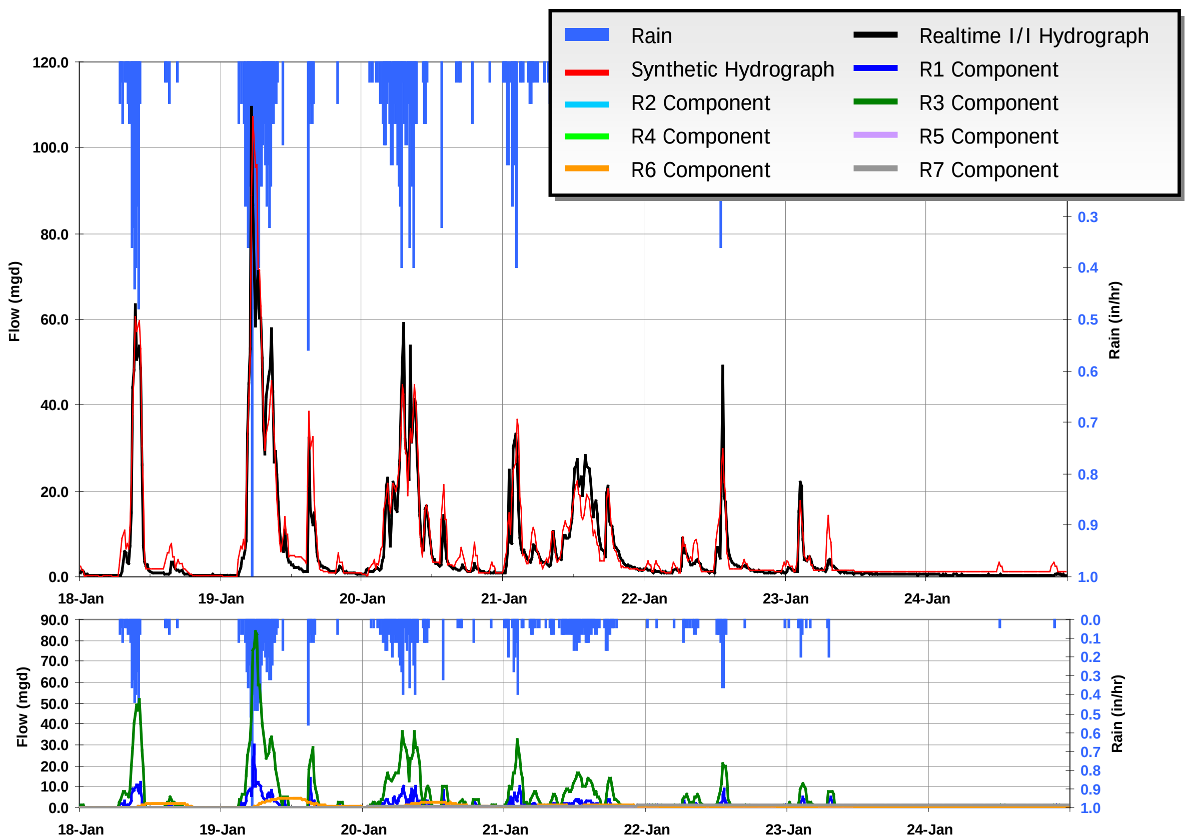


Figure 10. Site 1: Synthetic Hydrograph

Design Storm

With the I/I components defined, design storms can be applied and the resulting I/I flows can be predicted. The design storm used for this analysis was a 24-hour, 10-year storm event taken from the NOAA Western U.S. Precipitation Frequency Maps.

Figure 11 summarizes the design storm per hour and shows the storm profile for the 24-hour, 10-year event. This particular profile distribution also fits the criterion for a 2-hour, 6-hour and 24-hour event.

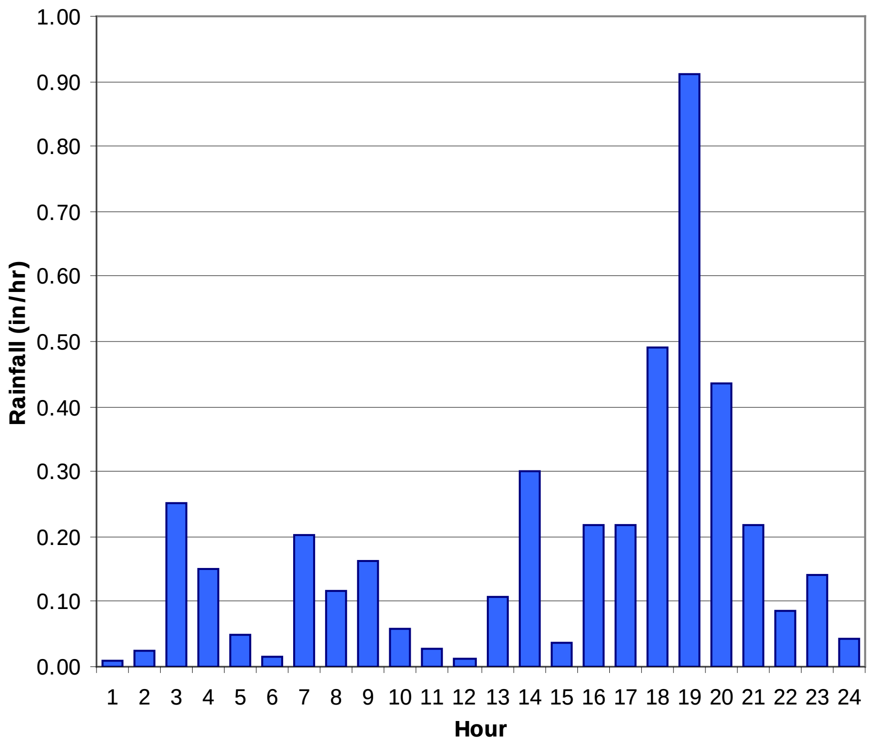


Figure 11. 10-Year, 24-Hour Design Storm Values

Table 6 summarizes the results for each design storm on a site-by-site basis. Figure 12 shows the synthetic hydrograph response for the 10-year event for Site 2.

Table 6.
10-Year, 24-Hour Design Storm Data Summary

Site	Peak Flow (mgd)	Totalized Flow (Gallons)
Site 1	12.28	1,784,000
Site 2	144.3	32,078,000
Site 3	257.9	73,888,000
Site 4	180.8	44,328,000

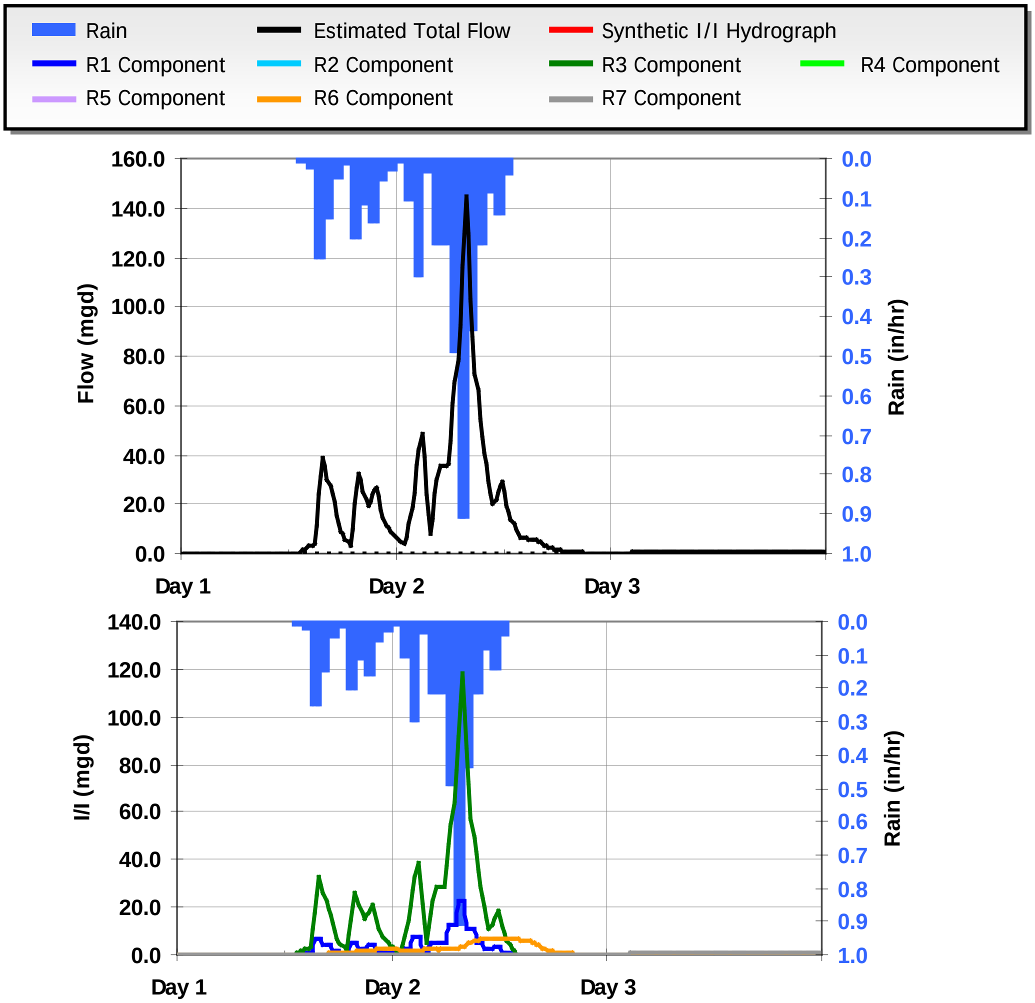


Figure 12. Site 1: 10-Year, 24-Hour Design Storm

APPENDIX A
FLOW MONITORING SITES: DATA, GRAPHS, INFORMATION

Temporary Flow Monitoring Study

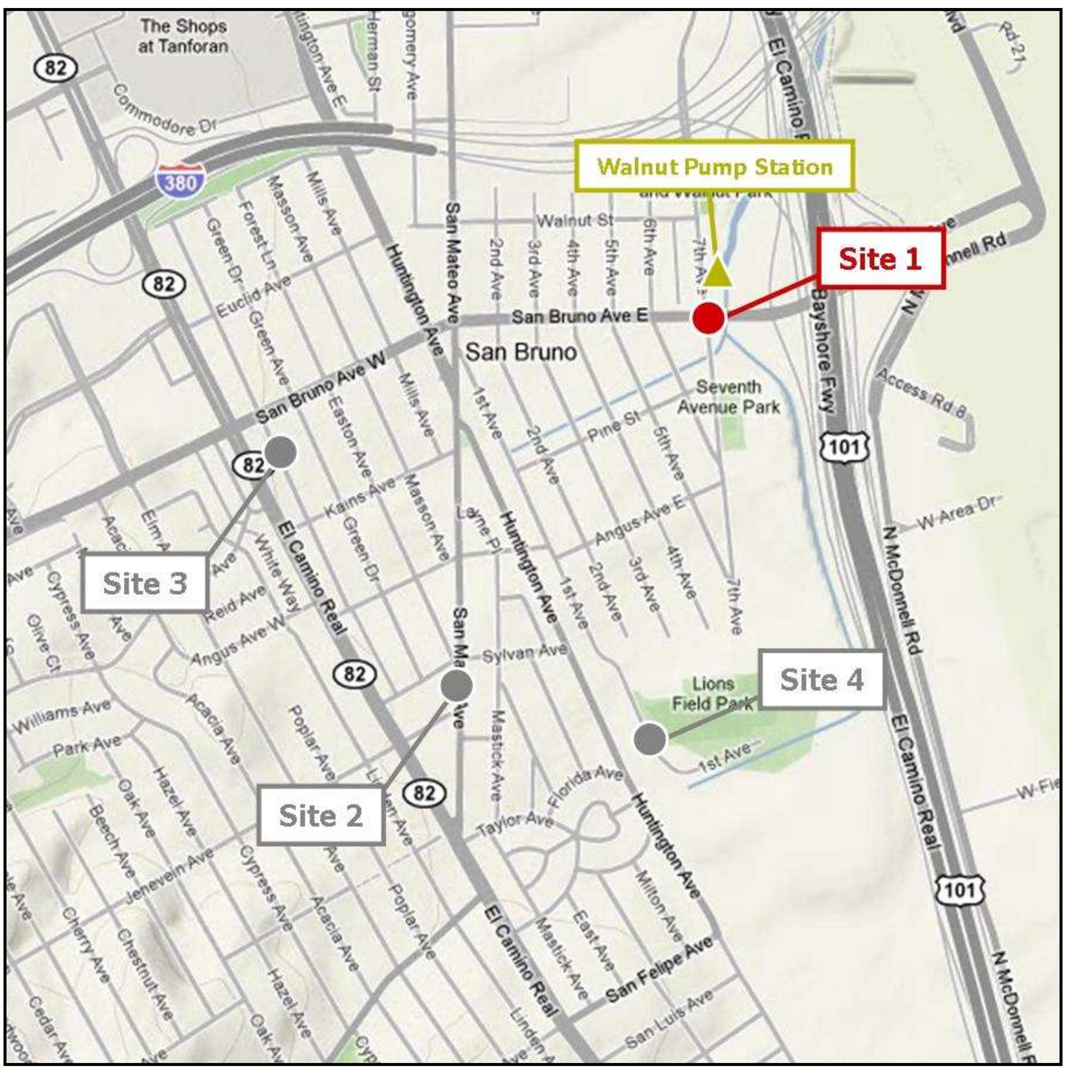
Storm Sewer Collection System

Monitoring Site: Site 1

Location: Intersection of 7th Avenue and San Bruno Avenue

Size/Type Line: 24-inch circular pipe

Data Summary Report



V&A

	Site Information Report	**Monitoring Site:** Site 1

Location: Intersection of 7th Avenue and San Bruno Avenue

Latitude: 37.6310°

Longitude: -122.4055°

Rim Elevation: 13 *feet*

Pipe size/type: 24-inch circular pipe

Peak Measured Flow: 10.85 *mgd*

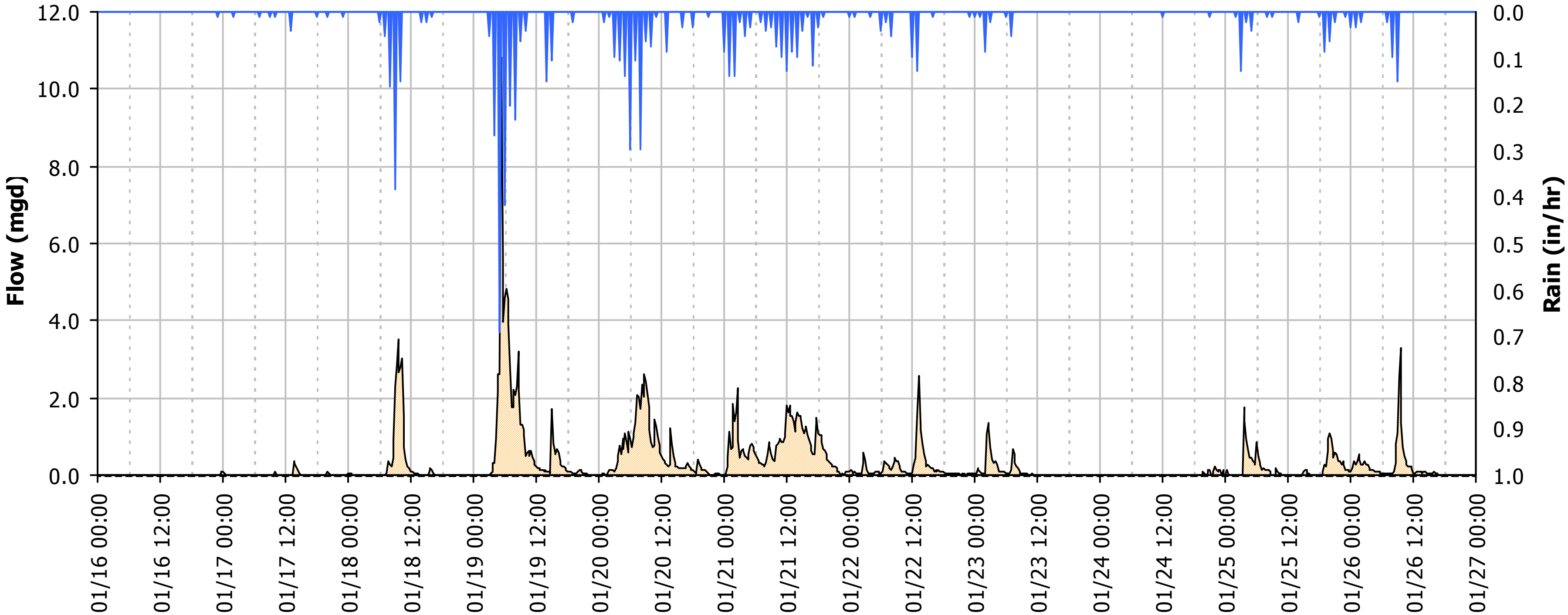
	Site Photos	Monitoring Site: Site 1

Plan View

View Looking Upstream

	Storm Sewer Flow Summary January 16 - January 27, 2010	**Monitoring Site:** Site 1

Storm Event #1 Detail Hydrograph Graph



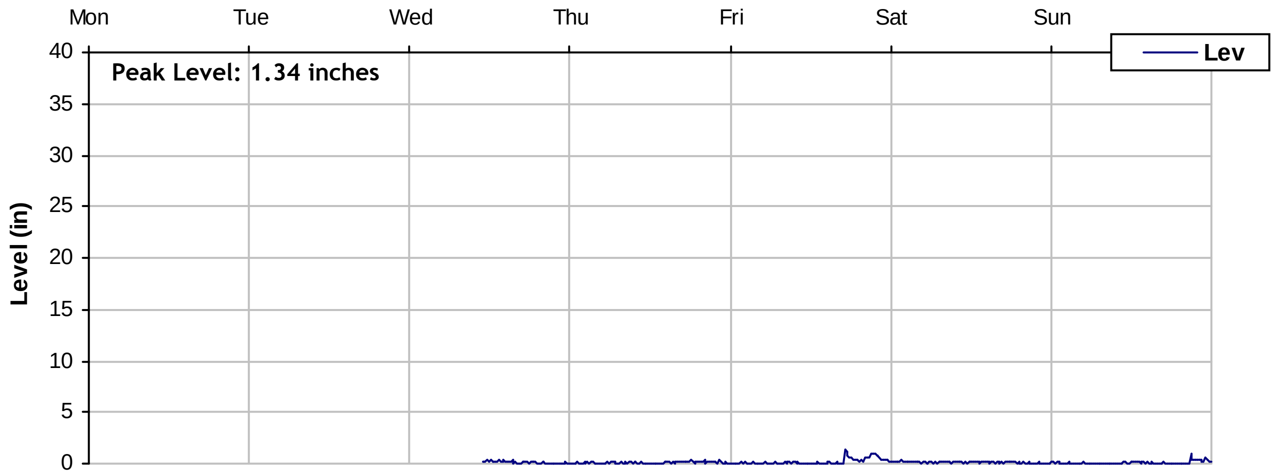
Storm Event #1 Analysis

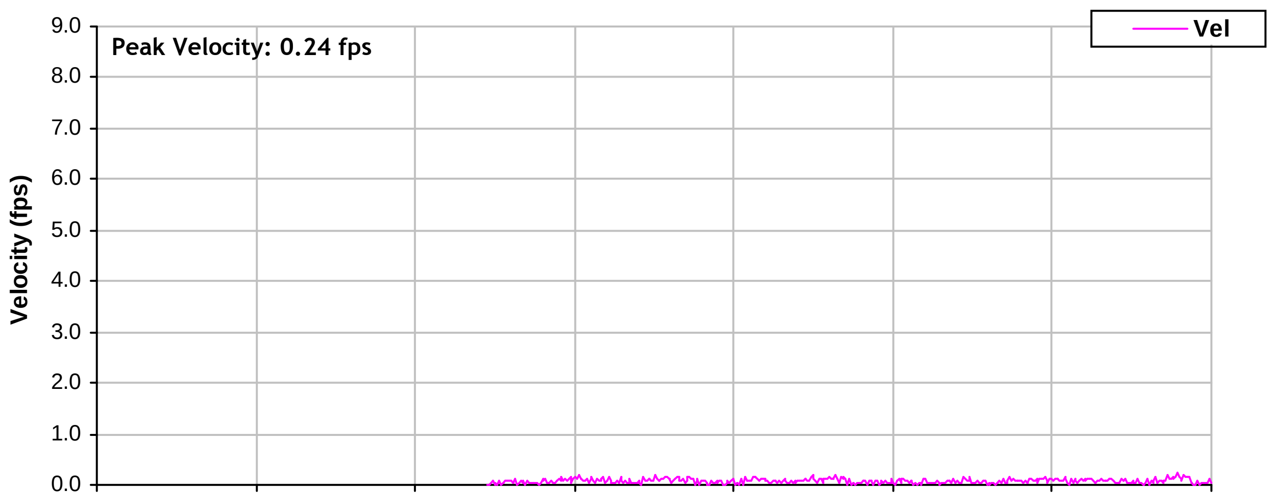
Rainfall:	7.24	*inches*
Peak Flow:	10.85	*mgd*
Peak Level:	38.19	*inches*
Percent Full:	159%	
Totalalized Flow:	3,186,000	*gallons*

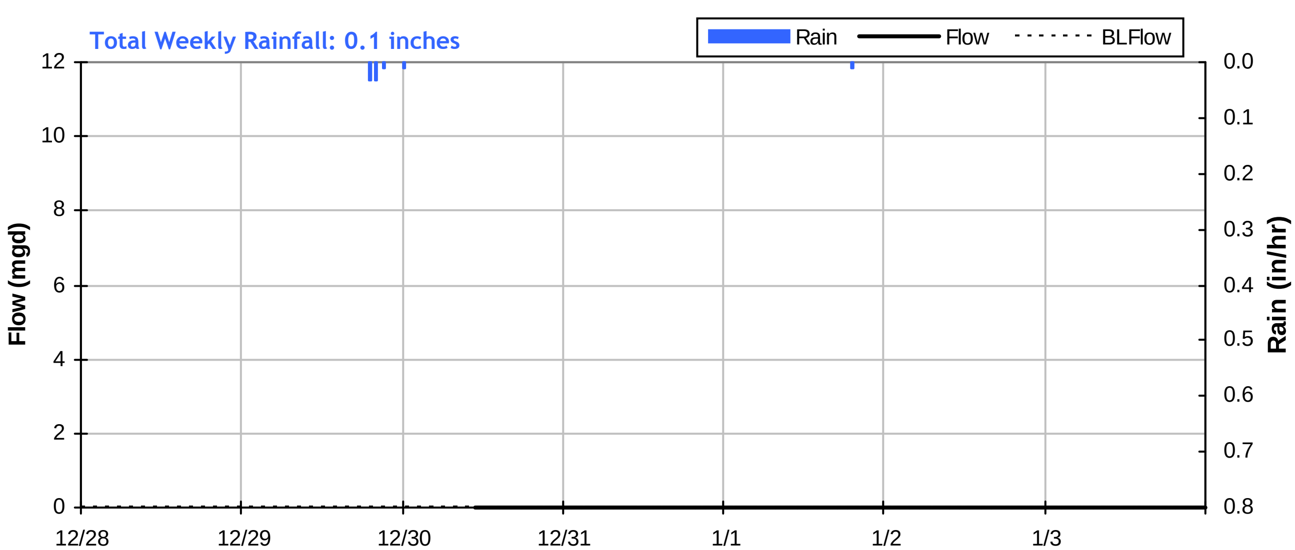
V&A

Level, Velocity and Flow
From 12/28/2009 to 1/4/2010

Monitoring Site:
Site 1



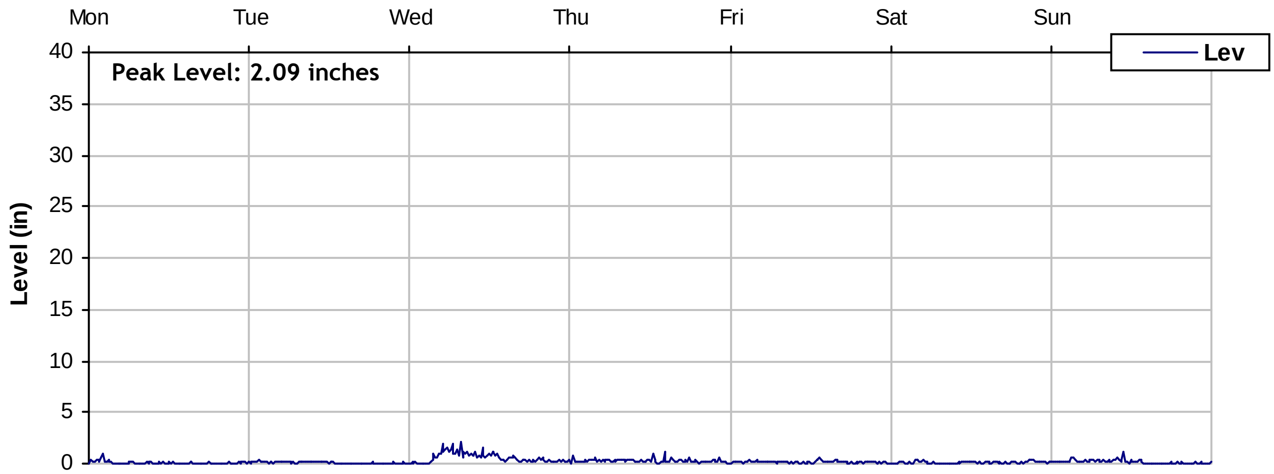


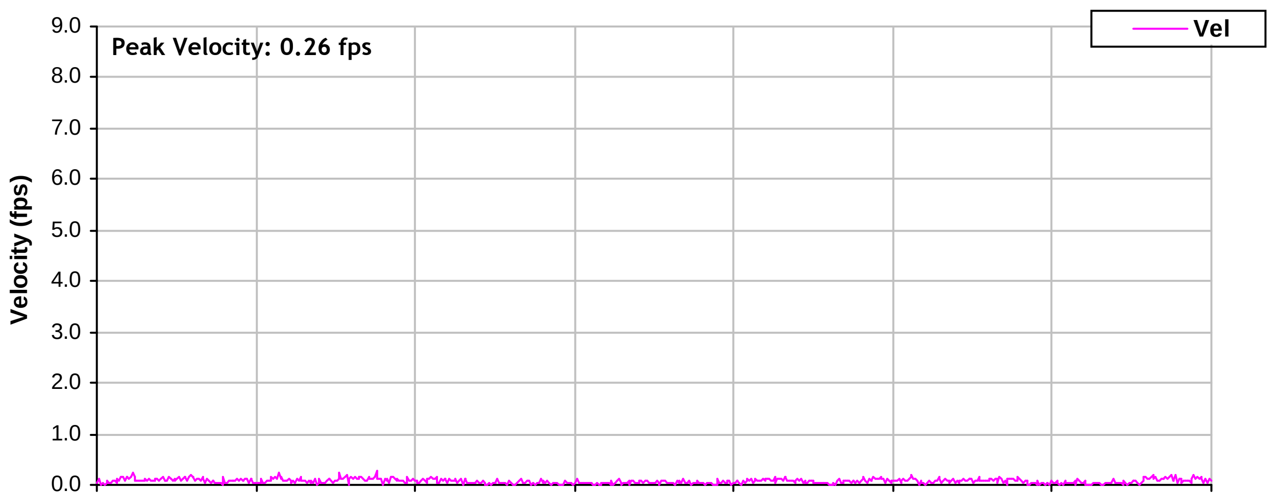


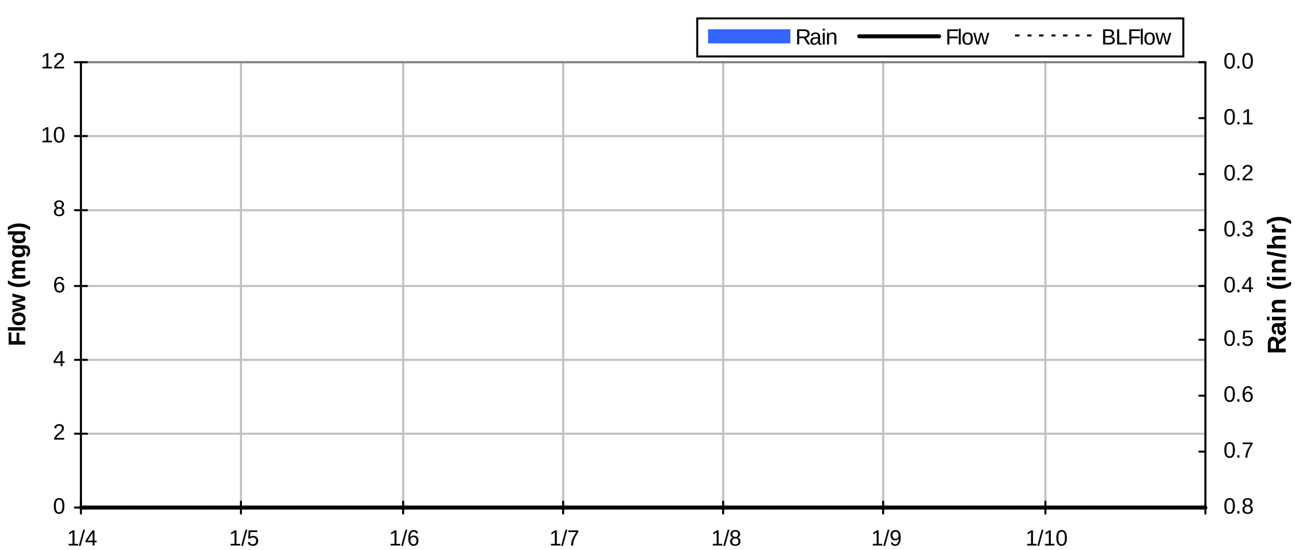
Peak Flow: 0 mgd

Level, Velocity and Flow
From 1/4/2010 to 1/11/2010

Monitoring Site:
Site 1



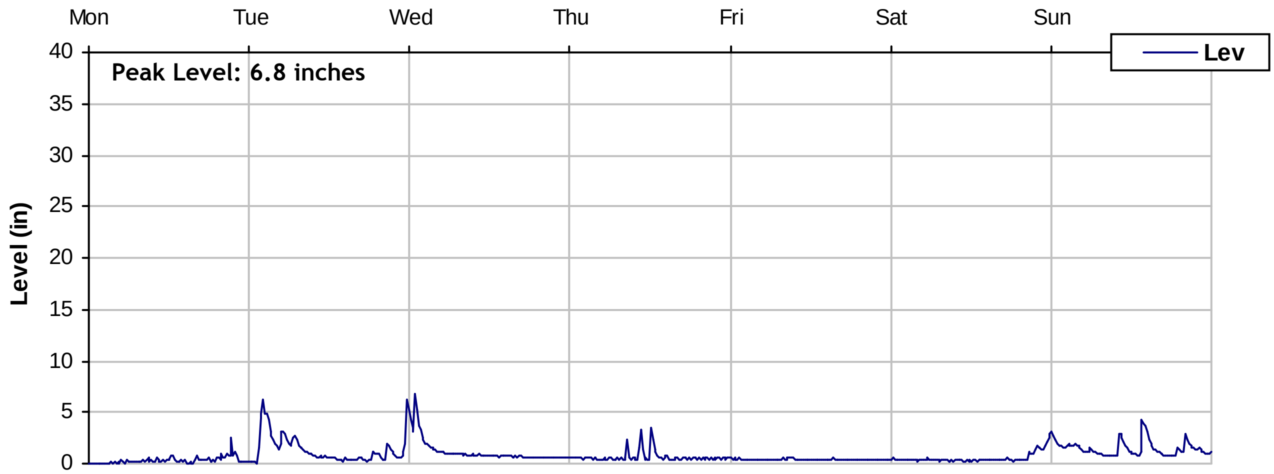


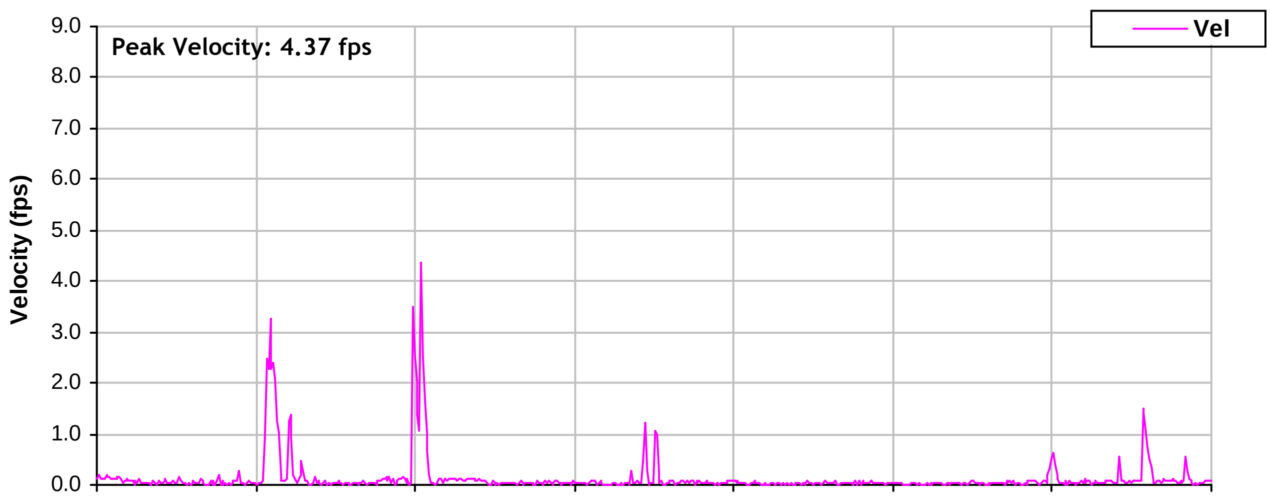


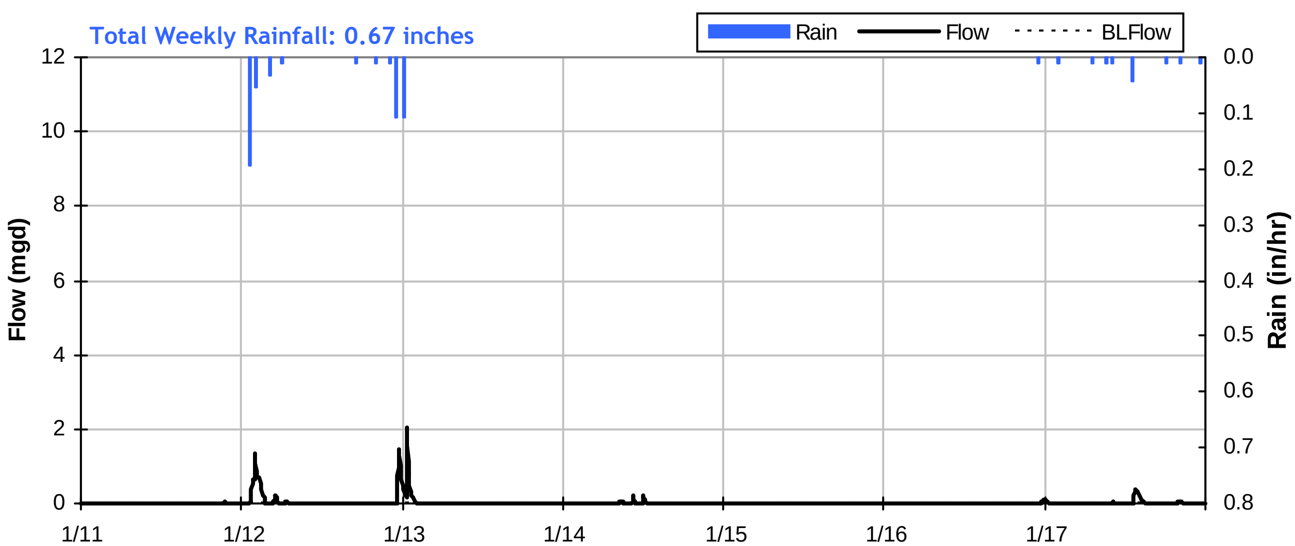
Peak Flow: 0.01 mgd

Level, Velocity and Flow
From 1/11/2010 to 1/18/2010

Monitoring Site:
Site 1



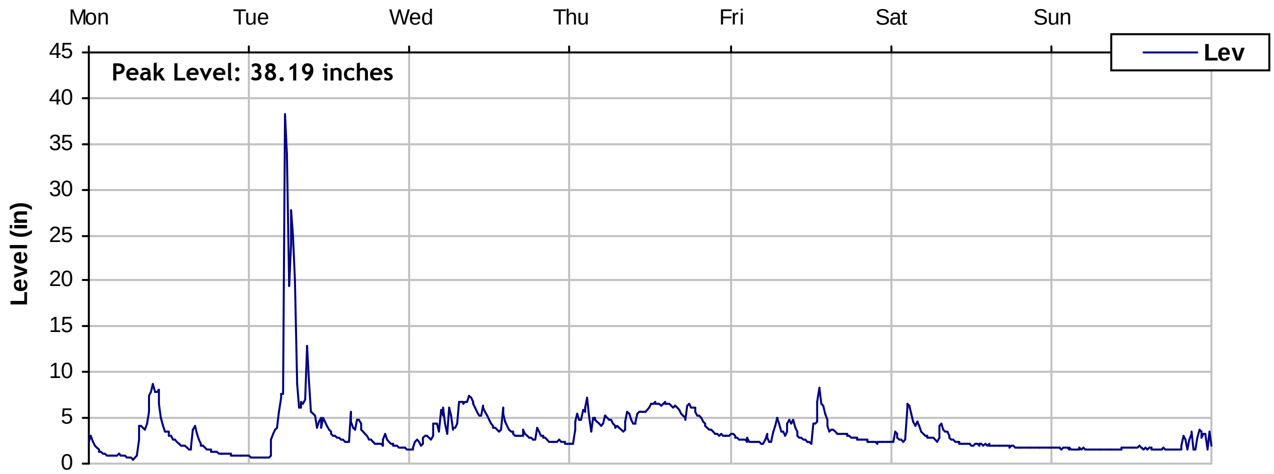


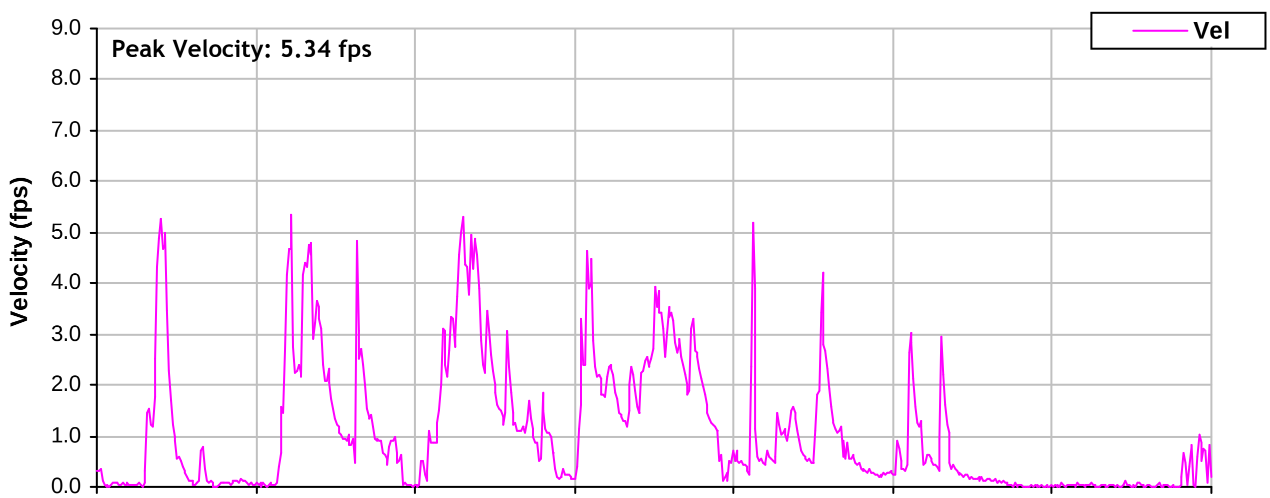


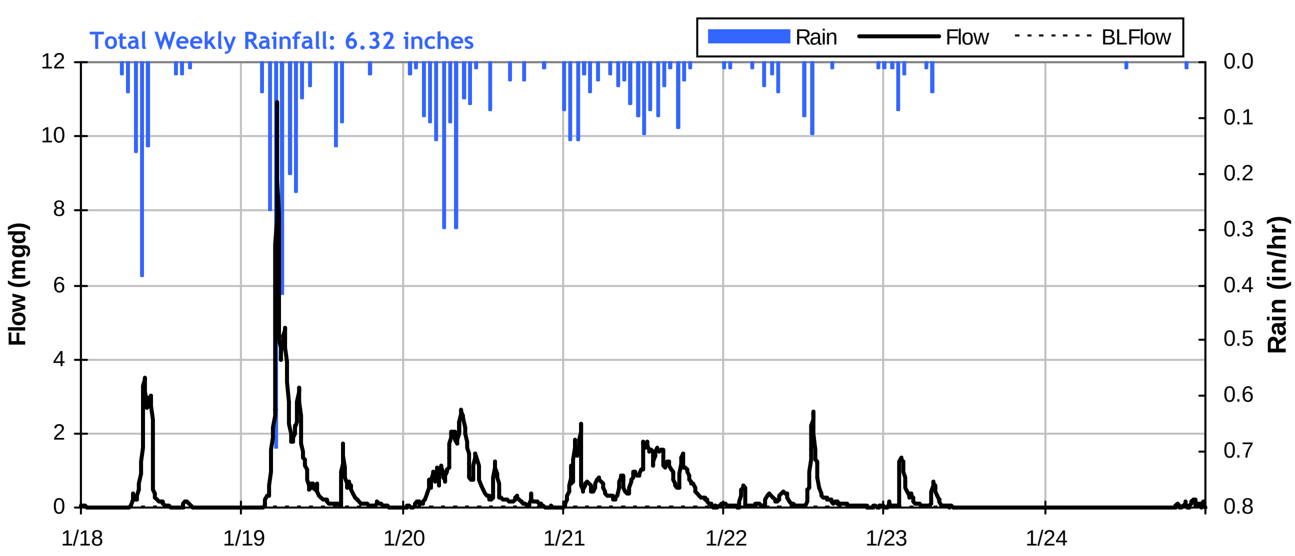
Peak Flow: 2.07 mgd

V&A

	Level, Velocity and Flow From 1/18/2010 to 1/25/2010	**Monitoring Site:** Site 1

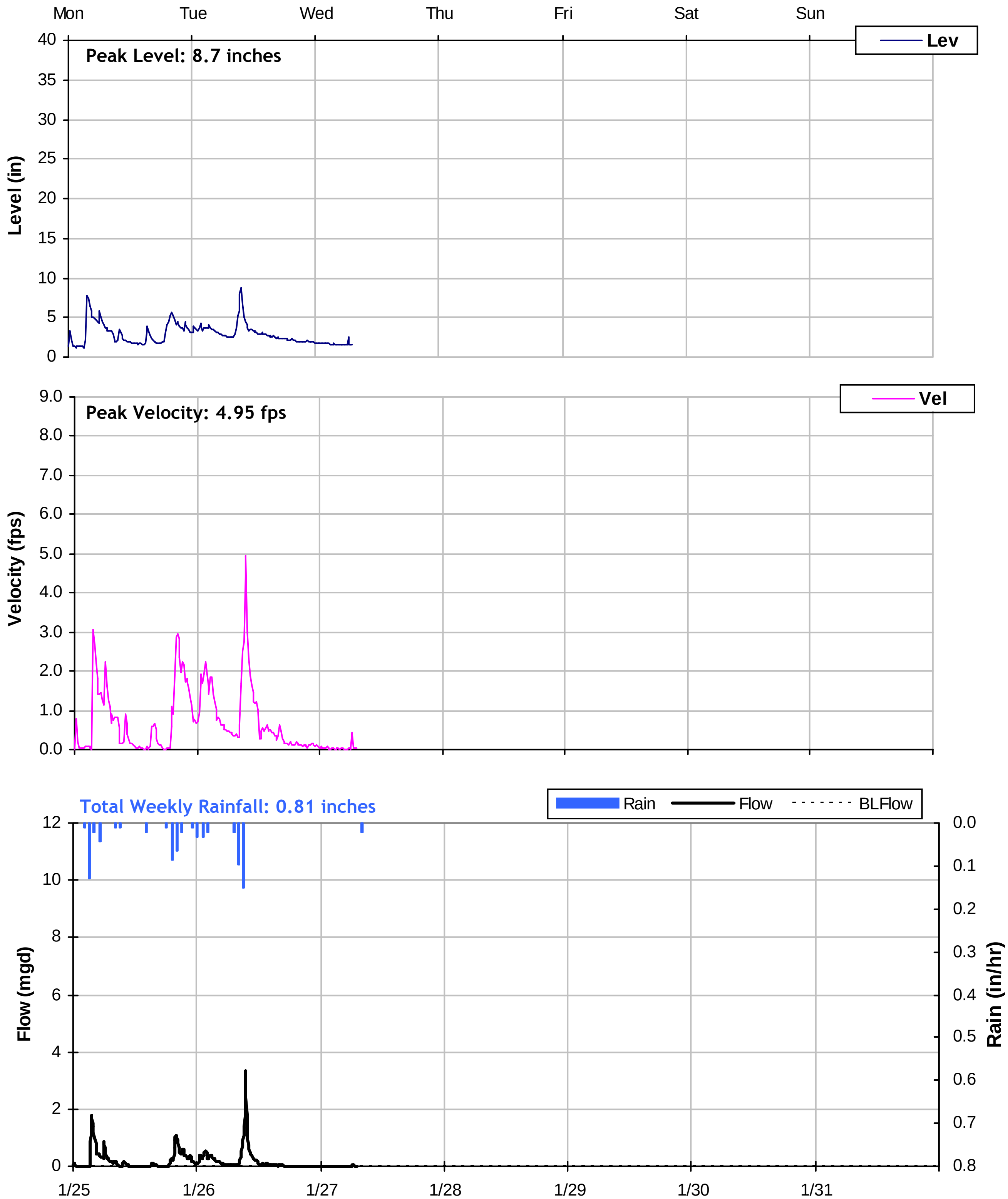






Peak Flow: 10.85 mgd

	Level, Velocity and Flow From 1/25/2010 to 2/1/2010	**Monitoring Site:** Site 1



Peak Flow: 3.29 mgd

Temporary Flow Monitoring Study

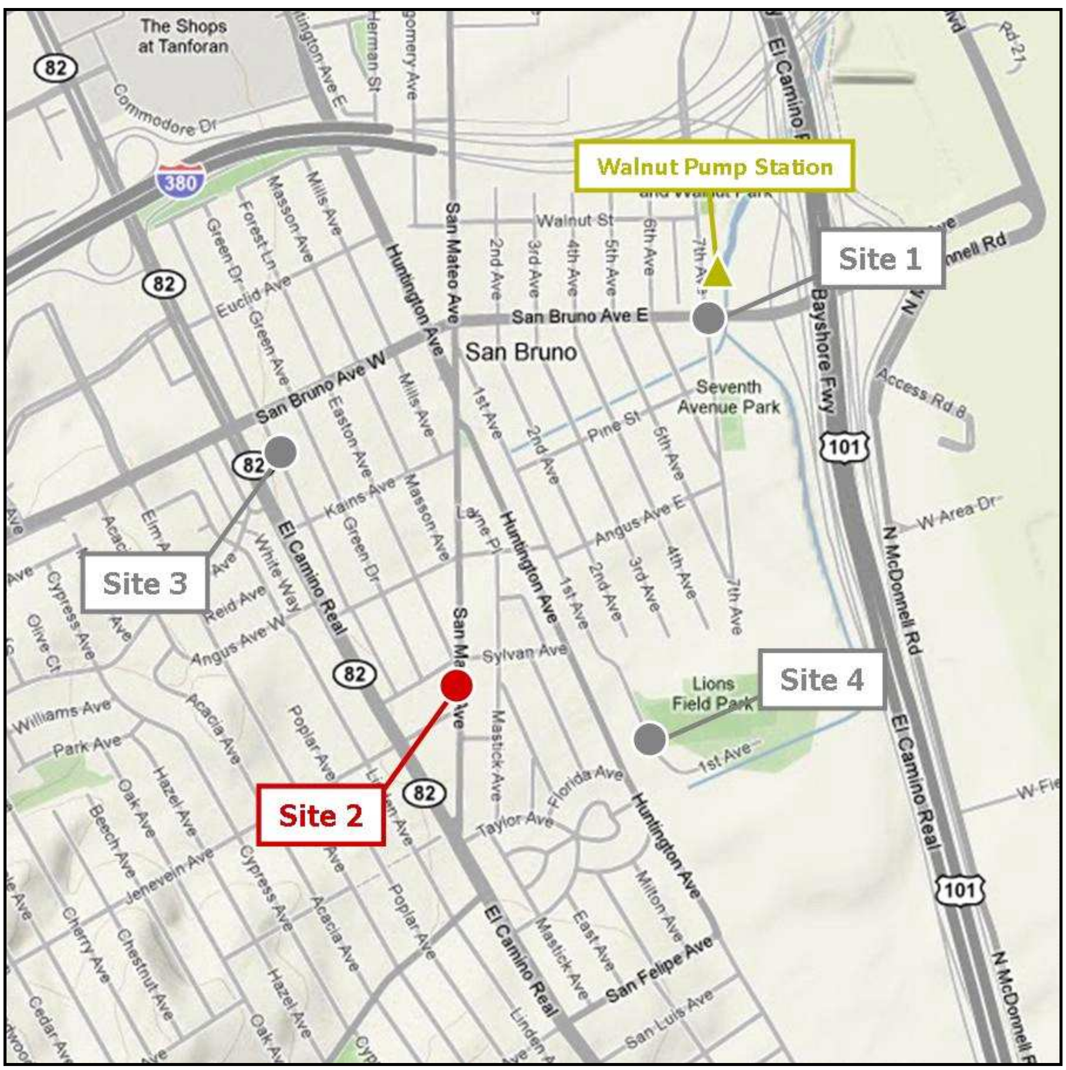
Storm Sewer Collection System

Monitoring Site: Site 2

Location: San Mateo Avenue between Sylvan Avenue and Angus Avenue

Size/Type Line: 39-inch tall by 120-inch wide box culvert

Data Summary Report



Site Information Report

Monitoring Site:
Site 2

Location: San Mateo Avenue between Sylvan Avenue and Angus Avenue

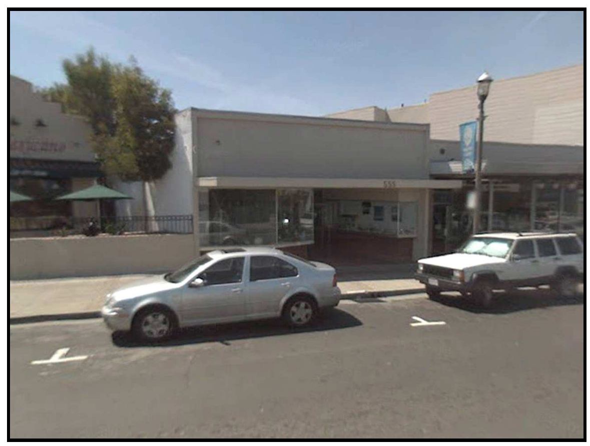
Latitude: 37.6255°

Longitude: -122.4113°

Rim Elevation: 27 *feet*

Pipe size/type: 39-inch tall by 120-inch wide box culvert

Peak Measured Flow: 109.51 *mgd*



V&A

	Site Photos	**Monitoring Site:** Site 2

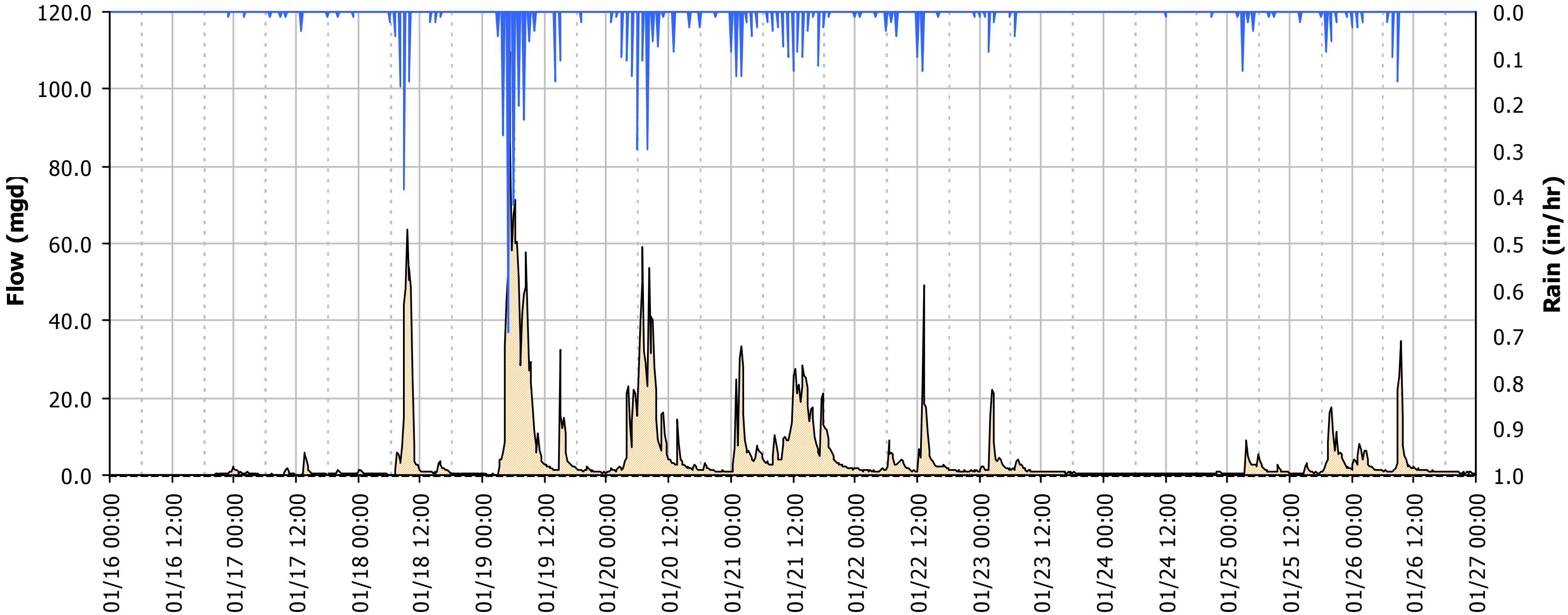
View Looking Upstream

Downstream Channel (right)

Storm Sewer Flow Summary
January 16 - January 27, 2010

Monitoring Site:
Site 2

Storm Event #1 Detail Hydrograph Graph

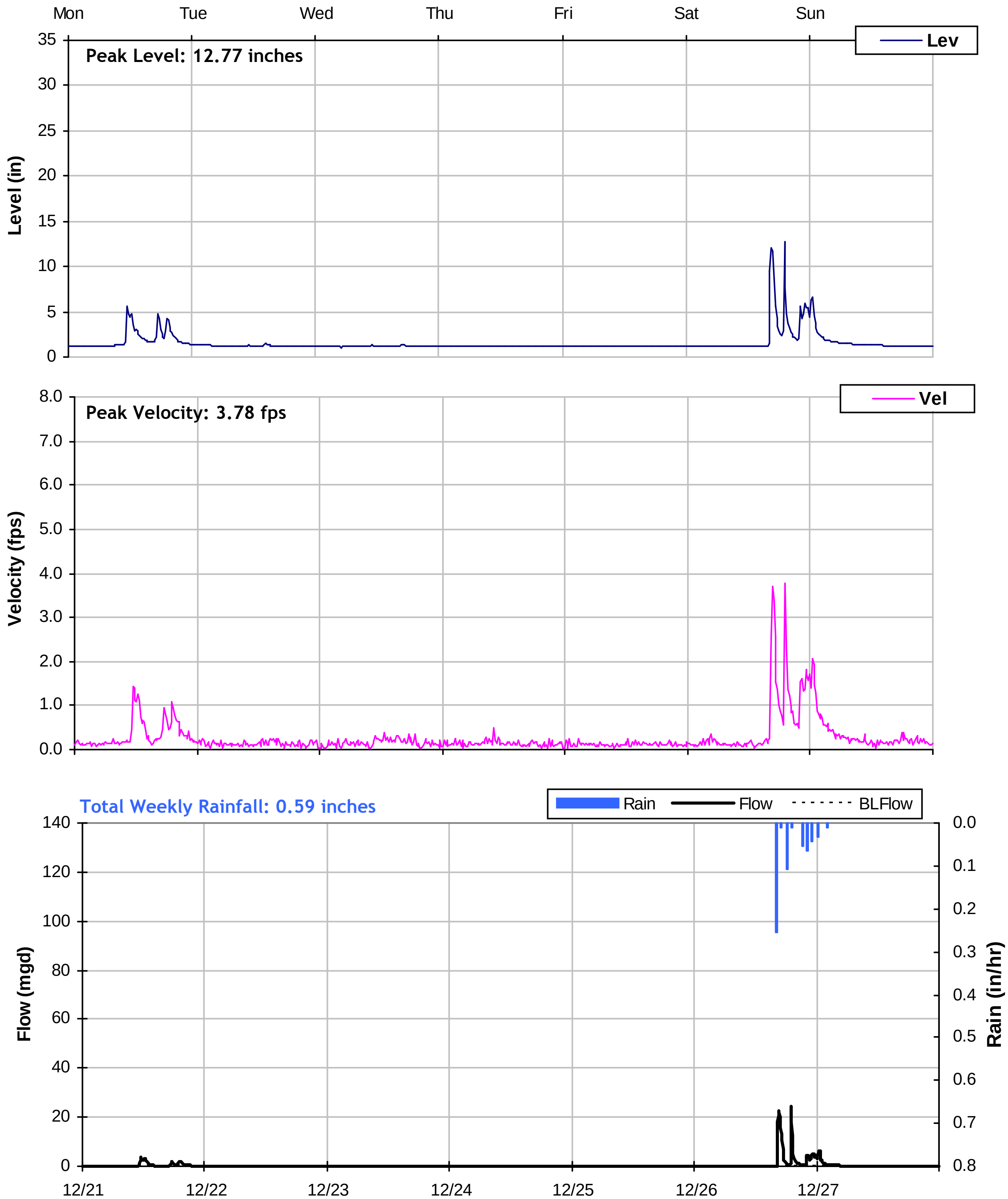


Storm Event #1 Analysis

Rainfall:	7.24	*inches*
Peak Flow:	109.51	*mgd*
Peak Level:	29.22	*inches*
Percent Full:	75%	
Totalalized Flow:	49,539,000	*gallons*

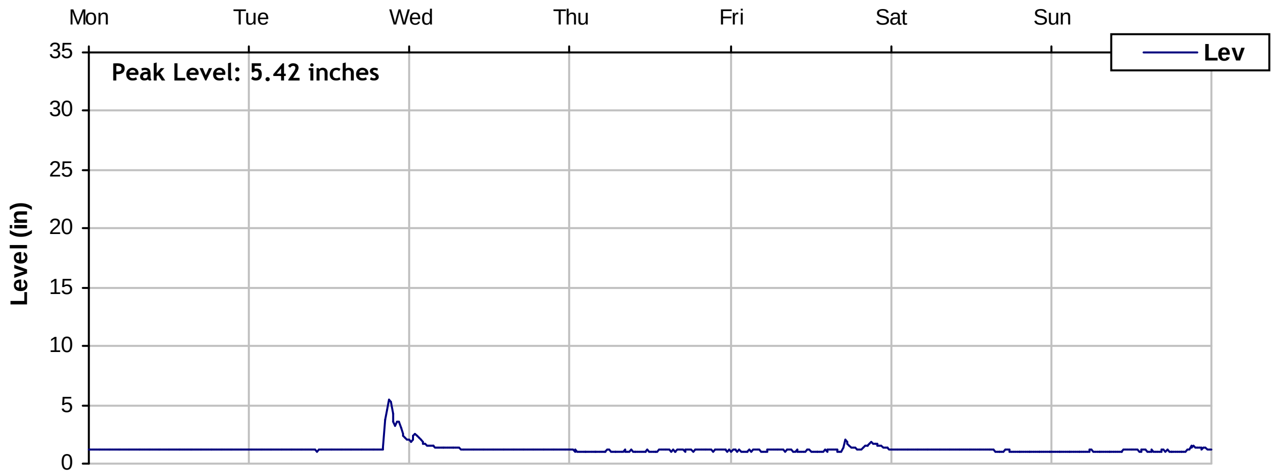
Level, Velocity and Flow
From 12/21/2009 to 12/28/2009

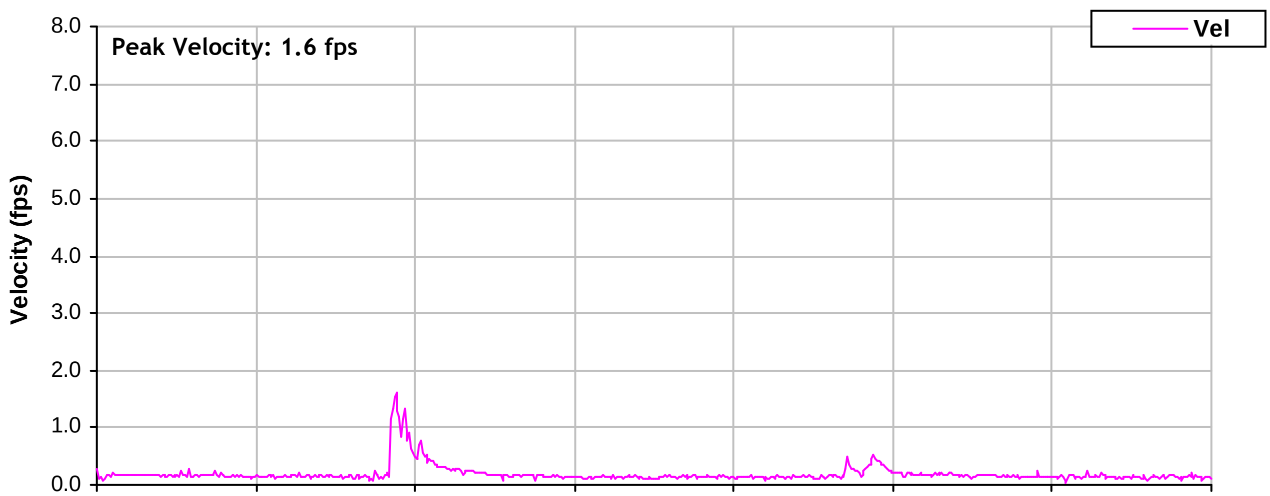
Monitoring Site:
Site 2

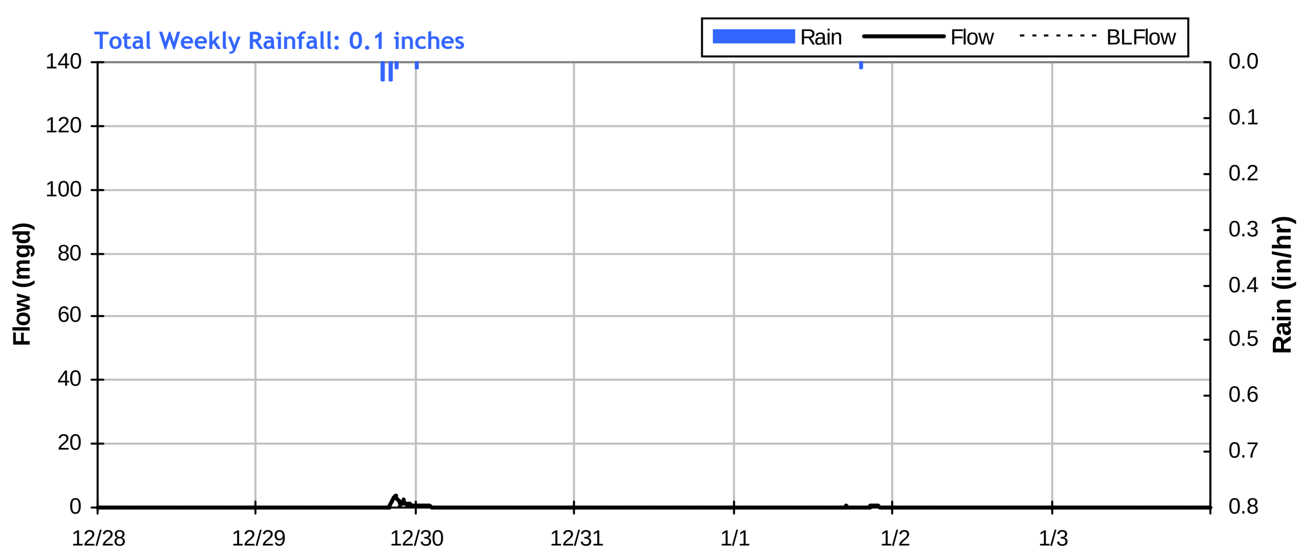


Peak Flow: 24.4 mgd

	Level, Velocity and Flow From 12/28/2009 to 1/4/2010	Monitoring Site: Site 2



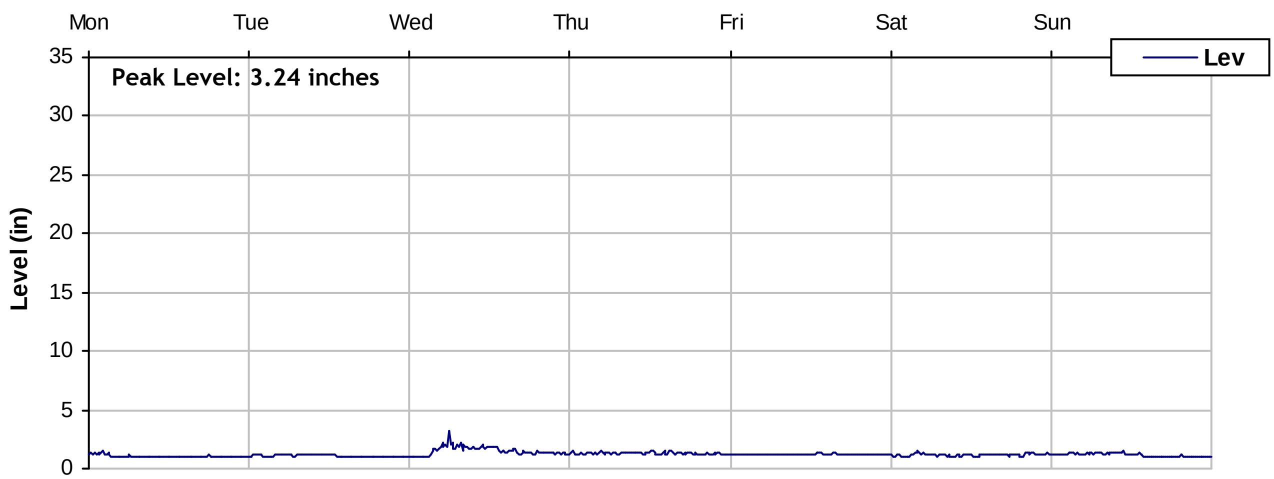


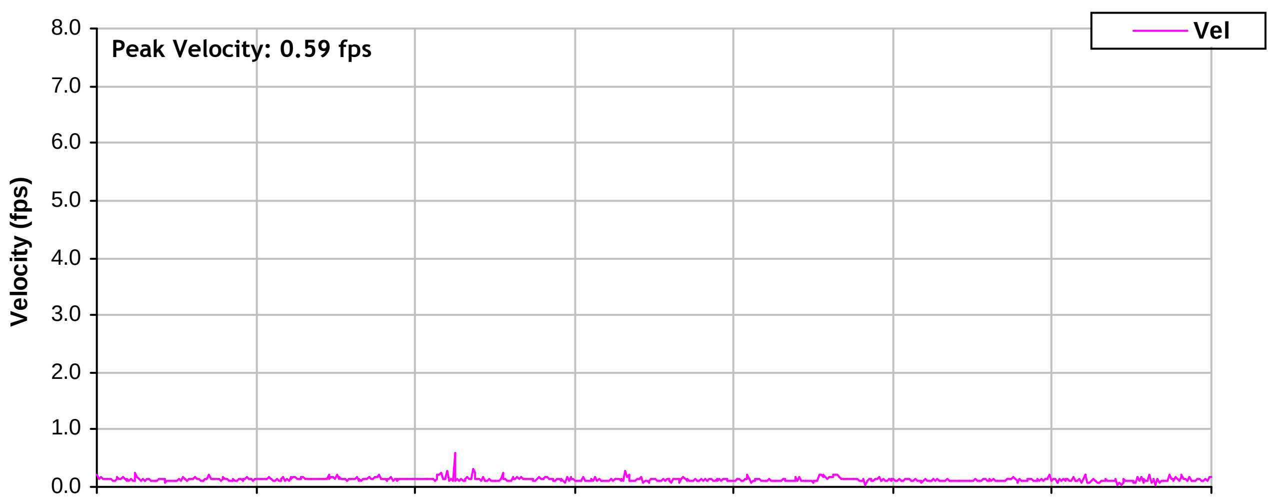


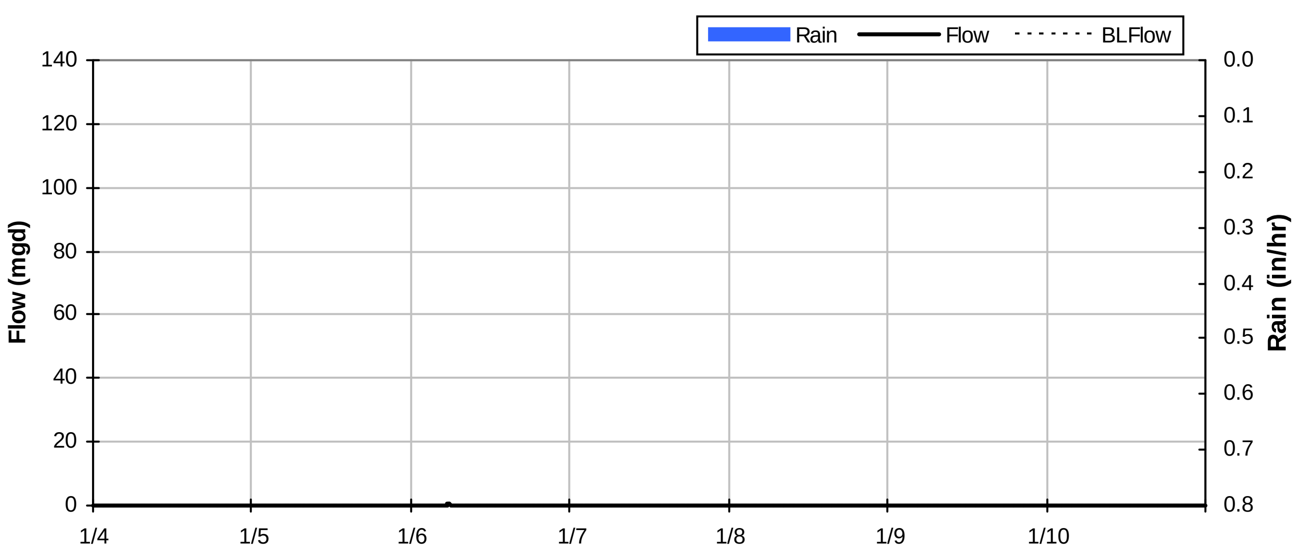
Peak Flow: 3.97 mgd

Level, Velocity and Flow
From 1/4/2010 to 1/11/2010

Monitoring Site:
Site 2





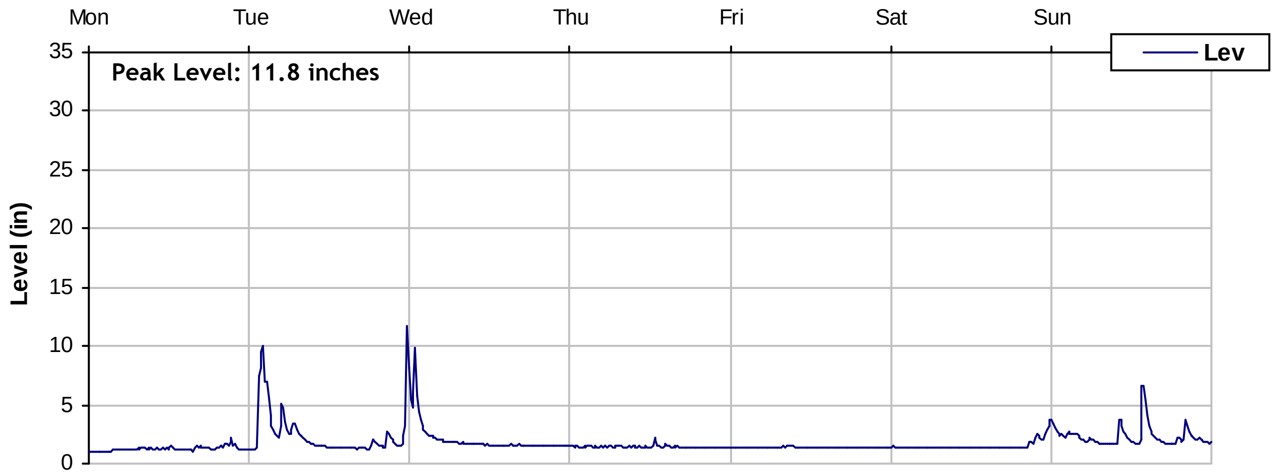


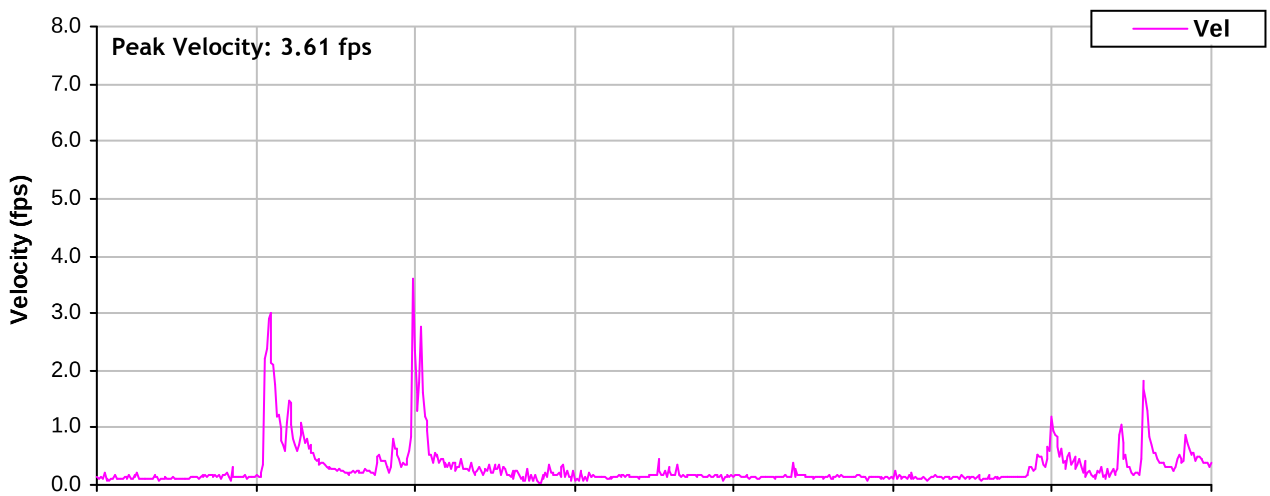
Peak Flow: 0.9 mgd

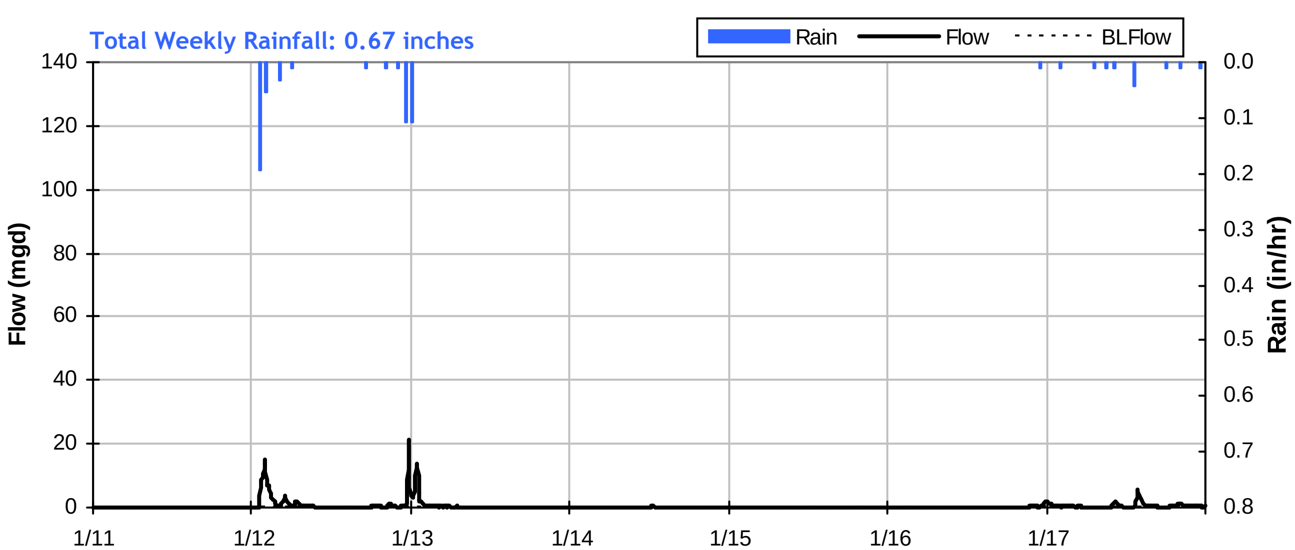
V&A

Level, Velocity and Flow
From 1/11/2010 to 1/18/2010

Monitoring Site:
Site 2



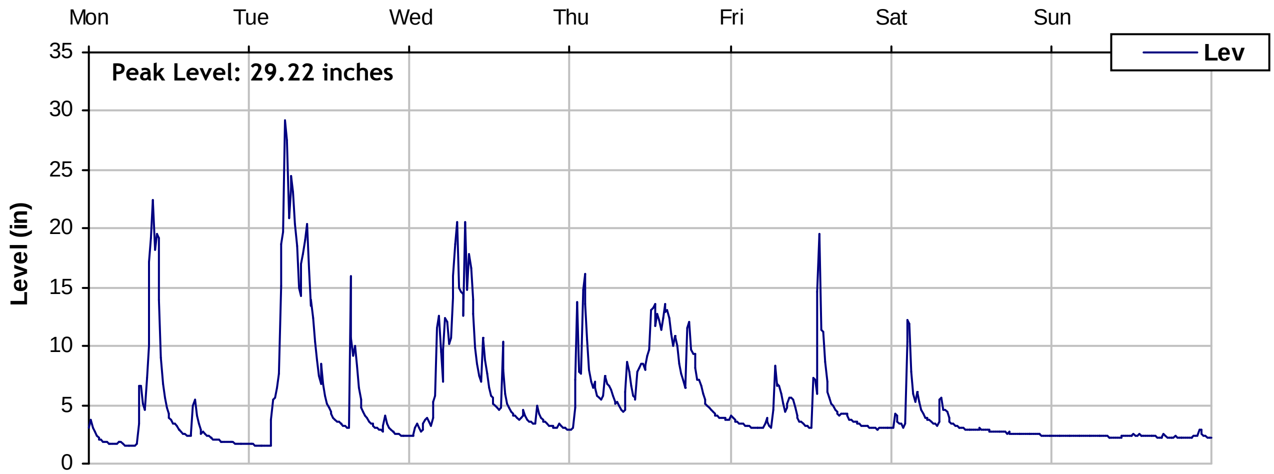


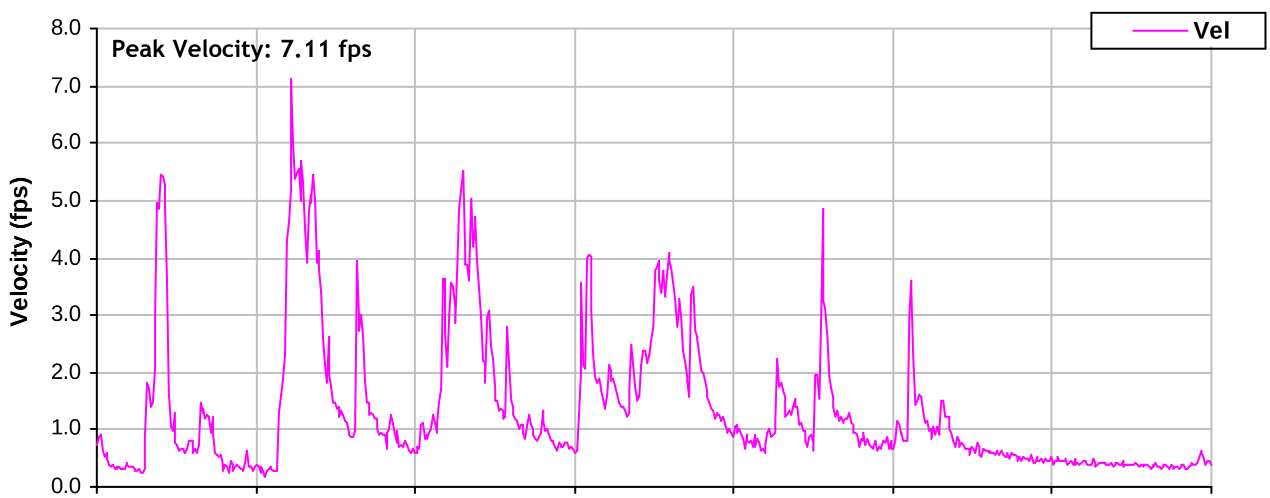


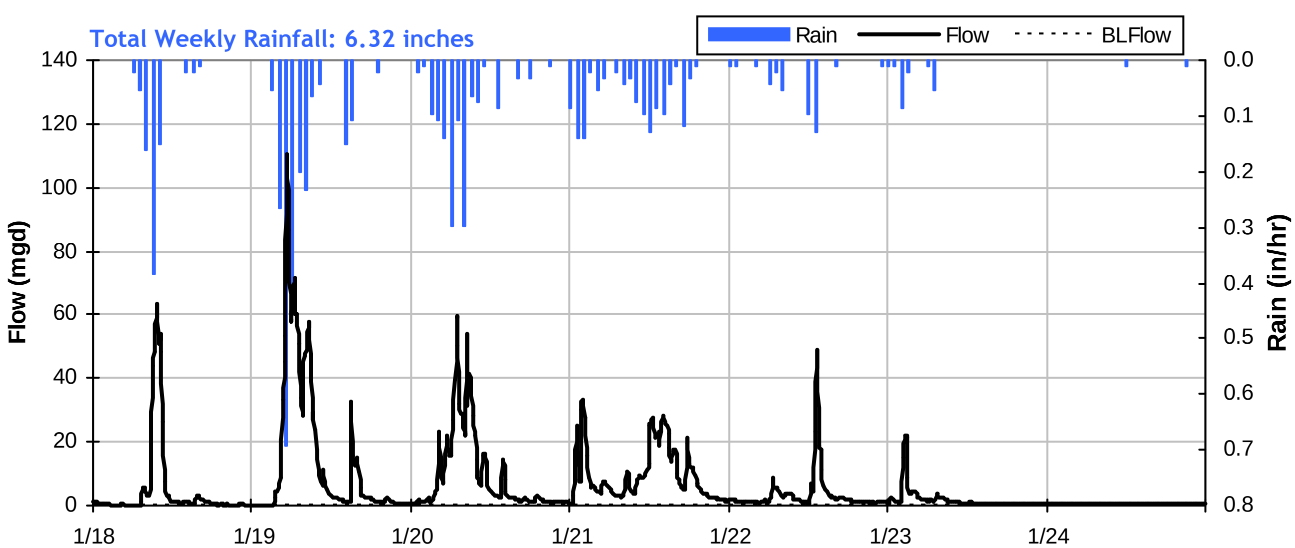
V&A

Level, Velocity and Flow
From 1/18/2010 to 1/25/2010

Monitoring Site:
Site 2

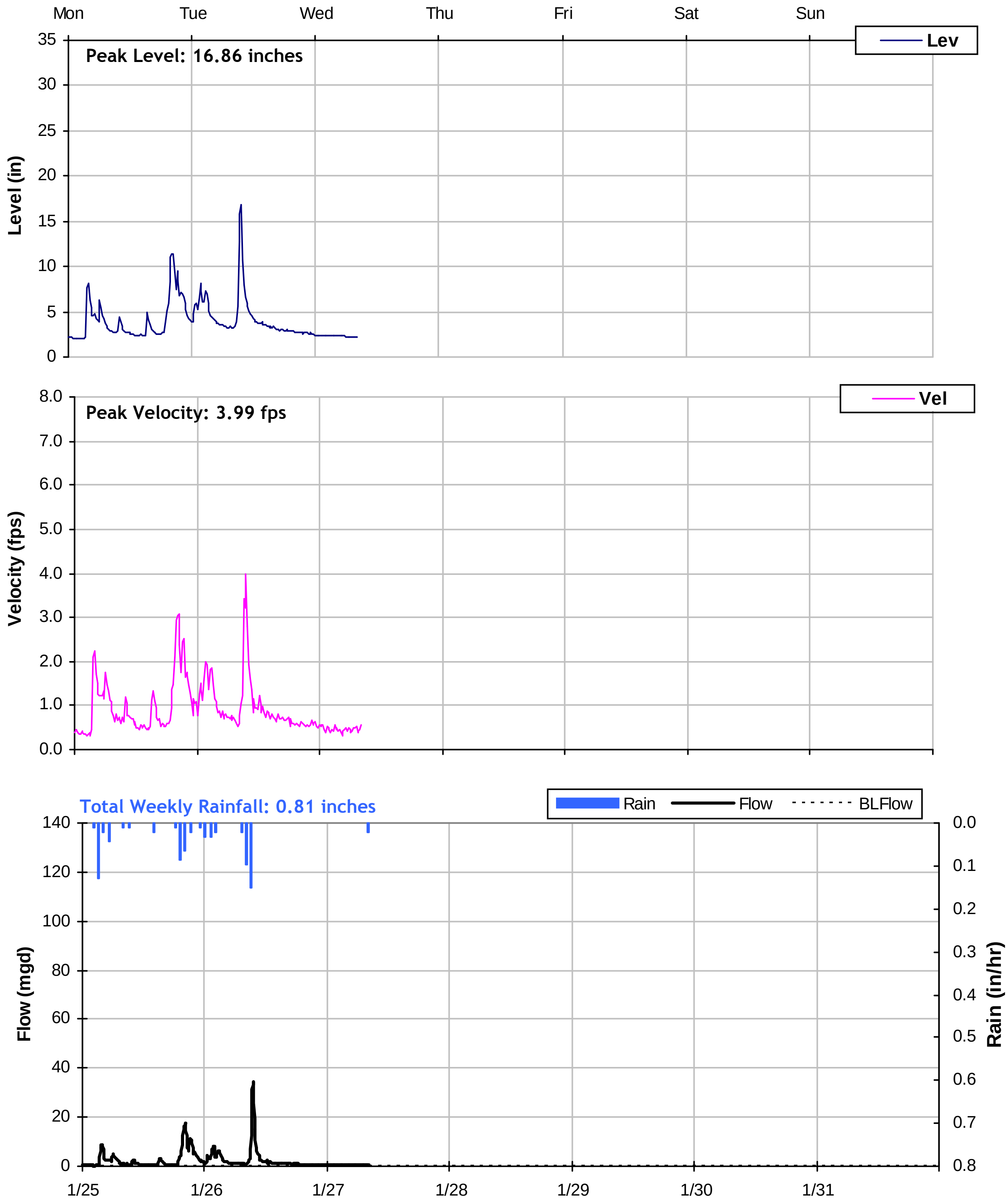






Peak Flow: 109.51 mgd

	Level, Velocity and Flow From 1/25/2010 to 2/1/2010	Monitoring Site: Site 2



Peak Flow: 34.62 mgd

Temporary Flow Monitoring Study

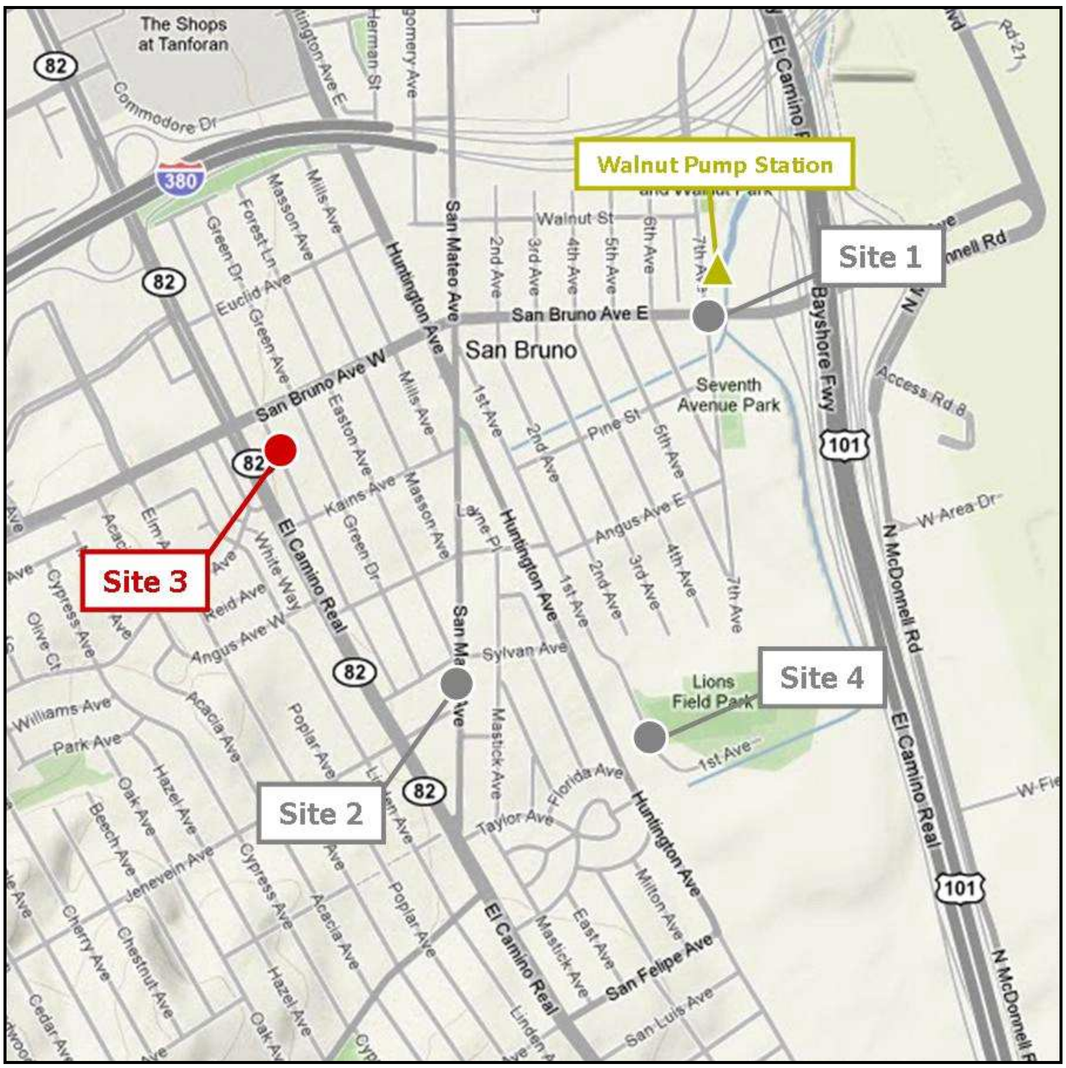
Storm Sewer Collection System

Monitoring Site: Site 3

Location: Hensley Avenue south of San Bruno Avenue (Next to the Toyota Dealership)

Size/Type Line: 10-foot wide irregular trapezoidal channel

Data Summary Report



	Site Information Report	**Monitoring Site:** Site 3

Location: Hensley Avenue south of San Bruno Avenue (Next to the Toyota Dealership)

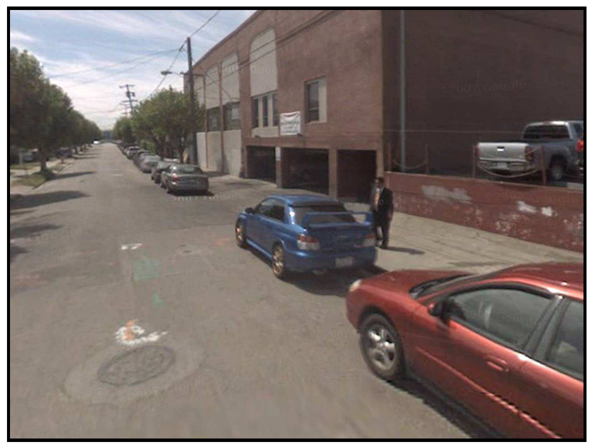
Latitude: 37.6284°

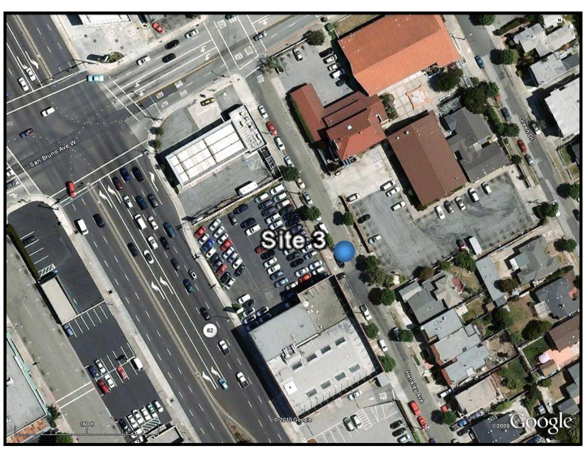
Longitude: -122.4155°

Rim Elevation: 38 *feet*

Pipe size/type: 10-foot wide irregular trapezoidal channel

Peak Measured Flow: 178.49 *mgd*





	Site Photos	**Monitoring Site:** Site 3

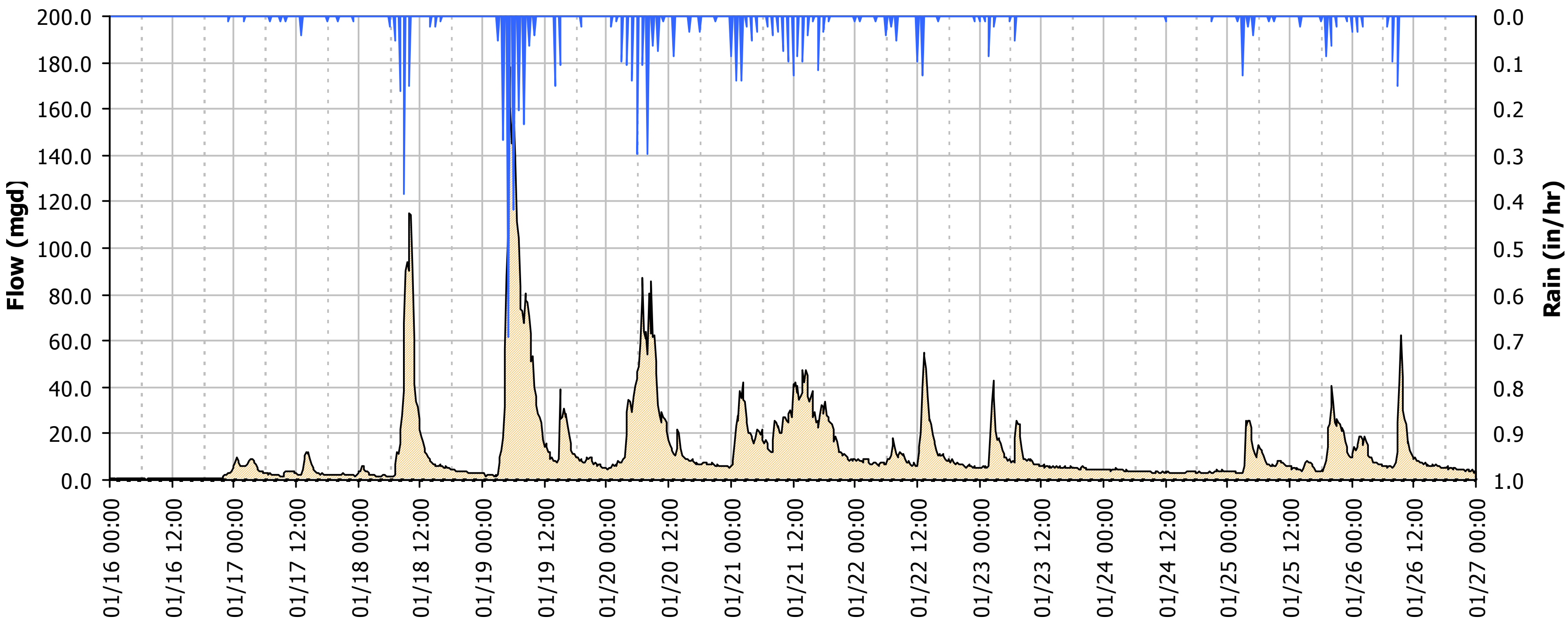
View Looking Upstream

Downstream Overflow Channel

Storm Sewer Flow Summary
January 16 - January 27, 2010

Monitoring Site:
Site 3

Storm Event #1 Detail Hydrograph Graph



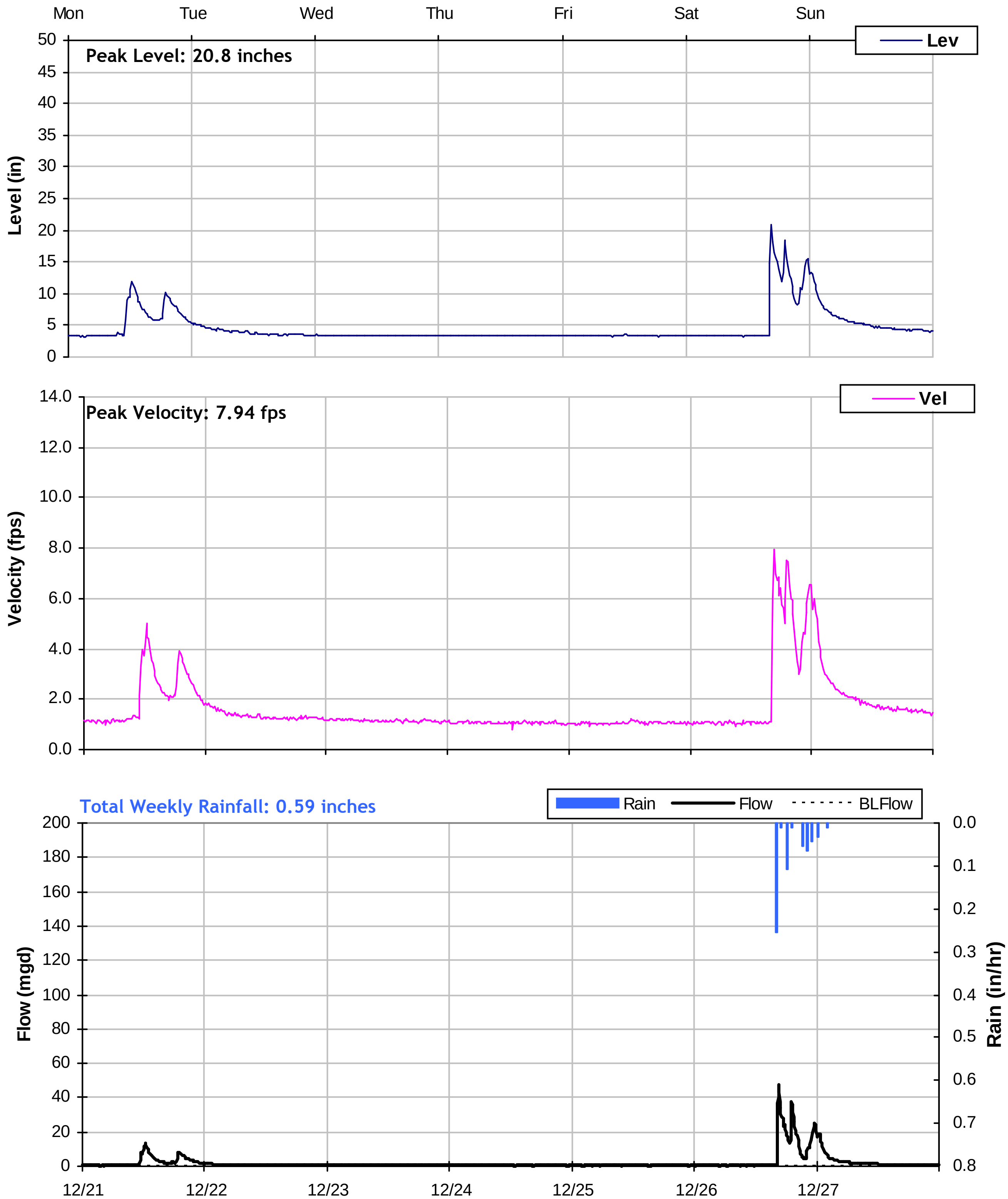
Storm Event #1 Analysis

Rainfall:	7.24	*inches*
Peak Flow:	178.49	*mgd*
Peak Level:	42.50	*inches*
Percent Full:	133%	
Totalalized Flow:	136,465,000	*gallons*

V&A

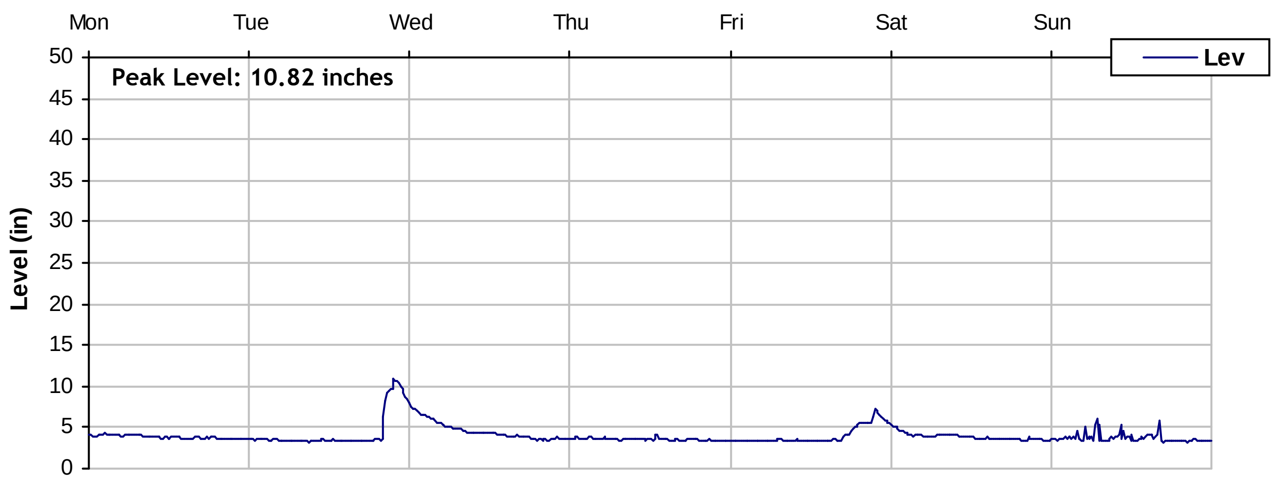
Level, Velocity and Flow
From 12/21/2009 to 12/28/2009

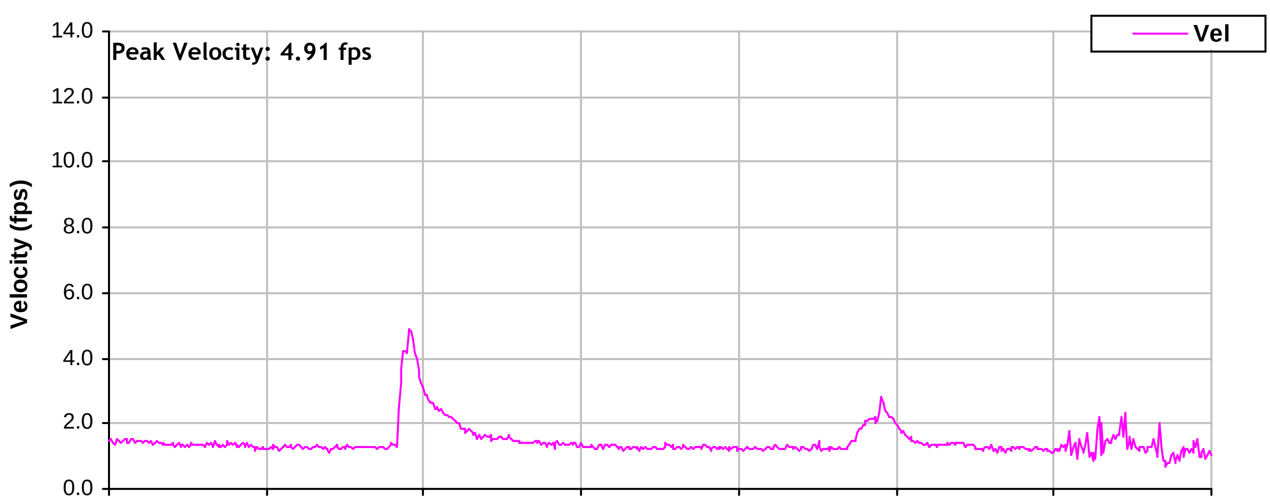
Monitoring Site:
Site 3

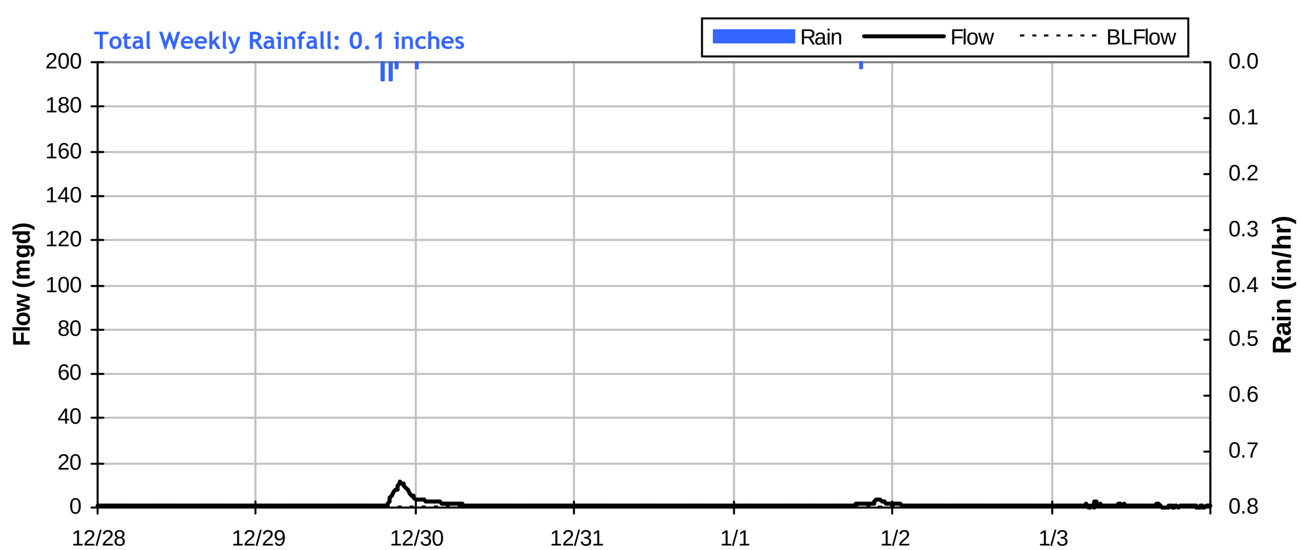


Peak Flow: 47.17 mgd

	Level, Velocity and Flow From 12/28/2009 to 1/4/2010	**Monitoring Site:** Site 3

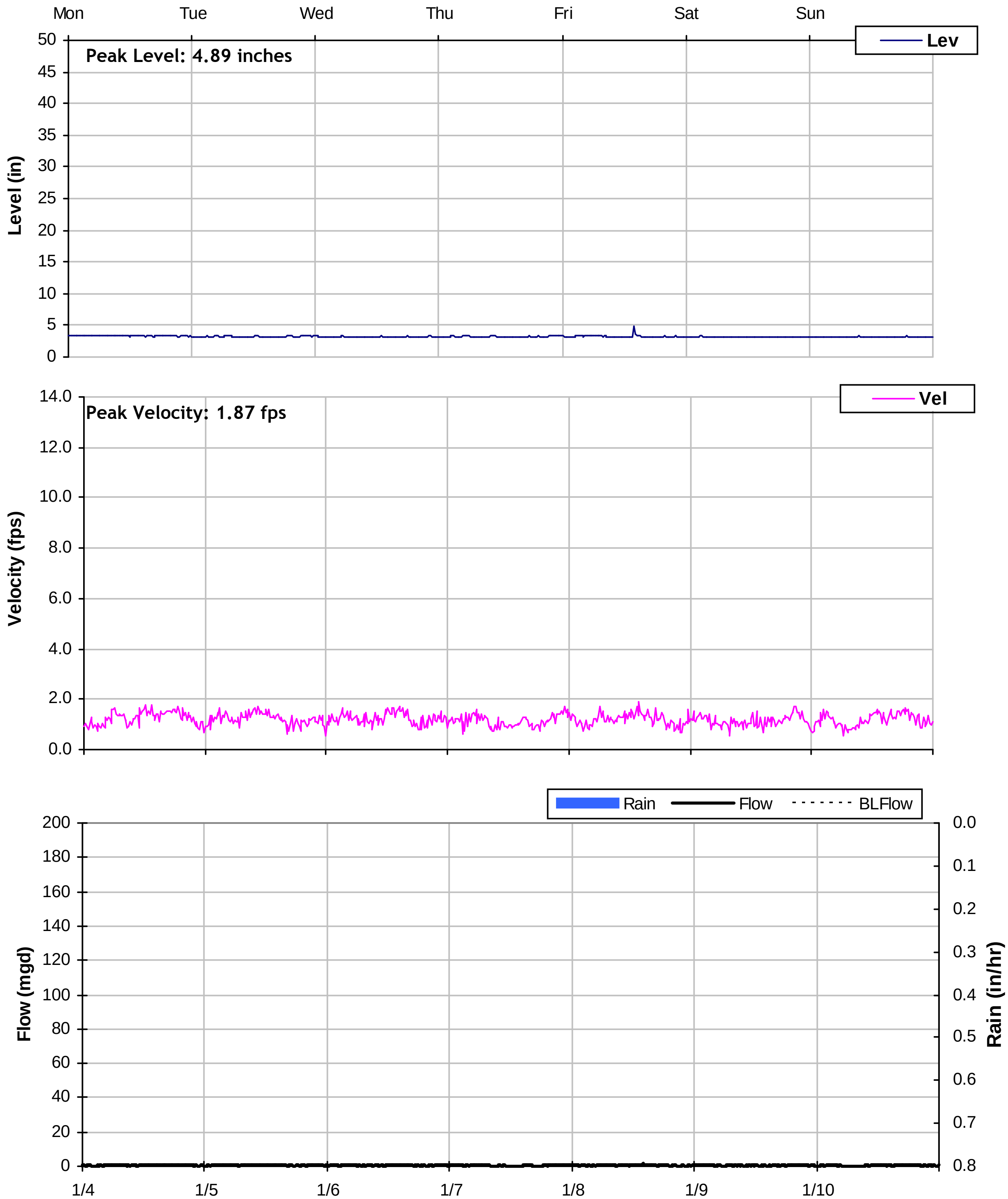






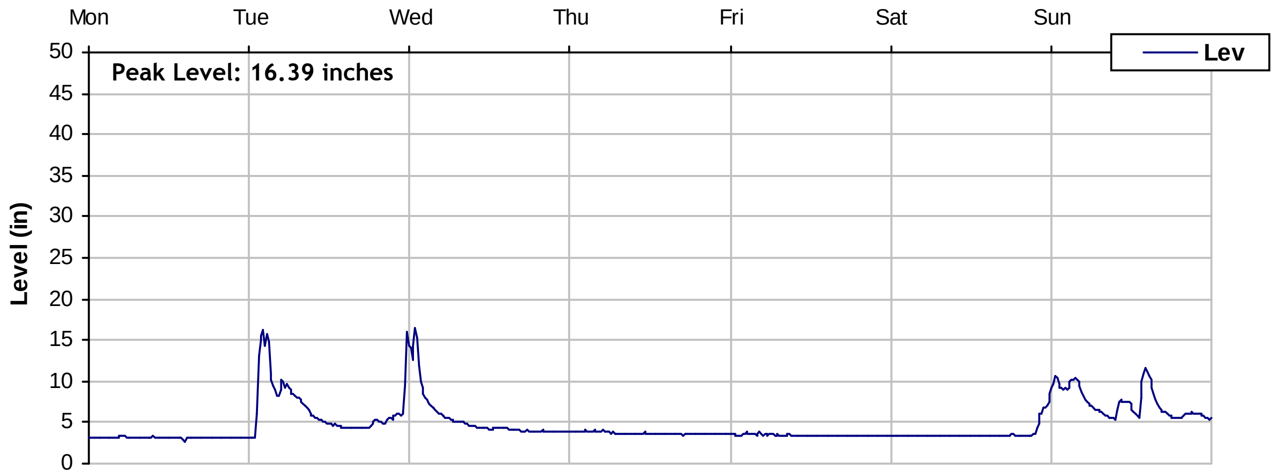
Peak Flow: 11.49 mgd

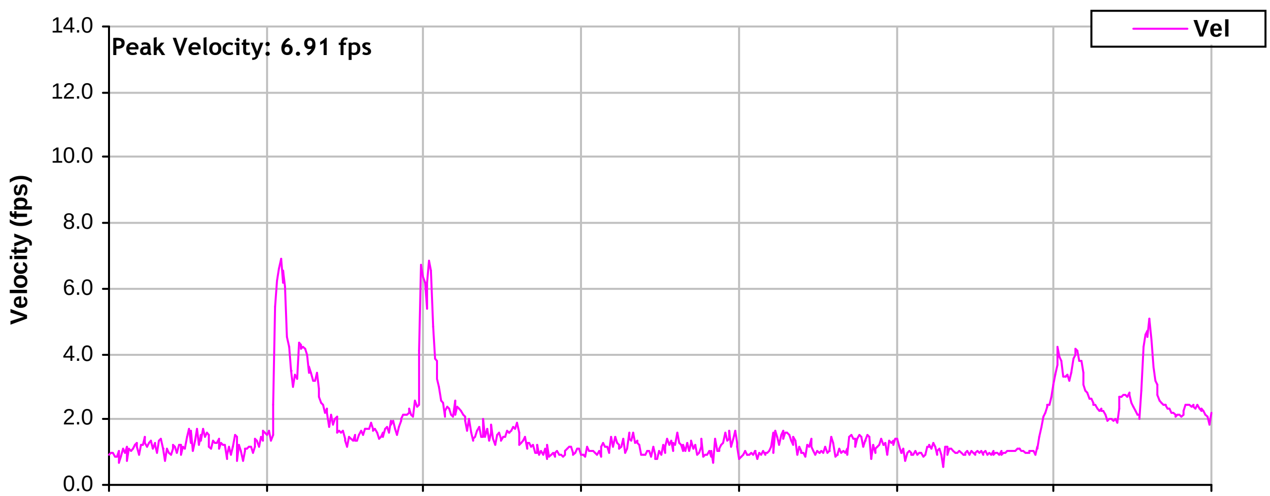
	Level, Velocity and Flow From 1/4/2010 to 1/11/2010	**Monitoring Site:** Site 3

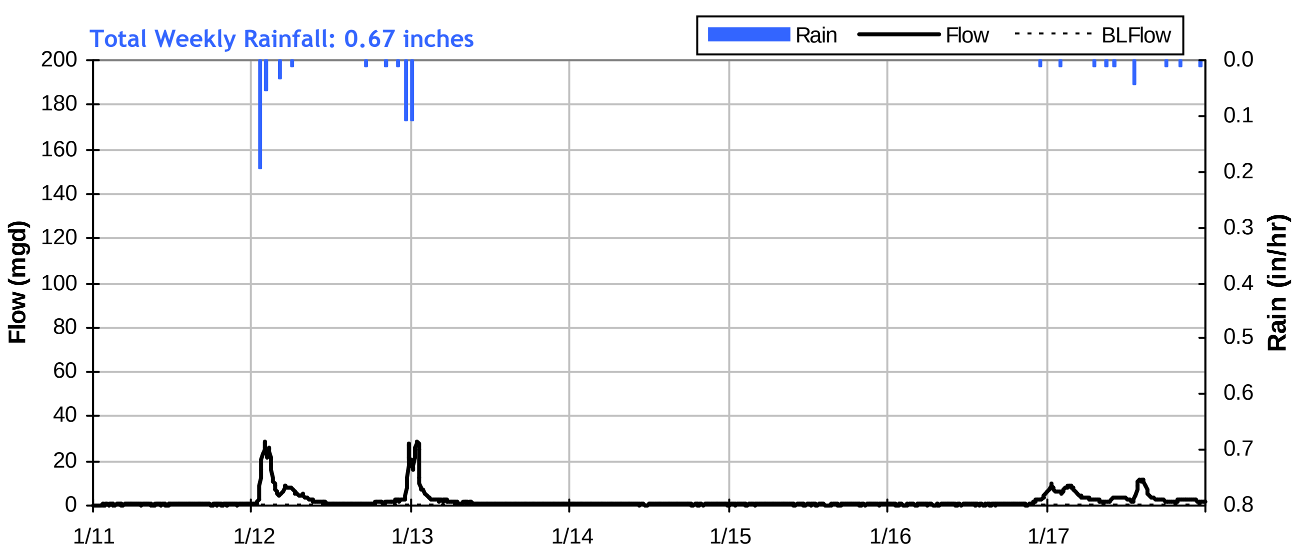


Peak Flow: 1.45 mgd

	Level, Velocity and Flow From 1/11/2010 to 1/18/2010	**Monitoring Site:** Site 3



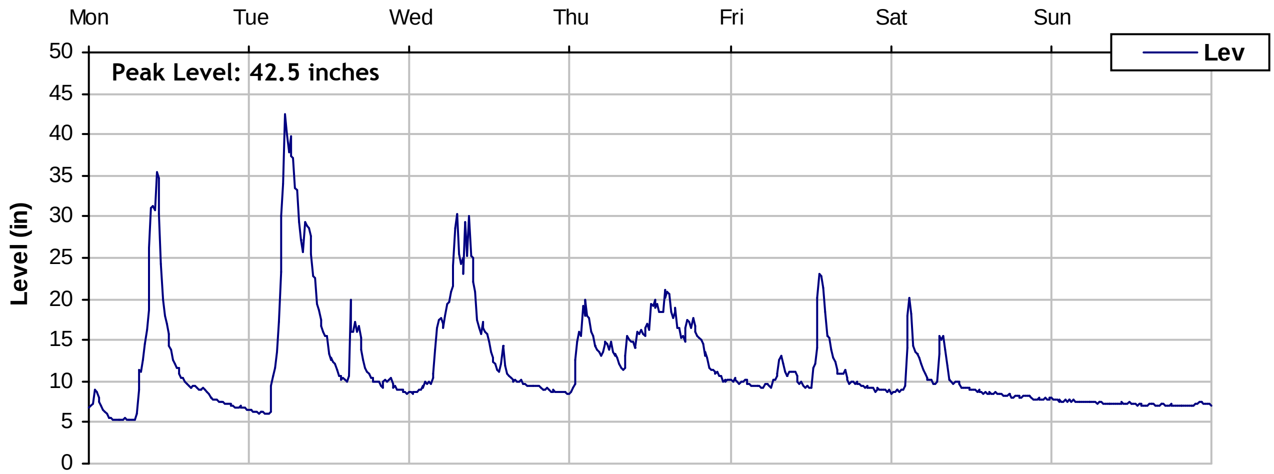


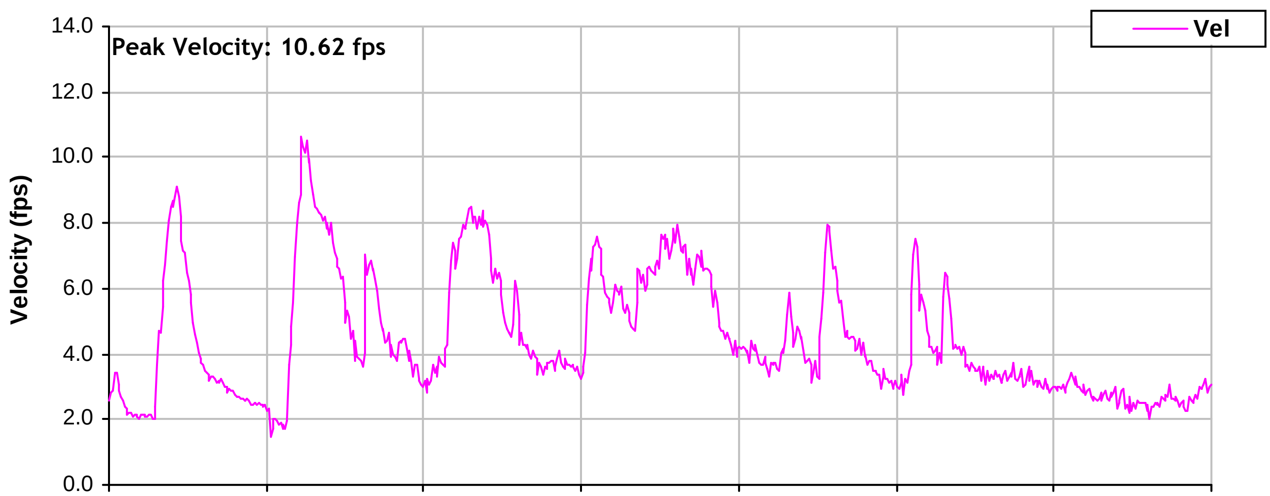


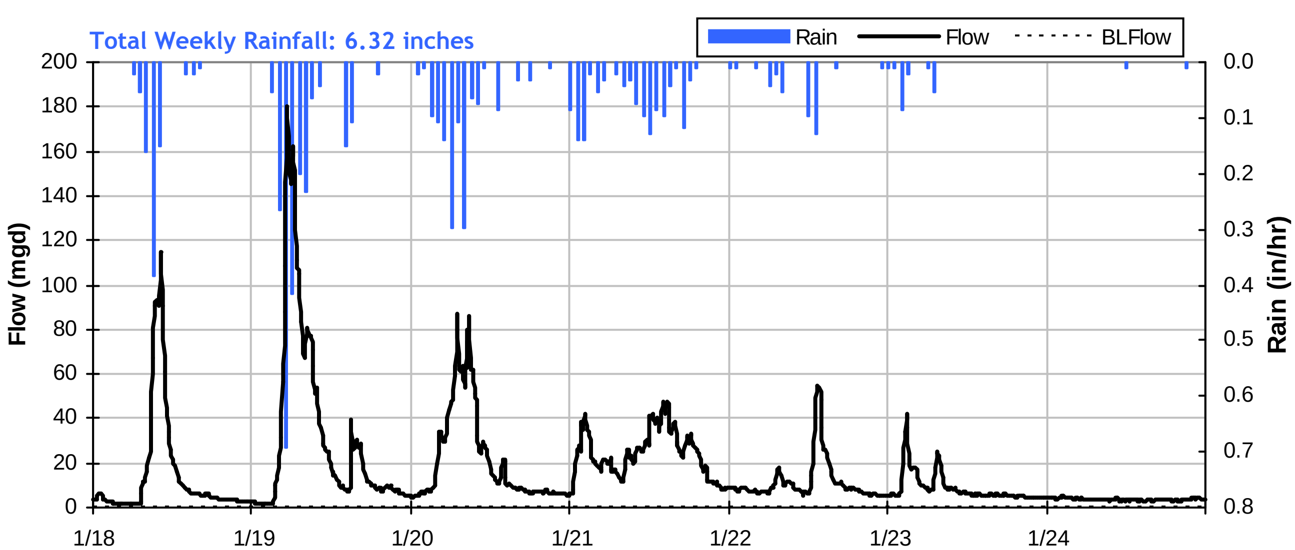
Peak Flow: 28.97 mgd

Level, Velocity and Flow
From 1/18/2010 to 1/25/2010

Monitoring Site:
Site 3







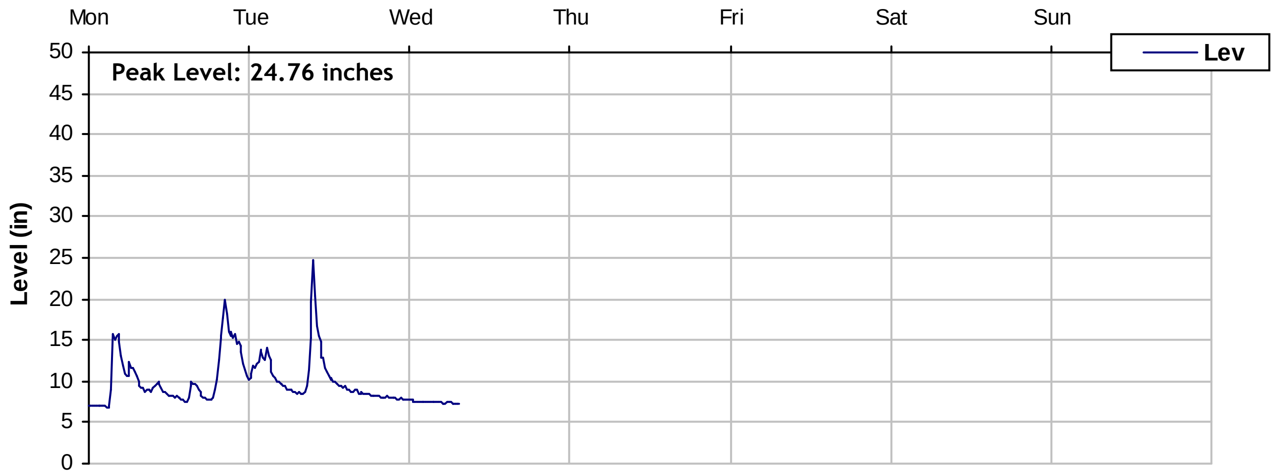
Peak Flow: 178.49 mgd

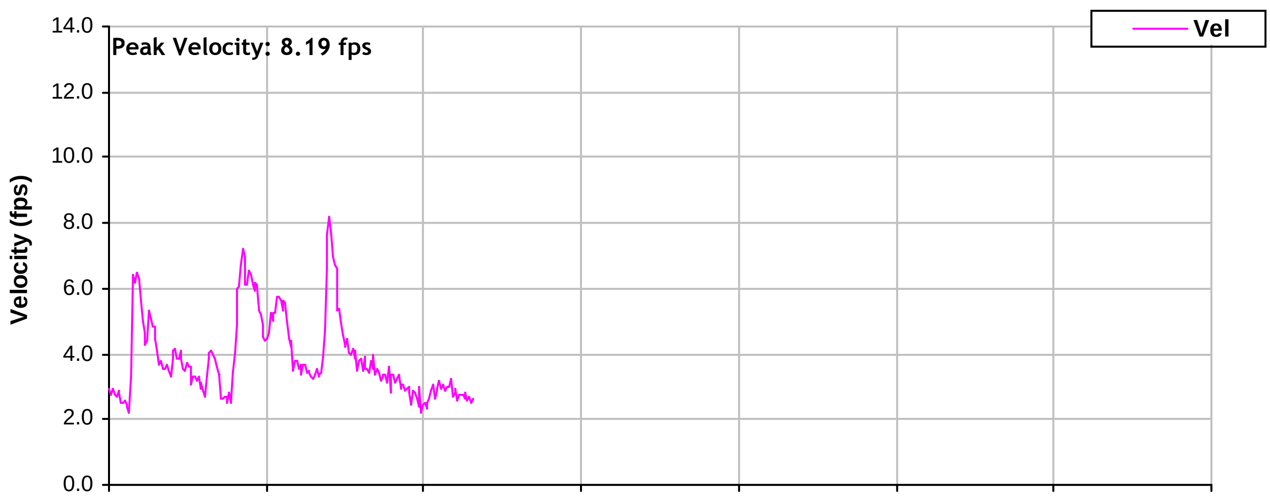
Level, Velocity and Flow

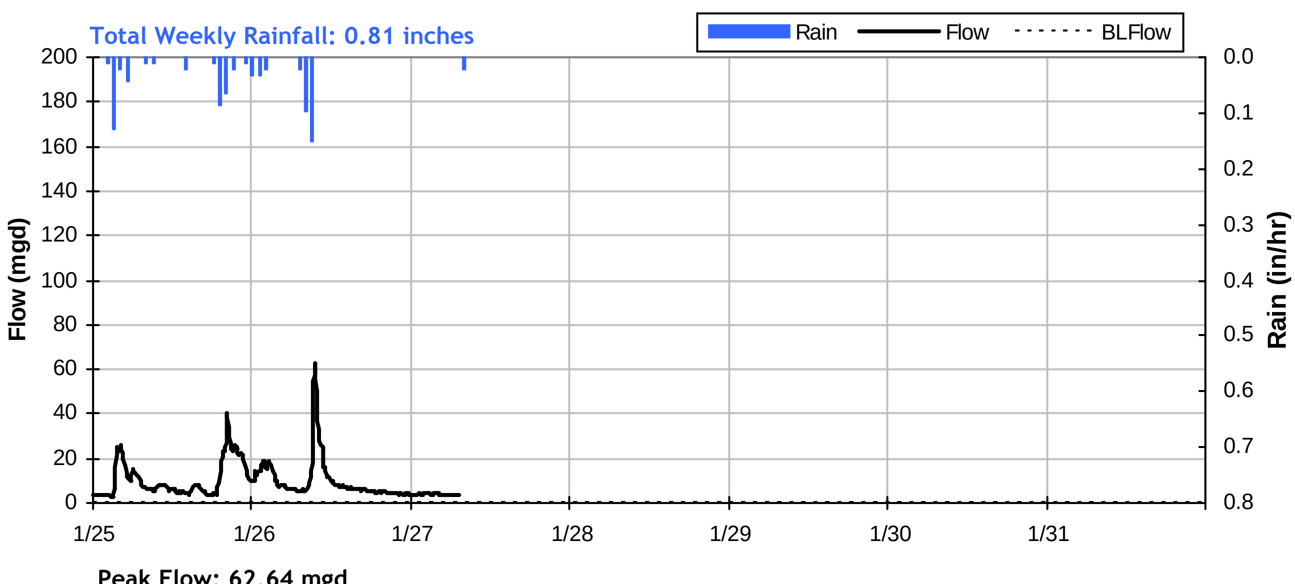
From 1/25/2010 to 2/1/2010

Monitoring Site:

Site 3







Temporary Flow Monitoring Study

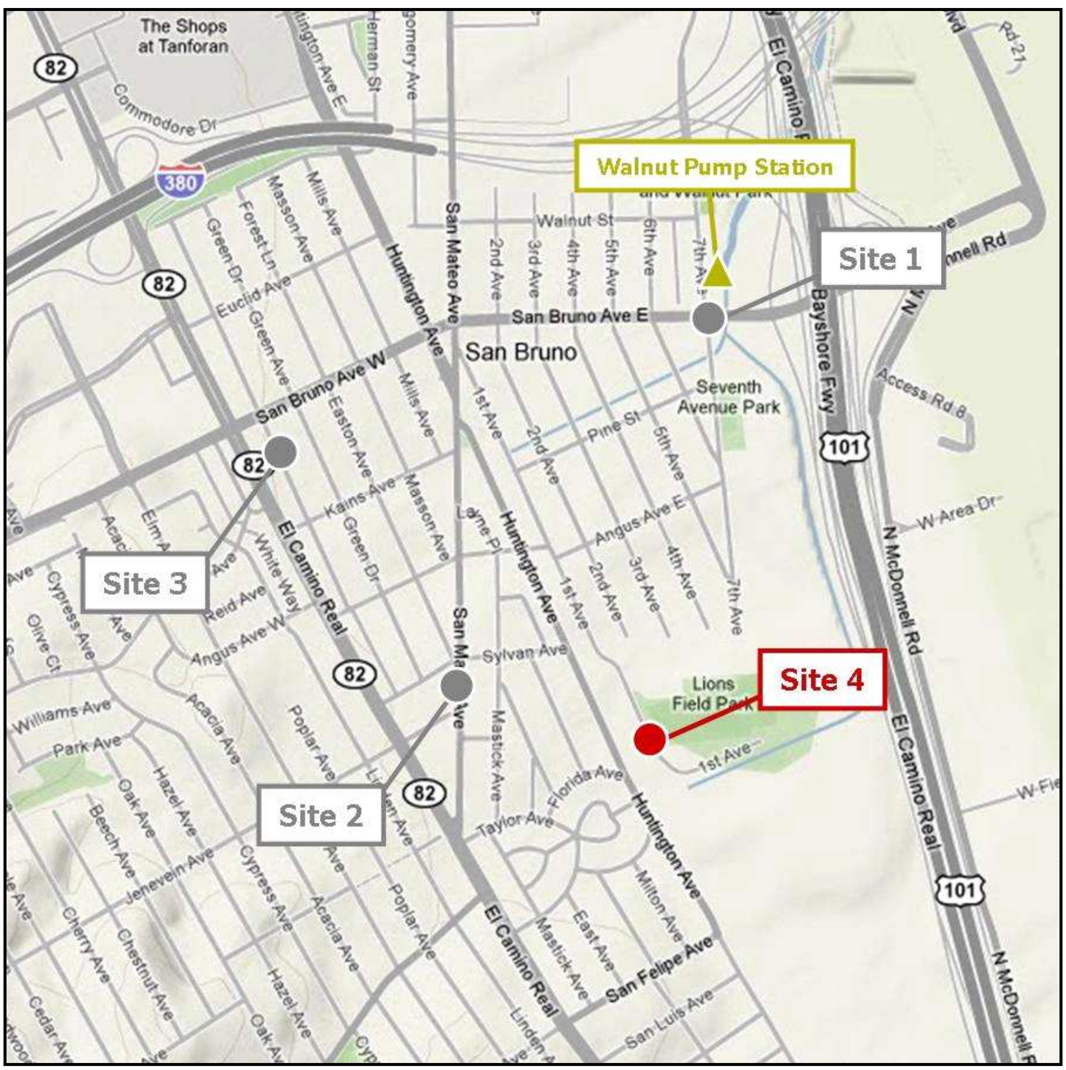
Storm Sewer Collection System

Monitoring Site: Site 4

Location: Creek along 1st Avenue (Parking Lot by Baseball Field of Belle Air School)

Size/Type Line: 40-foot wide trapezoidal channel

Data Summary Report



Site Information Report

Monitoring Site: Site 4

Location: Creek along 1st Avenue (Parking Lot by Baseball Field of Belle Air School)

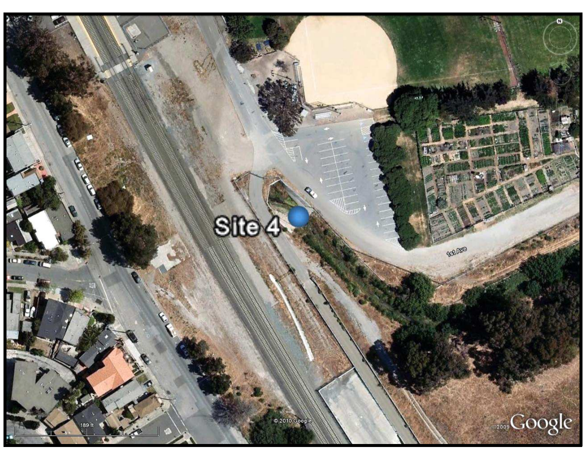
Latitude: 37.6226°

Longitude: -122.4066°

Rim Elevation: 10 *feet*

Pipe size/type: 40-foot wide trapezoidal channel

Peak Measured Flow: 103.54 *mgd*



V&A

	Site Photos	**Monitoring Site:** Site 4

Trapezoidal Channel

Upstream Inlets to Channel

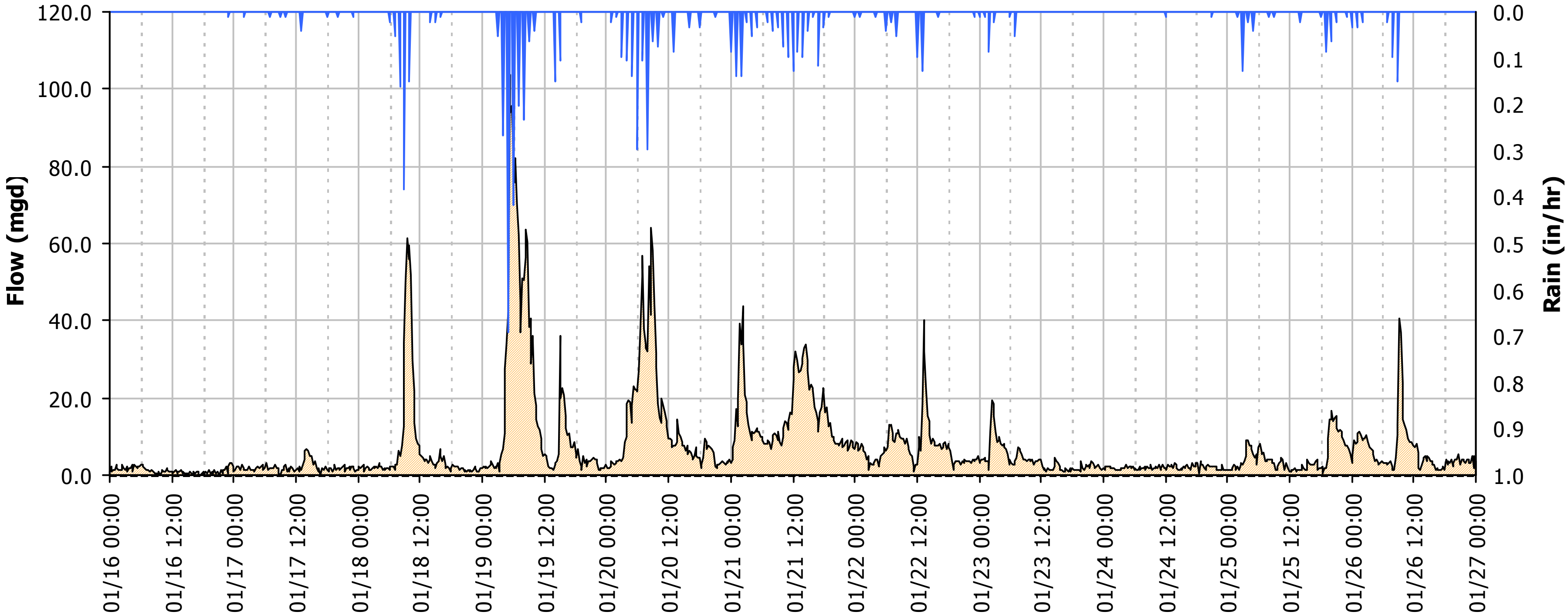
Storm Sewer Flow Summary

January 16 - January 27, 2010

Monitoring Site:

Site 4

Storm Event #1 Detail Hydrograph Graph



Storm Event #1 Analysis

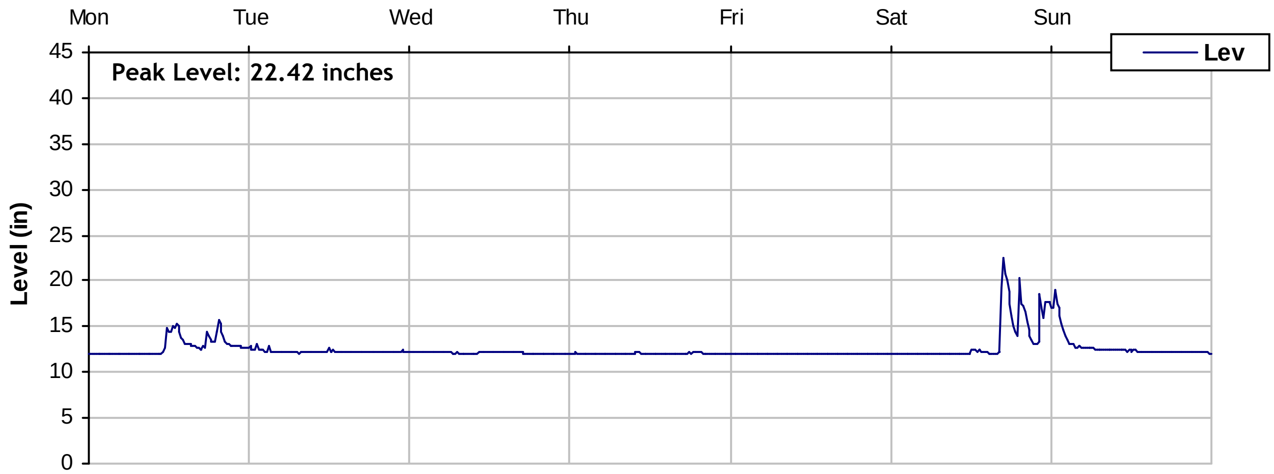
Rainfall:	7.24	*inches*
Peak Flow:	103.54	*mgd*
Peak Level:	38.42	*inches*
Percent Full:	48%	
Totalalized Flow:	80,423,000	*gallons*

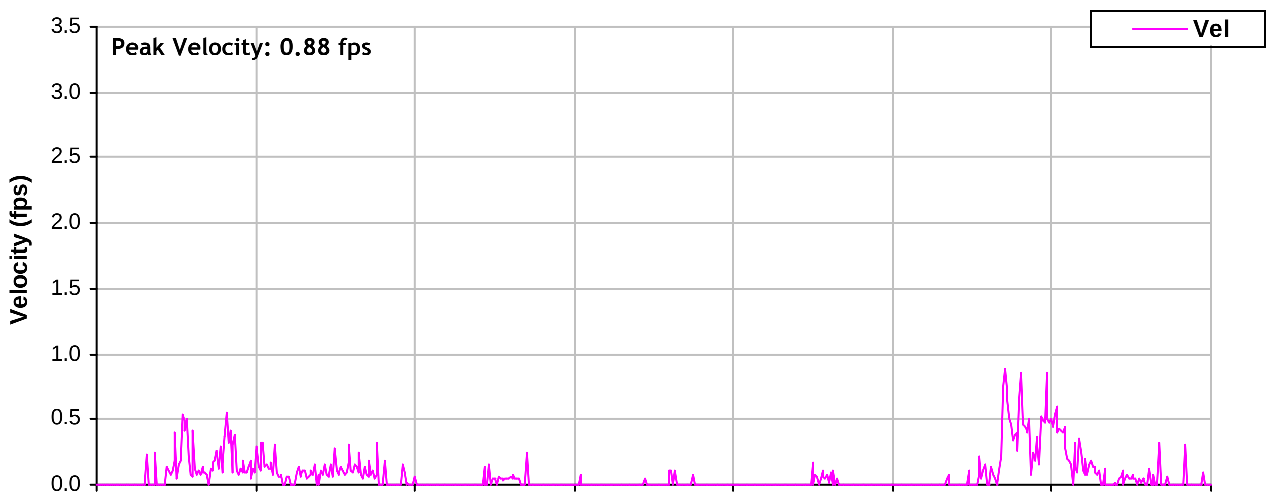
Level, Velocity and Flow

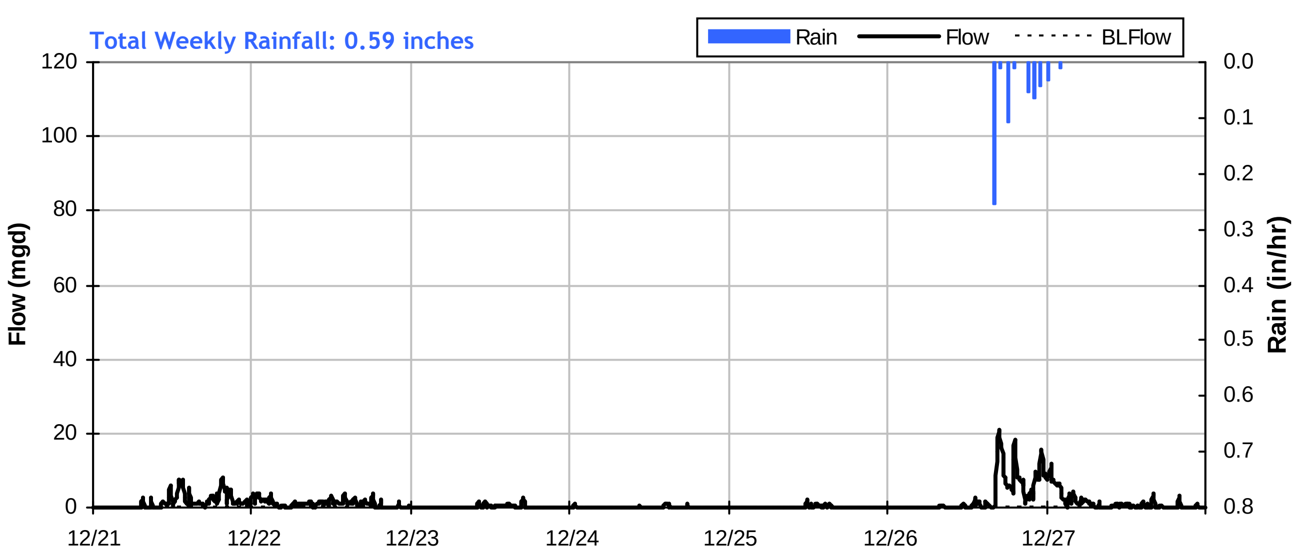
From 12/21/2009 to 12/28/2009

Monitoring Site:

Site 4

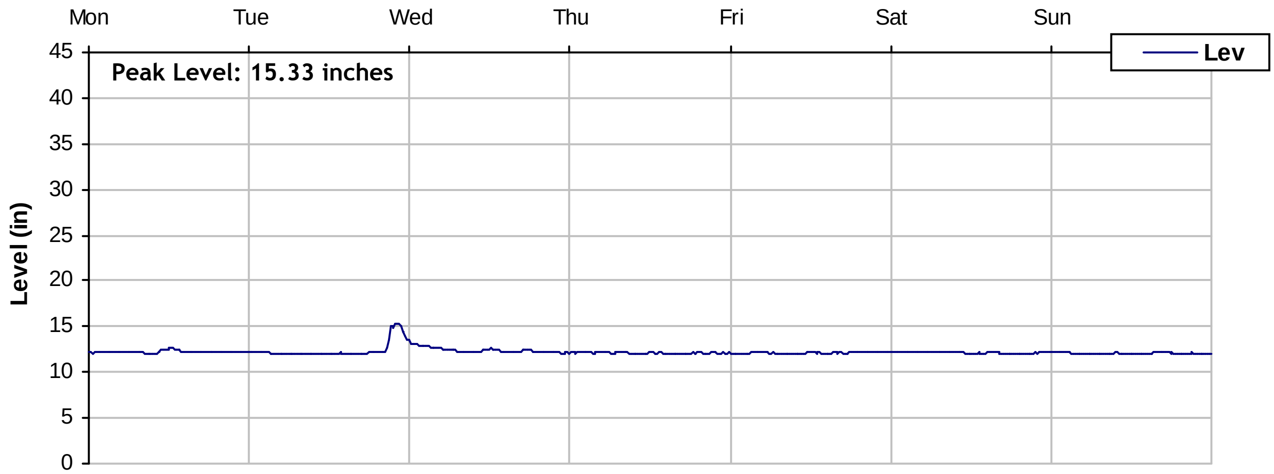


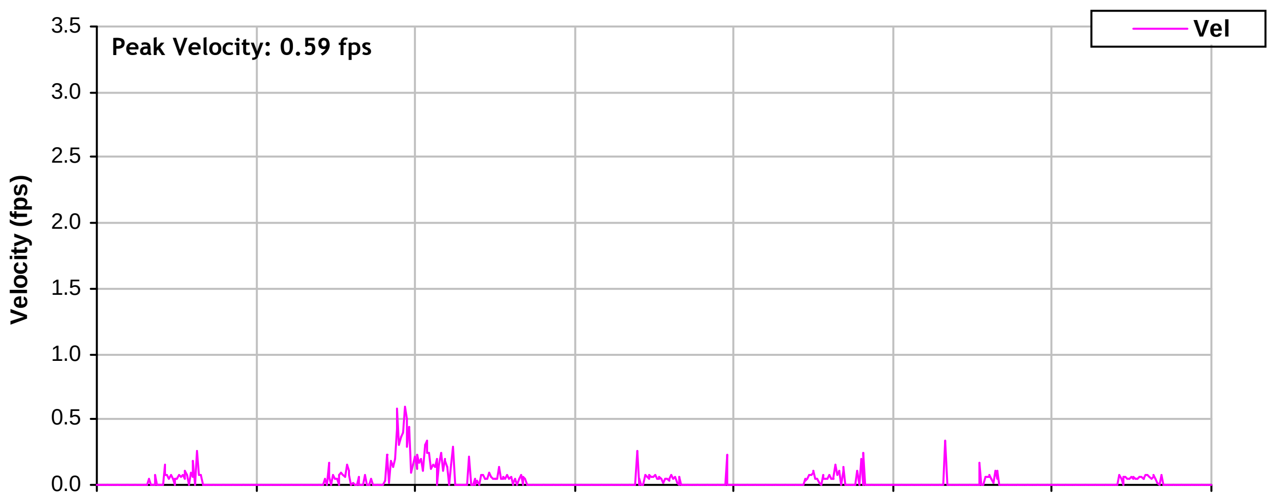


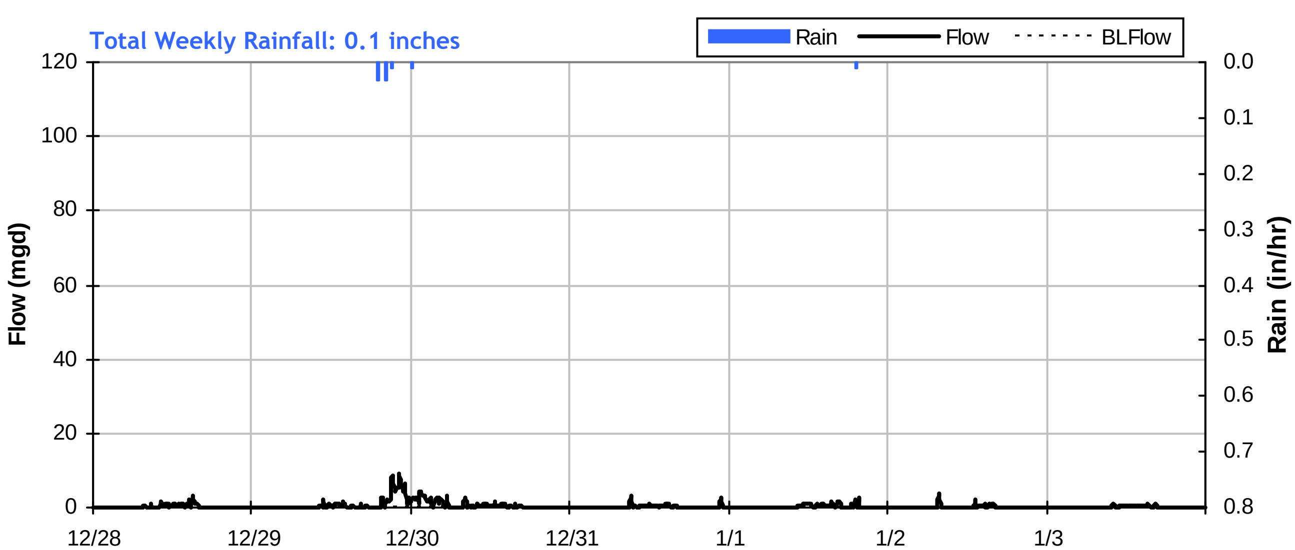


Peak Flow: 21.07 mgd

	Level, Velocity and Flow From 12/28/2009 to 1/4/2010	**Monitoring Site:** Site 4



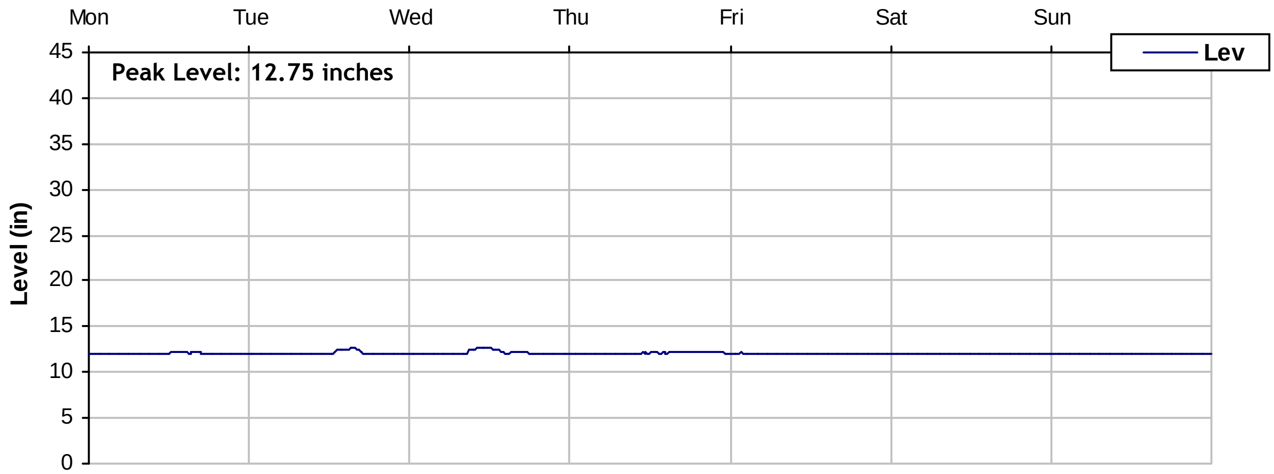


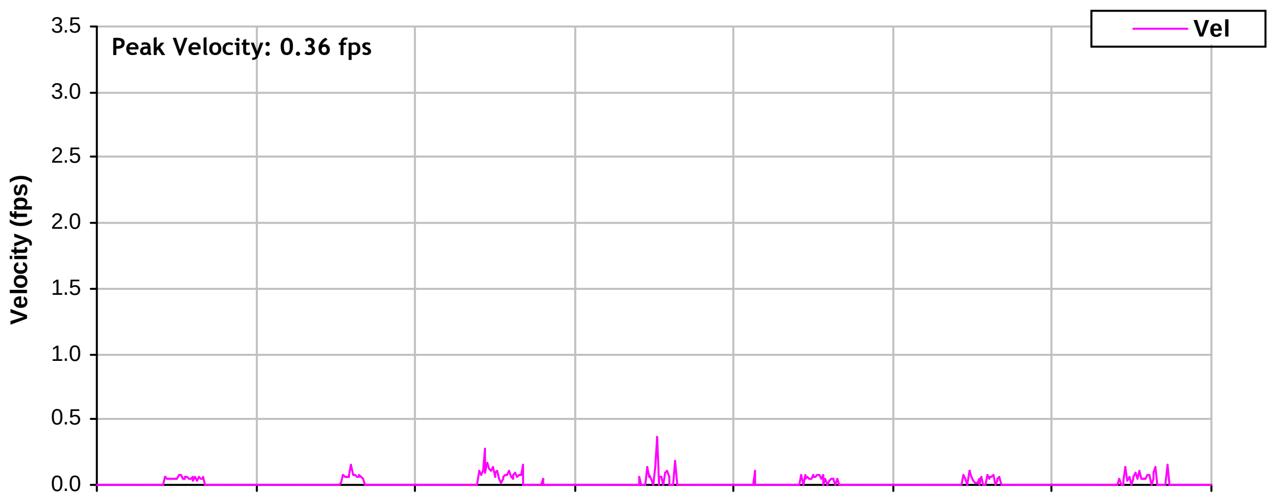


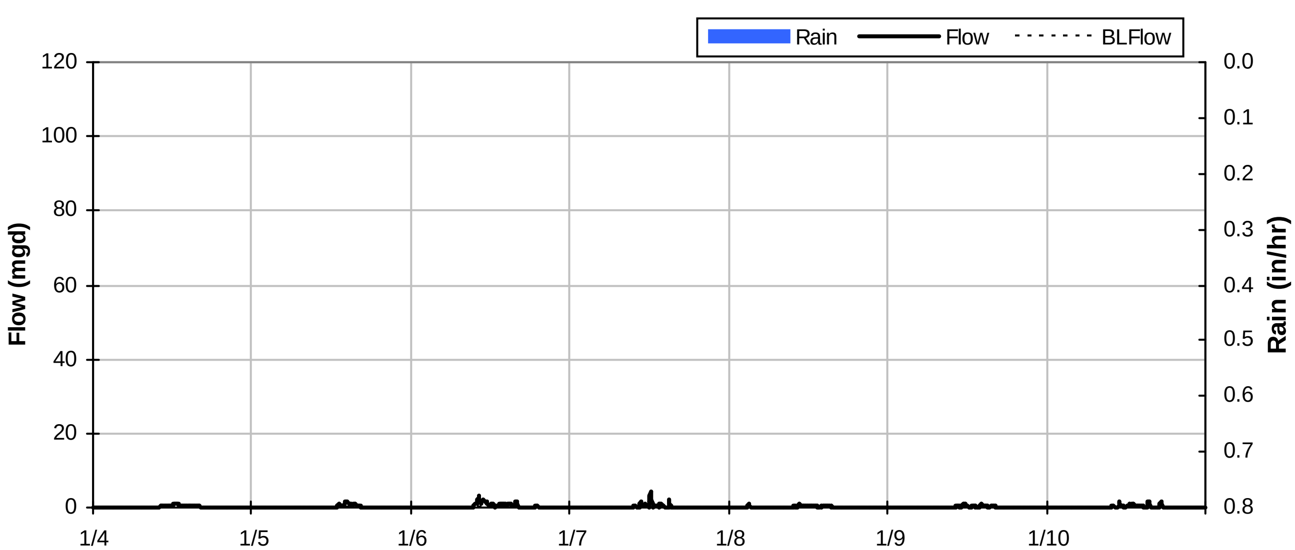
Peak Flow: 8.98 mgd

Level, Velocity and Flow
From 1/4/2010 to 1/11/2010

Monitoring Site:
Site 4



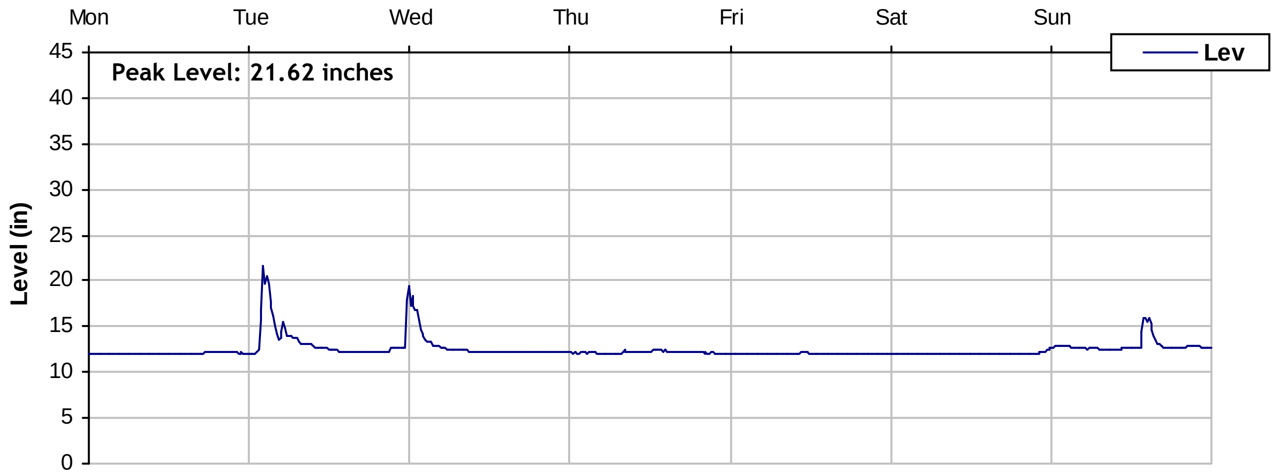


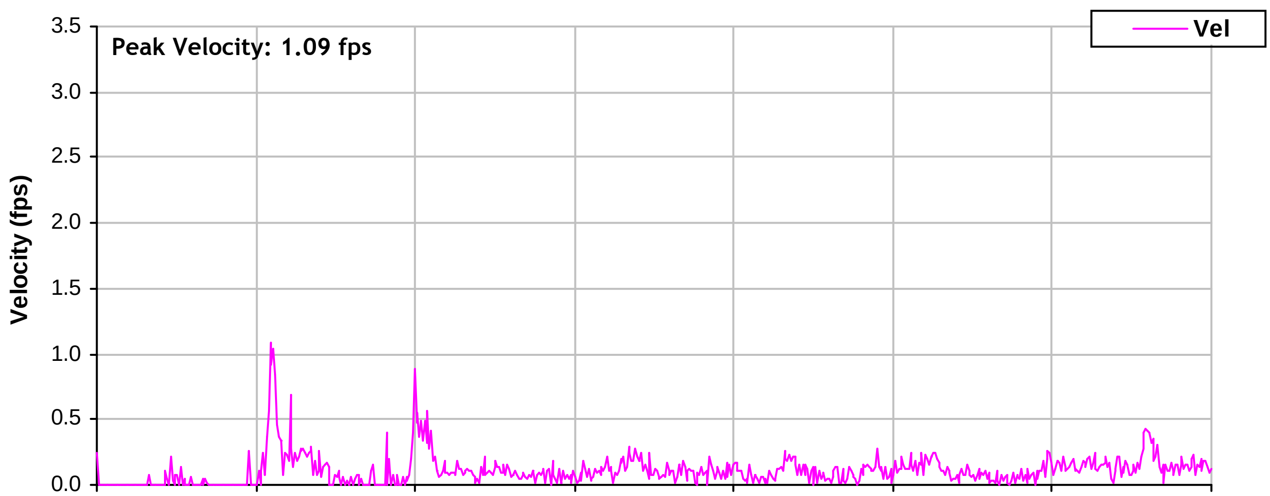


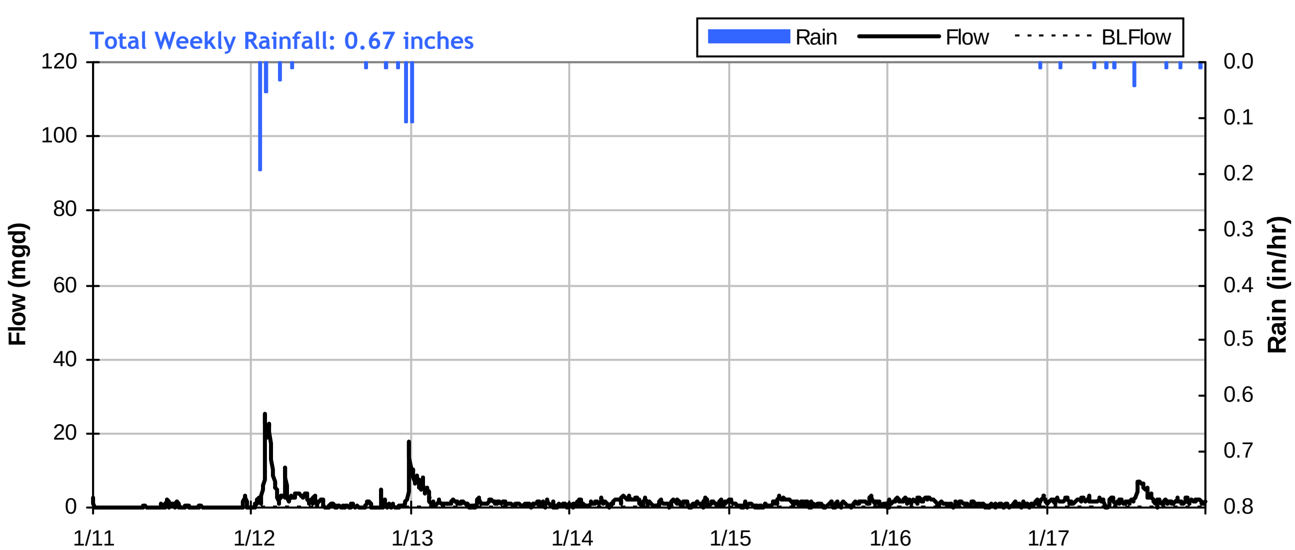
Peak Flow: 4.16 mgd

V&A

	Level, Velocity and Flow From 1/11/2010 to 1/18/2010	**Monitoring Site:** Site 4

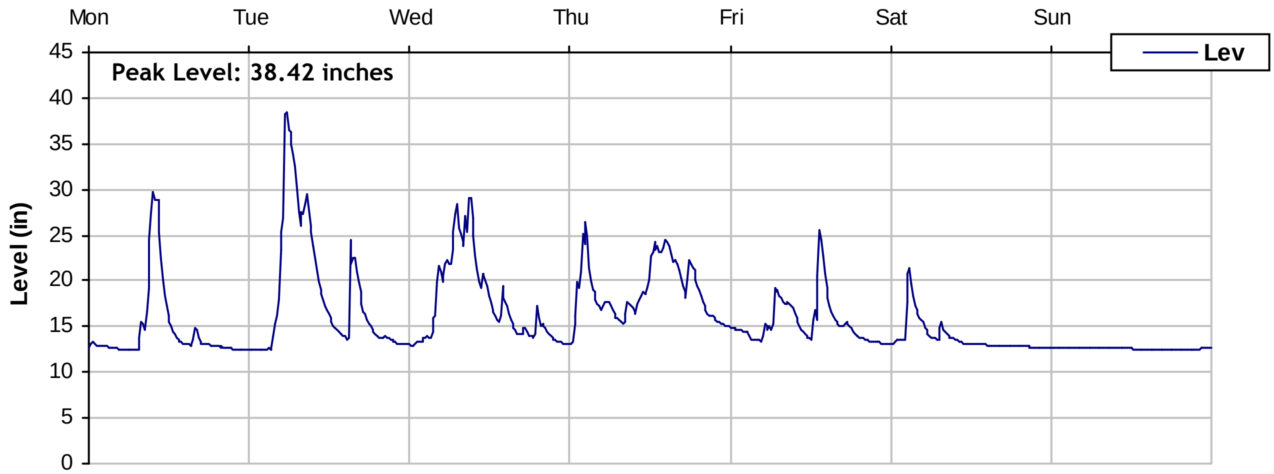


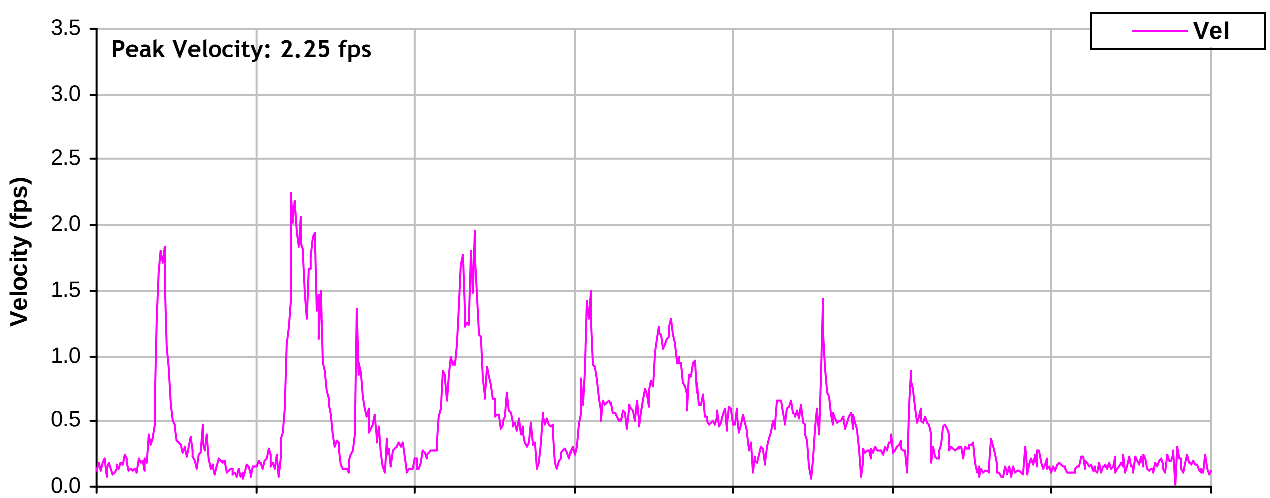


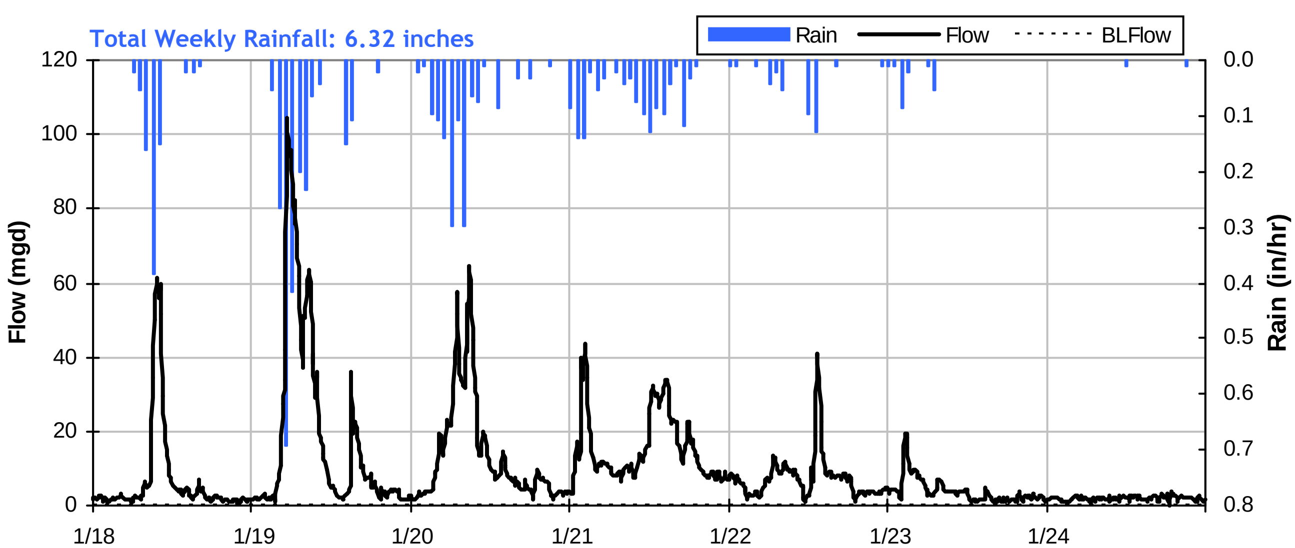


Peak Flow: 25.03 mgd

	Level, Velocity and Flow From 1/18/2010 to 1/25/2010	**Monitoring Site:** Site 4







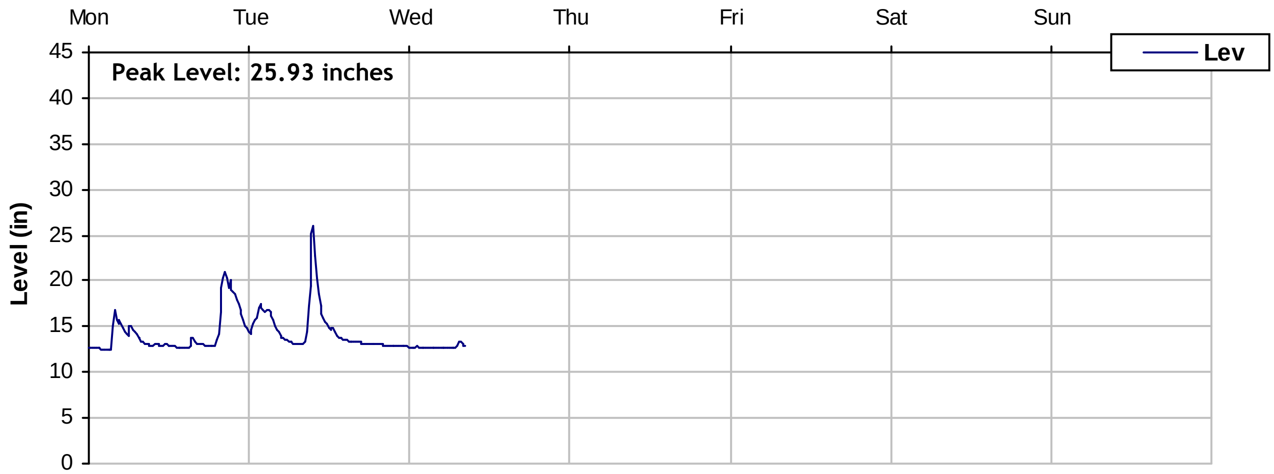
Peak Flow: 103.54 mgd

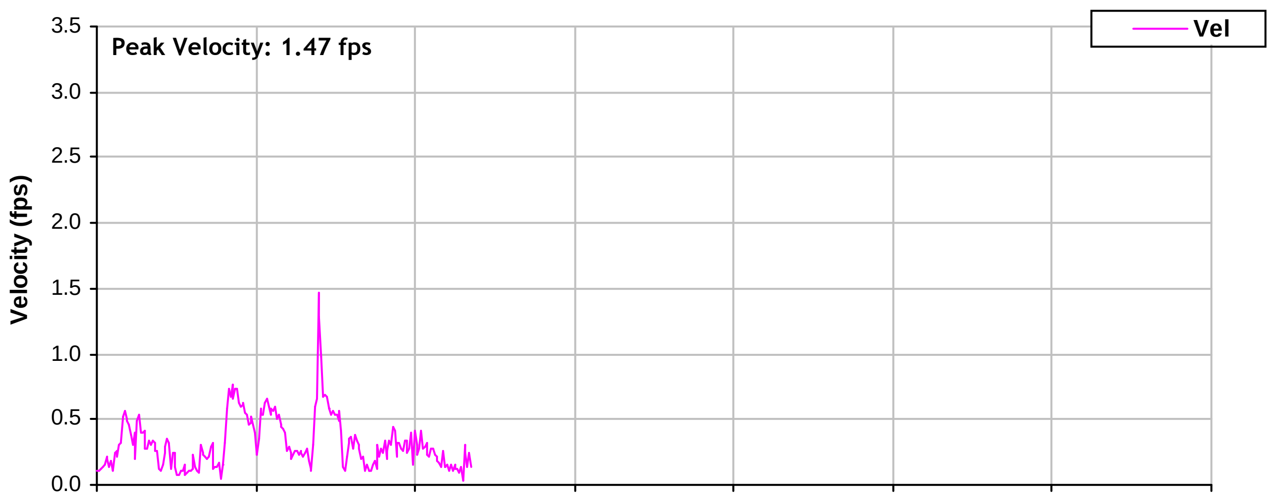
Level, Velocity and Flow

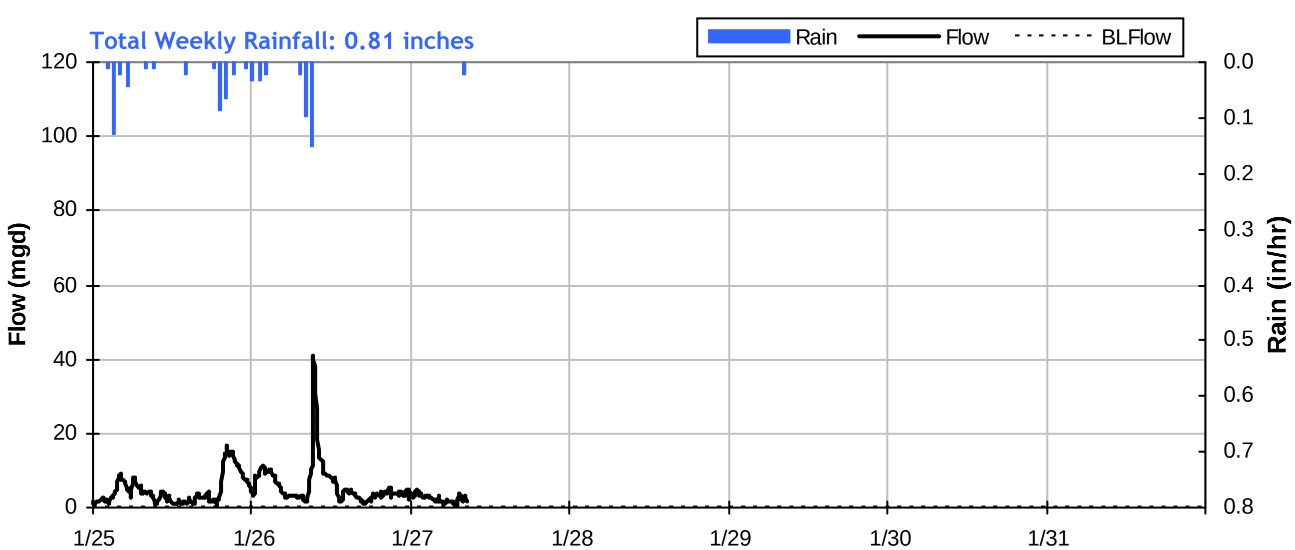
From 1/25/2010 to 2/1/2010

Monitoring Site:

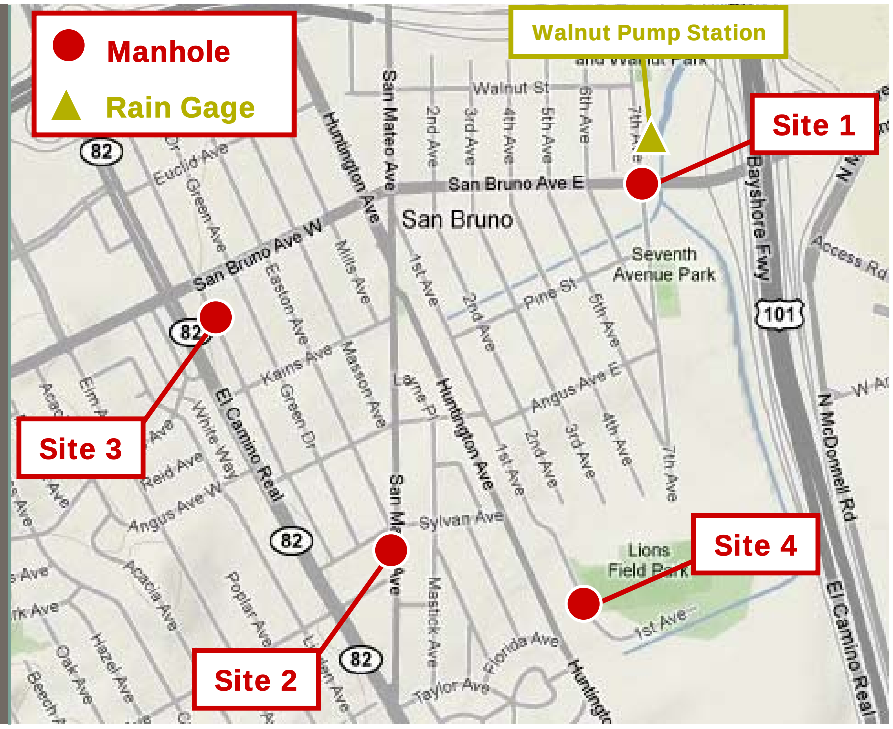
Site 4







Peak Flow: 40.41 mgd



Oakland
155 Grand Avenue, Suite 700
Oakland, CA 94612
510.903.6600 **Tel**
510.903.6601 **Fax**

San Diego
8291 Aero Place, Suite 110
San Diego, CA 92123
858.576.0226 **Tel**
858.576.0004 **Fax**

Seattle
14900 Interurban Avenue, Suite 268
Seattle, WA 96818
206.674.4560 **Tel**
206.674.4561 **Fax**

Houston
8220 Jones Road, Suite 500
Houston, TX 77065
713.840.6490 **Tel**
713.840.6491 **Fax**

vaengineering.com

Appendix C – CIP Cost Estimate Worksheets

City of San Bruno Storm Drain System CIP - Cost Estimate Summary[1]

Estimate of Probable Project Cost (incl. Engineering & CM)		
Watershed	**Pipe Improvement Option**	**Detention Option**
A-Total	$15,950,000	$8,680,000
A-1	$5,070,000	$5,070,000
A-2	$2,670,000	$2,790,000
A-3	$820,000	$820,000
A-4	$2,720,000	-
A-5	$4,670,000	-
B-Total	$1,180,000	$1,890,000
B-1	$1,090,000	$1,890,000
B-2	$90,000	-
C-Total	$5,180,000	$5,180,000
C-1	$150,000	$150,000
C-2	$2,240,000	$2,240,000
C-3	$1,410,000	$1,410,000
C-4	$1,380,000	$1,380,000
D	$220,000	$220,000
E	$1,960,000	$1,960,000
F	$1,890,000	$1,890,000
Subtotal	***$26,380,000***	***$19,820,000***

1 - costs reflect escalation to March 2013

Table
City of San Bruno - Storm Drain CIP
Project: Line A-1 - No Detention - Belle Air Box

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	168	CY	$10	$1,677
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	3,396	LF	$3	$10,188
9' x 5' RCB (< 10' deep)	1,698	LF	$1,309	$2,222,682
Manholes and Covers	6	EA	$6,000	$33,960
Storm Drain Catch Basins	11	EA	$4,000	$45,280
Construction Subtotal				$2,343,787
Mobilization/Demobilization (4%)				$93,751
Contractor's Bonds and Insurance (3%)				$70,314
Contractor's Overhead and Profit (15%)				$351,568
Estimated Bid Price				$2,859,420
Construction Contingency (30%)				$857,826
Total Estimate of Probable Construction Cost				$3,717,246
Engineering/CM				
- Pre-Design (5%)	1	LS		$185,862
- Contract Documents (11%)	1	LS		$408,897
- Engineering Support During Construction - Office (4%)	1	LS		$148,690
- Construction Management - Field (14%)	1	LS		$520,414
Grand Total				**$4,981,110**

Table
City of San Bruno - Storm Drain CIP
Project: Line A-2 - No Detention (ID 363,365)

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	178	CY	$10	$1,779
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	3,602	LF	$3	$10,806
72-inch RCP (<10' deep)	1,469	LF	$599	$879,931
72-inch RCP (<15' deep)	332	LF	$690	$229,080
Manholes and Covers	6	EA	$6,000	$36,020
Storm Drain Catch Basins	12	EA	$4,000	$48,027
Construction Subtotal				$1,235,642
Mobilization/Demobilization (4%)				$49,426
Contractor's Bonds and Insurance (3%)				$37,069
Contractor's Overhead and Profit (15%)				$185,346
Estimated Bid Price				$1,507,484
Construction Contingency (30%)				$452,245
Total Estimate of Probable Construction Cost				$1,959,729
Engineering/CM				
- Pre-Design (5%)	1	LS		$97,986
- Contract Documents (11%)	1	LS		$215,570
- Engineering Support During Construction - Office (4%)	1	LS		$78,389
- Construction Management - Field (14%)	1	LS		$274,362
Grand Total				**$2,626,037**

Table

City of San Bruno - Storm Drain CIP

Project: Line A-4 - No Detention (ID 367)

	QUANTITY			
ITEM DESCRIPTION	No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	48	CY	$10	$476
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	964	LF	$3	$2,892
72-inch RCP (<10' deep)	482	LF	$599	$288,718
Manholes and Covers	2	EA	$6,000	$9,640
Storm Drain Catch Basins	3	EA	$4,000	$12,853
72-inch RCP in J&B	700	LF	$400	$280,000
72-inch RCP J&B/tunneling	700	LF	$800	$560,000
J&B Pits	2	EA	$35,000	$70,000
Construction Subtotal				$1,254,579
Mobilization/Demobilization (4%)				$50,183
Contractor's Bonds and Insurance (3%)				$37,637
Contractor's Overhead and Profit (15%)				$188,187
Estimated Bid Price				$1,530,587
Construction Contingency (30%)				$459,176
Total Estimate of Probable Construction Cost				$1,989,763
Engineering/CM				
- Pre-Design (5%)	1	LS		$99,488
- Contract Documents (11%)	1	LS		$218,874
- Engineering Support During Construction - Office (4%)	1	LS		$79,591
- Construction Management - Field (14%)	1	LS		$278,567
Grand Total				**$2,666,282**

Table
City of San Bruno - Storm Drain CIP
Project: Line A-3 - No Detention (ID 435,441,443,445,447,449)

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	105	CY	$10	$1,050
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	2,126	LF	$3	$6,378
Remove Existing 18"and 24" RCP and Disposal	1,063	LF	$22	$23,386
30-inch RCP (<10' deep)	970	LF	$229	$222,130
Dual 30-inch RCP (< 10'd deep)	93	LF	$458	$42,594
Manholes and Covers	4	EA	$6,000	$21,260
Storm Drain Catch Basins	7	EA	$4,000	$28,347
Construction Subtotal				$375,145
Mobilization/Demobilization (4%)				$15,006
Contractor's Bonds and Insurance (3%)				$11,254
Contractor's Overhead and Profit (15%)				$56,272
Estimated Bid Price				$457,676
Construction Contingency (30%)				$137,303
Total Estimate of Probable Construction Cost				$594,979
Engineering/CM				
- Pre-Design (5%)	1	LS		$29,749
- Contract Documents (11%)	1	LS		$65,448
- Engineering Support During Construction - Office (4%)	1	LS		$23,799
- Construction Management - Field (14%)	1	LS		$83,297
Grand Total				**$797,272**

Table
City of San Bruno - Storm Drain CIP
Project: Line A-5 - No Detention (ID 376, 566)

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	220	CY	$10	$2,197
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	4,448	LF	$3	$13,344
Remove Existing 54", 60" and 72" RCP and Disposal	2,224	LF	$67	$149,008
84-inch RCP (<15' deep)	2,224	LF	$837	$1,861,488
Manholes and Covers	7	EA	$6,000	$44,480
Storm Drain Catch Basins	15	EA	$4,000	$59,307
Construction Subtotal				$2,159,823
Mobilization/Demobilization (4%)				$86,393
Contractor's Bonds and Insurance (3%)				$64,795
Contractor's Overhead and Profit (15%)				$323,973
Estimated Bid Price				$2,634,984
Construction Contingency (30%)				$790,495
Total Estimate of Probable Construction Cost				$3,425,480
Engineering/CM				
- Pre-Design (5%)	1	LS		$171,274
- Contract Documents (11%)	1	LS		$376,803
- Engineering Support During Construction - Office (4%)	1	LS		$137,019
- Construction Management - Field (14%)	1	LS		$479,567
Grand Total				**$4,590,143**

Table
City of San Bruno - Storm Drain CIP
Project: Line A - No Detention

October-11

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	719	CY	$10	$7,190
Trench Shoring	1	LS	$150,000	$150,000
Sawcut (initial and final)	14,536	LF	$3	$43,608
Remove Existing 18"and 24" RCP and Disposal	1,063	LF	$22	$23,386
Remove Existing 54", 60" and 72" RCP and Disposal	2,224	LF	$67	$149,008
30-inch RCP (<10' deep)	970	LF	$229	$222,130
Dual 30-inch RCP (< 10'd deep)	93	LF	$458	$42,594
42-inch RCP (< 10'd deep)	0	LF	$380	$0
72-inch RCP (<10' deep)	1,951	LF	$599	$1,168,649
72-inch RCP (<15' deep)	332	LF	$690	$229,080
84-inch RCP (<15' deep)	2,224	LF	$837	$1,861,488
7' x 6' RCB (< 10' deep)	0	LF	$1,076	$0
9' x 5' RCB (< 10' deep)	1,698	LF	$1,309	$2,222,682
Manholes and Covers	25	EA	$6,000	$150,000
Storm Drain Catch Basins	48	EA	$4,000	$192,000
72-inch RCP in J&B	700	LF	$400	$280,000
72-inch RCP J&B/tunneling	700	LF	$800	$560,000
J&B Pits	2	EA	$35,000	$70,000
Construction Subtotal				$7,371,815
Mobilization/Demobilization (4%)				$294,873
Contractor's Bonds and Insurance (3%)				$221,154
Contractor's Overhead and Profit (15%)				$1,105,772
Estimated Bid Price				$8,993,614
Construction Contingency (30%)				$2,698,084
Total Estimate of Probable Construction Cost				$11,691,699
Engineering/CM				
- Pre-Design (5%)	1	LS		$584,585
- Contract Documents (11%)	1	LS		$1,286,087
- Engineering Support During Construction - Office (4%)	1	LS		$467,668
- Construction Management - Field (14%)	1	LS		$1,636,838
Grand Total				**$15,666,876**

Table

City of San Bruno - Storm Drain CIP

Project: Line A-5 - Detention (ID 435, 441, 443, 445, 447, 449)

November-11

ITEM DESCRIPTION	QUANTITY No.	QUANTITY Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	105	CY	$10	$1,050
Trench Shoring	1	LS	$30,000	$30,000
Sawcut (initial and final)	2,126	LF	$3	$6,378
Remove Existing 18"and 24" RCP and Disposal	1,063	LF	$22	$23,386
30-inch RCP (<10' deep)	970	LF	$229	$222,130
Dual 30-inch RCP (< 10'd deep)	93	LF	$458	$42,594
Manholes and Covers	4	EA	$6,000	$21,260
Storm Drain Catch Basins	7	EA	$4,000	$28,347
				$0
				$0
Construction Subtotal				$375,145
Mobilization/Demobilization (4%)				$15,006
Contractor's Bonds and Insurance (3%)				$11,254
Contractor's Overhead and Profit (15%)				$56,272
Estimated Bid Price				$457,676
Construction Contingency (30%)				$137,303
Total Estimate of Probable Construction Cost				$594,979
Engineering/CM				
- Pre-Design (5%)	1	LS		$29,749
- Contract Documents (11%)	1	LS		$65,448
- Engineering Support During Construction - Office (4%)	1	LS		$23,799
- Construction Management - Field (14%)	1	LS		$83,297
Grand Total				**$797,272**

Table
City of San Bruno - Storm Drain CIP
Project: Line B - Detention October-11

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Clear & Grab	5.5	AC	$25,000	$137,500
Scarify & Compact	13300	SY	$5	$66,500
Excavation	27100	CY	$15	$406,500
Backfill (assume local matrerial, no import)	2000	CY	$20	$40,000
Erosion & Sediment Control	13300	SY	$12	$159,600
Hydro Seeding	120	MSF	$50	$6,000
Aggregate Base	260	CY	$50	$13,000
Outlet Structure	1	LS	$25,000	$25,000
Channel Regrade in Park	380	LF	$40	$15,200
Revegetation of channel	1	LS	$5,000	$5,000
				$0
				$0
Construction Subtotal				$874,300
Mobilization/Demobilization (4%)				$34,972
Contractor's Bonds and Insurance (3%)				$26,229
Contractor's Overhead and Profit (15%)				$131,145
Estimated Bid Price				$1,066,646
Construction Contingency (30%)				$319,994
Total Estimate of Probable Construction Cost				$1,386,640
Engineering/CM				
- Pre-Design (5%)	1	LS		$69,332
- Contract Documents (11%)	1	LS		$152,530
- Engineering Support During Construction - Office (4%)	1	LS		$55,466
- Construction Management - Field (14%)	1	LS		$194,130
Grand Total				**$1,858,097**

Table
City of San Bruno - Storm Drain CIP
Project: Line B-2 -No Detention -Channel Improvements October-11

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Reconstruct Channel in Park	842	LF	$25	$21,050
Channel Regrade in Park	380	LF	$40	$15,200
Revegetation of channel	1	LS	$5,000	$5,000
				$0
				$0
Construction Subtotal				$41,250
Mobilization/Demobilization (4%)				$1,650
Contractor's Bonds and Insurance (3%)				$1,238
Contractor's Overhead and Profit (15%)				$6,188
Estimated Bid Price				$50,325
Construction Contingency (30%)				$15,098
Total Estimate of Probable Construction Cost				$65,423
Engineering/CM				
- Pre-Design (5%)	1	LS		$3,271
- Contract Documents (11%)	1	LS		$7,196
- Engineering Support During Construction - Office (4%)	1	LS		$2,617
- Construction Management - Field (14%)	1	LS		$9,159
Grand Total				**$87,666**

Table
City of San Bruno - Storm Drain CIP
Project: C-1 - Local Angus and Huntington Pump Station June-11

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Bolt down manholes in lower watershed and install backflow preventors on catch basins	1	LS	$45,000	$45,000
Install DI Gallaries at Cupid Row	1	LS	$25,000	$25,000
Construction Subtotal				$70,000
Mobilization/Demobilization (4%)				$2,800
Contractor's Bonds and Insurance (3%)				$2,100
Contractor's Overhead and Profit (15%)				$10,500
Estimated Bid Price				$85,400
Construction Contingency (30%)				$25,620
Total Estimate of Probable Construction Cost				$111,020
Engineering/CM				
- Pre-Design (5%)	1	LS		$5,551
- Contract Documents (11%)	1	LS		$12,212
- Engineering Support During Construction - Office (4%)	1	LS		$4,441
- Construction Management - Field (14%)	1	LS		$15,543
Grand Total				**$148,767**

Table
City of San Bruno - Storm Drain CIP
Project: Line C-4 (ID 280, 482,254, 256, 278) October-11

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	123	CY	$10	$1,234
Sawcut (initial and final)	2,474	LF	$3	$7,422
Remove Existing 18"and 24" RCP and Disposal	744	LF	$22	$16,368
Remove Existing 54", 60" and 72" RCP and Disposal	493	LF	$67	$33,031
36-inch RCP (< 10'd deep)	478	LF	$266	$127,148
42-inch RCP (< 9'd deep)	266	LF	$376	$100,016
66-inch RCP (<10' deep)	493	LF	$597	$294,321
Manholes and Covers	4	EA	$6,000	$24,000
Storm Drain Catch Basins	8	EA	$4,000	$32,000
Construction Subtotal				$635,540
Mobilization/Demobilization (4%)				$25,422
Contractor's Bonds and Insurance (3%)				$19,066
Contractor's Overhead and Profit (15%)				$95,331
Estimated Bid Price				$775,358
Construction Contingency (30%)				$232,607
Total Estimate of Probable Construction Cost				$1,007,966
Engineering/CM				
- Pre-Design (5%)	1	LS		$50,398
- Contract Documents (11%)	1	LS		$110,876
- Engineering Support During Construction - Office (4%)	1	LS		$40,319
- Construction Management - Field (14%)	1	LS		$141,115
Grand Total				**$1,350,674**

Table

City of San Bruno - Storm Drain CIP

Project: Line C-2 (ID 240, 184, 552)

October-11

	QUANTITY			
ITEM DESCRIPTION	No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	64	CY	$10	$637
Sawcut (initial and final)	1,278	LF	$3	$3,834
Remove Existing 54", 60" and 72" RCP and Disposal	639	LF	$67	$42,813
6' x 4' RCB (< 10' deep)	430	LF	$1,309	$562,870
10' x 4' RCB (< 10' deep)	209	LF	$1,894	$395,846
Manholes and Covers	2	EA	$6,000	$12,780
Storm Drain Catch Basins	4	EA	$4,000	$17,040
Construction Subtotal				$1,035,820
Mobilization/Demobilization (4%)				$41,433
Contractor's Bonds and Insurance (3%)				$31,075
Contractor's Overhead and Profit (15%)				$155,373
Estimated Bid Price				$1,263,701
Construction Contingency (30%)				$379,110
Total Estimate of Probable Construction Cost				$1,642,811
Engineering/CM				
- Pre-Design (5%)	1	LS		$82,141
- Contract Documents (11%)	1	LS		$180,709
- Engineering Support During Construction - Office (4%)	1	LS		$65,712
- Construction Management - Field (14%)	1	LS		$229,994
Grand Total				**$2,201,367**

Table

City of San Bruno - Storm Drain CIP

Project: Line C -3 (ID 160, 162, 170, 172, 174, 176) October-11

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	142	CY	$10	$1,415
Sawcut (initial and final)	2,838	LF	$3	$8,514
Remove Existing 18" to 30" RCP and Disposal	1,419	LF	$22	$31,218
36-inch RCP (< 10'd deep)	210	LF	$266	$55,860
36-inch RCP (< 19'd deep)	257	LF	$508	$130,556
42-inch RCP (< 9'd deep)	952	LF	$376	$357,952
Manholes and Covers	5	EA	$6,000	$28,380
Storm Drain Catch Basins	9	EA	$4,000	$37,840
Construction Subtotal				$651,735
Mobilization/Demobilization (4%)				$26,069
Contractor's Bonds and Insurance (3%)				$19,552
Contractor's Overhead and Profit (15%)				$97,760
Estimated Bid Price				$795,117
Construction Contingency (30%)				$238,535
Total Estimate of Probable Construction Cost				$1,033,652
Engineering/CM				
- Pre-Design (5%)	1	LS		$51,683
- Contract Documents (11%)	1	LS		$113,702
- Engineering Support During Construction - Office (4%)	1	LS		$41,346
- Construction Management - Field (14%)	1	LS		$144,711
Grand Total				**$1,385,094**

Table
City of San Bruno - Storm Drain CIP
Project: Line C

October-11

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	329	CY	$10	$3,288
Sawcut (initial and final)	6,590	LF	$3	$19,770
Remove Existing 18"and 24" RCP and Disposal	2,163	LF	$22	$47,586
Remove Existing 54", 60" and 72" RCP and Disposal	1,132	LF	$67	$75,844
36-inch RCP (< 10'd deep)	688	LF	$266	$183,008
36-inch RCP (< 19'd deep)	257	LF	$508	$130,556
42-inch RCP (< 9'd deep)	1,218	LF	$376	$457,968
48-inch RCP (< 9'd deep)	0	LF	$500	$0
66-inch RCP (<10' deep)	493	LF	$597	$294,321
6' x 4' RCB (< 10' deep)	430	LF	$1,309	$562,870
10' x 4' RCB (< 10' deep)	209	LF	$1,894	$395,846
Manholes and Covers	11	EA	$6,000	$66,000
Storm Drain Catch Basins	21	EA	$4,000	$84,000
Bolt down MHs & Install backflow preventors	1	LS	$45,000	$45,000
Install DI Gallaries at cupid Row	1	LS	$25,000	$25,000
Construction Subtotal				$2,391,057
Mobilization/Demobilization (4%)				$95,642
Contractor's Bonds and Insurance (3%)				$71,732
Contractor's Overhead and Profit (15%)				$358,659
Estimated Bid Price				$2,917,089
Construction Contingency (30%)				$875,127
Total Estimate of Probable Construction Cost				$3,792,216
Engineering/CM				
- Pre-Design (5%)	1	LS		$189,611
- Contract Documents (11%)	1	LS		$417,144
- Engineering Support During Construction - Office (4%)	1	LS		$151,689
- Construction Management - Field (14%)	1	LS		$530,910
Grand Total				**$5,081,570**

Table

City of San Bruno - Storm Drain CIP

Project: Line E October-11

	QUANTITY			
ITEM DESCRIPTION	**No.**	**Unit**	**Total**	**TOTAL COST**
General				
Pavement Removal and Disposal	200	CY	$10	$2,000
Sawcut (initial and final)	4,050	LF	$3	$12,150
Remove Existing 18"and 24" RCP and Disposal	462	LF	$22	$10,164
42-inch RCP (< 10'd deep)	1,700	LF	$380	$646,000
3' x 3' RCB (< 10' deep)	325	LF	$429	$139,425
Manholes and Covers	7	EA	$6,000	$40,500
Storm Drain Catch Basins	6	EA	$4,000	$24,000
12' Catch Basin Gallery & Trench Drain	1	LS	$30,000	$30,000
Construction Subtotal				$904,239
Mobilization/Demobilization (4%)				$36,170
Contractor's Bonds and Insurance (3%)				$27,127
Contractor's Overhead and Profit (15%)				$135,636
Estimated Bid Price				$1,103,172
Construction Contingency (30%)				$330,951
Total Estimate of Probable Construction Cost				$1,434,123
Engineering/CM				
- Pre-Design (5%)	1	LS		$71,706
- Contract Documents (11%)	1	LS		$157,754
- Engineering Support During Construction - Office (4%)	1	LS		$57,365
- Construction Management - Field (14%)	1	LS		$200,777
Grand Total				**$1,921,725**

Table
City of San Bruno - Storm Drain CIP
Project: Line F

October-11

ITEM DESCRIPTION	QUANTITY No.	Unit	Total	TOTAL COST
General				
Pavement Removal and Disposal	186	CY	$10	$1,863
Sawcut (initial and final)	3,772	LF	$3	$11,316
Remove Existing 18"and 24" RCP and Disposal	1,886	LF	$22	$41,492
30-inch RCP (< 10'd deep)	526	LF	$322	$169,372
36-inch RCP (< 10'd deep)	1,194	LF	$429	$512,226
36-inch RCP (< 19'd deep)	166	LF	$508	$84,328
Manholes and Covers	6	EA	$6,000	$34,400
Storm Drain Catch Basins	4	EA	$4,000	$16,000
Construction Subtotal				$870,997
Mobilization/Demobilization (4%)				$34,840
Contractor's Bonds and Insurance (3%)				$26,130
Contractor's Overhead and Profit (15%)				$130,650
Estimated Bid Price				$1,062,616
Construction Contingency (30%)				$318,785
Total Estimate of Probable Construction Cost				$1,381,401
Engineering/CM				
- Pre-Design (5%)	1	LS		$69,070
- Contract Documents (11%)	1	LS		$151,954
- Engineering Support During Construction - Office (4%)	1	LS		$55,256
- Construction Management - Field (14%)	1	LS		$193,396
Grand Total				**$1,851,077**

Appendix D – Model Output Files

CATCH BASIN TABLE

Id	Label	Rim Elevation (ft)	Hydraulic Grade (ft)	Is Flooded Ever?	Depth (Flooding) (ft)	Flow (Overflow Maximum) (cfs)
96	MH-10	22.29	17	FALSE	-5.3	0
98	MH-9	18.8	13.8	FALSE	-5	0
100	MH-8	16.5	11.5	TRUE	-5	32
102	MH-7	13.31	7.31	TRUE	-6	0.5
104	MH-5	9.04	4.54	TRUE	-4.5	6.8
106	MH-4	7.52	3.02	FALSE	-4.5	0
108	MH-3	5.62	2.62	FALSE	-3	0
110	MH-2	5	2.4	FALSE	-2.6	0
112	MH-1	3.83	0.43	FALSE	-3.4	0
136	MH-29	2.92	-0.83	FALSE	-3.7	0
148	MH-156	160	147	FALSE	-13	0
149	MH-155	153.49	145.03	FALSE	-8.5	0
151	MH-154	138.24	132.4	FALSE	-5.8	0
153	MH-153	138.24	130.49	FALSE	-7.7	0
155	MH-152	115.94	106.69	FALSE	-9.2	0
157	MH-151	97.18	91	TRUE	-6.2	23.6
159	MH-150	100.47	90	FALSE	-10.5	0
161	MH-149	111.2	88.98	FALSE	-22.2	0
163	MH-148	100	85	FALSE	-15	0
165	MH-147	69.8	61.8	FALSE	-8	0
167	MH-146	47.4	43.68	TRUE	-3.7	25.7
169	MH-145	47.33	43.66	FALSE	-3.7	0
171	MH-144	43.27	39.77	TRUE	-3.5	1.9
173	MH-143	49.03	39.5	FALSE	-9.5	0
181	MH-139	34.51	29.89	FALSE	-4.6	0
183	MH-138	34.51	29.61	FALSE	-4.9	0
187	MH-136	32.86	25.22	FALSE	-7.6	0
189	MH-135	29.38	24.99	FALSE	-4.4	0
191	MH-134	30.32	24.93	FALSE	-5.4	0
193	MH-133	24.25	20.46	FALSE	-3.8	0
195	MH-132	24.25	20.15	FALSE	-4.1	0
197	MH-131	22.1	18.11	FALSE	-4	0
199	MH-130	21.96	18.06	FALSE	-3.9	0
218	MH-166	58.96	52.76	FALSE	-6.2	0
220	MH-165	63.95	57.75	FALSE	-6.2	0
222	MH-164	64.37	58.67	FALSE	-5.7	0
224	MH-163	71	65.6	FALSE	-5.4	0
226	MH-162	73.38	67.45	FALSE	-5.9	0
228	MH-161	77	72	FALSE	-5	0
230	MH-160	82.5	75.5	FALSE	-7	0
232	MH-159	89.81	85.11	FALSE	-4.7	0
234	MH-158	94.09	89.5	FALSE	-4.6	0
236	MH-157	99.48	91.94	FALSE	-7.5	0

239	MH-168	58.5	53.29	TRUE	-5.2	29.3
241	MH-169	62.75	57.35	FALSE	-5.4	0
243	MH-170	66.9	58	FALSE	-8.9	0
245	MH-171	81.47	75	FALSE	-6.5	0
247	MH-172	101.05	95.05	FALSE	-6	0
257	MH-183	270	264.16	FALSE	-5.8	0
259	MH-184	282.5	272	FALSE	-10.5	0
261	MH-185	281.95	274.2	FALSE	-7.7	0
263	MH-186	295.63	289.2	FALSE	-6.4	0
265	MH-187	303	297.4	FALSE	-5.6	0
267	MH-188	344.3	339	FALSE	-5.3	0
269	MH-189	401.16	396.5	FALSE	-4.7	0
271	MH-190	418	402.13	FALSE	-15.9	0
273	MH-191	237.54	228.7	FALSE	-8.8	0
275	MH-192	242.36	234.25	FALSE	-8.1	0
277	MH-193	243.3	237.05	TRUE	-6.2	58.4
279	MH-194	266	261.9	FALSE	-4.1	0
281	MH-195	284	276	FALSE	-8	0
286	CB-65	12.5	6	FALSE	-6.5	0
288	MH-34	13	6.55	FALSE	-6.4	0
290	MH-35	14	7.81	FALSE	-6.2	0
292	MH-36	15.24	8.94	FALSE	-6.3	0
294	MH-37	20.44	14.04	FALSE	-6.4	0
296	MH-38	29.98	17.29	FALSE	-12.7	0
298	MH-39	30.28	20.78	FALSE	-9.5	0
300	MH-40	34.32	21.12	FALSE	-13.2	0
302	MH-41	41.01	30.07	FALSE	-10.9	0
304	CH-7	54.12	46.64	FALSE	-7.5	0
312	MH-111	16	11.01	FALSE	-5	0
316	MH-196	20.05	17.05	FALSE	-3	0
328	MH-104	34.5	31.9	FALSE	-2.6	0
334	MH-45	15.85	11.65	FALSE	-4.2	0
336	MH-46	16.3	11.85	FALSE	-4.4	0
338	MH-47	19	15.74	FALSE	-3.3	0
340	MH-48	19	15.76	FALSE	-3.2	0
342	MH-49	22.24	17.14	FALSE	-5.1	0
344	MH-50	22.31	17.52	FALSE	-4.8	0
346	MH-51	24.5	19.8	FALSE	-4.7	0
348	MH-52	24.6	20	FALSE	-4.6	0
350	MH-53	29.82	21	FALSE	-8.8	0
360	MH-59	40	33	FALSE	-7	0
362	MH-77	56.5	50.3	TRUE	-6.2	25.2
364	MH-78	66.4	54.5	TRUE	-11.9	45.4
366	MH-79	85.23	75	TRUE	-10.2	188
372	MH-80	101.15	88.08	FALSE	-13.1	0
377	MH-82	186.13	180.13	FALSE	-6	0
387	MH-85	354.73	339.5	FALSE	-15.2	0

389	MH-86	355.98	339.6	FALSE	-16.4	0
391	MH-87	354.74	339.63	TRUE	-15.1	244.2
393	MH-88	413.05	390.55	FALSE	-22.5	0
395	MH-89	418.85	393.85	FALSE	-25	0
397	MH-90	418.85	393.9	TRUE	-24.9	108.9
399	MH-91	426.8	414.8	FALSE	-12	0
401	MH-96	438.8	430.8	FALSE	-8	0
403	MH-97	445.22	436.55	FALSE	-8.7	0
405	MH-98	487.63	483.3	FALSE	-4.3	0
407	MH-99	536.28	532.11	FALSE	-4.2	0
409	MH-100	633.86	630.19	FALSE	-3.7	0
411	MH-101	685.71	681.54	FALSE	-4.2	0
413	MH-102	711	707	FALSE	-4	0
415	MH-103	724.6	719.83	FALSE	-4.8	0
417	MH-92	489	483.4	FALSE	-5.6	0
421	MH-94	565.6	561.05	FALSE	-4.6	0
423	MH-95	584.06	580.6	FALSE	-3.5	0
434	MH-65	37	33.19	TRUE	-3.8	25.4
436	MH-67	47.2	40.3	FALSE	-6.9	0
438	MH-66	51.7	44.7	FALSE	-7	0
440	MH-68	49	45.2	FALSE	-3.8	0
442	MH-69	49.5	46.2	FALSE	-3.3	0
444	MH-70	51.5	46.6	FALSE	-4.9	0
446	MH-71	54	48	TRUE	-6	26.7
448	MH-72	55.7	49.2	FALSE	-6.5	0
452	MH-74	54.8	50.3	FALSE	-4.5	0
454	MH-75	55.2	50.4	FALSE	-4.8	0
456	MH-76	57.9	53.6	FALSE	-4.3	0
470	MH-60	16.98	12	FALSE	-5	0

Id	Start-node Id	Invert (Start) (ft)	Stop-node Id	Invert (Stop) (ft)	Length (ft)	Constructed Slope (ft/ft)	Material	Section Type	Number of Barrels	Diameter (in)	Rise (ft)	Span (ft)	Full Capacity (cfs)	Flow (Maximum) (cfs)	Velocity (Maximum) (ft/s)	Hydraulic Grade (ft)	Is Overflowing/ Surcharged?
95	MH-12	17.5	MH-11	17.15	718	0	Concrete	Circle	1	12			0.8	0.4	0.63	17.33	FALSE
97	MH-11	17.15	MH-10	17	330	0	Concrete	Circle	1	12			0.8	0.9	1.29	17.08	FALSE
99	MH-10	17	MH-9	13.8	322	0.01	Concrete	Circle	1	12			3.6	1.5	1.9	15.4	FALSE
101	MH-9	13.8	MH-8	11.5	282	0.008	Concrete	Circle	1	12			3.2	2.3	2.99	12.65	FALSE
103	MH-8	11.5	MH-7	7.31	259	0.016	Concrete	Circle	1	24			28.8	28.9	9.2	9.45	FALSE
105	MH-7	7.31	MH-5	4.54	260	0.011	Concrete	Circle	1	24			23.3	27.8	8.84	5.93	FALSE
107	MH-5	4.54	MH-4	3.02	262	0.006	Concrete	Circle	1	24			17.2	21.2	6.74	3.78	FALSE
109	MH-4	3.02	MH-3	2.62	266	0.002	Concrete	Circle	1	24			8.8	21	6.68	2.82	FALSE
111	MH-3	2.62	MH-2	2.4	329	0.001	Concrete	Circle	1	24			5.8	21.4	6.82	2.51	FALSE
113	MH-2	2.4	MH-1	0.43	46	0.043	Concrete	Circle	1	24			46.9	21.4	6.84	1.52	FALSE
115	MH-1	0.43	OF-1	0	166	0.003	Concrete	Circle	1	24			11.5	21.4	6.8	0.22	FALSE
132	MH-22	2.62	MH-14	0.82	176	0.01	Concrete	Box	2		5	9	714.1	1,232.00	13.69	7.58	TRUE
134	MH-14	0.82	OF-2	0.82	210	0	Concrete	Box	2		8	10	0	1,232.60	8.82	7.58	FALSE
137	MH-23	0	MH-29	-0.83	321	0.003	Concrete	Circle	1	24			11.5	23.7	7.54	-0.41	FALSE
140	MH-33	4.94	MH-32	1.78	256	0.012	Concrete	Circle	1	30			45.6	0	0	3.39	FALSE
142	MH-32	1.78	MH-31	-0.46	270	0.008	Concrete	Circle	1	30			37.4	0	0.01	0.66	FALSE
143	MH-31	-0.46	MH-29	-0.83	294	0.001	Concrete	Circle	1	30			14.6	0.7	0.15	-0.64	FALSE
145	MH-29	-0.83	MH-30	-1.5	243	0.003	Concrete	Circle	1	36			35	50.9	7.2	-1.16	FALSE
147	MH-30	-1.5	OF-3	-2	207	0.002	Concrete	Circle	1	36			32.8	50.9	7.56	-1.74	FALSE
150	MH-156	147	MH-155	145.03	154	0.013	Concrete	Circle	1	18			11.9	0	0	146.01	FALSE
152	MH-155	145.03	MH-154	132.4	127	0.1	Concrete	Circle	1	18			33.2	0.1	0.93	138.97	FALSE
154	MH-154	132.4	MH-153	130.49	87	0.022	Concrete	Circle	1	24			33.5	30.4	12.09	131.5	FALSE
156	MH-153	130.49	MH-152	106.69	255	0.093	Concrete	Circle	1	30			125.3	53.5	24.47	118.82	FALSE
158	MH-152	106.69	MH-151	91	240	0.065	Concrete	Circle	1	30			104.8	64.5	13.14	98.85	FALSE
160	MH-151	91	MH-150	90	210	0.005	Concrete	Circle	1	30			28.3	50.2	10.23	90.5	FALSE
162	MH-150	90	MH-149	88.98	257	0.004	Concrete	Circle	1	30			25.8	57.8	11.77	89.5	FALSE
164	MH-149	88.98	MH-148	85	250	0.016	Concrete	Circle	1	30			51.8	57.8	11.97	87.03	FALSE
166	MH-148	85	MH-147	61.8	251	0.093	Concrete	Circle	1	30			124.8	57.8	24.92	73.4	FALSE
168	MH-147	61.8	MH-146	43.23	242	0.077	Concrete	Circle	1	30			113.6	57.8	23.16	52.51	FALSE
170	MH-146	43.23	MH-145	43.66	304	-0.001	Concrete	Circle	1	30			15.4	34.5	7.03	43.68	FALSE
172	MH-145	43.66	MH-144	39.77	475	0.008	Concrete	Circle	1	30			37.1	35.8	7.29	41.74	FALSE
174	MH-144	39.77	MH-143	39.5	139	0.002	Concrete	Circle	1	30			18.1	64.9	13.22	39.64	FALSE
176	MH-143	39.5	MH-142	38.24	34	0.037	Concrete	Circle	1	30			78.9	64.9	17.9	38.87	FALSE
184	MH-139	29.89	MH-138	29.61	30	0.009	Concrete	Box	1		3	10	366.8	451	15.03	29.78	FALSE
190	MH-136	25.21	MH-135	24.98	218	0.001	Concrete	Box	1		5	9	229.4	450.9	10.91	25.1	FALSE
192	MH-135	24.98	MH-134	24.92	22	0.003	Concrete	Box	1		3	10	195.7	450.8	15.03	24.96	FALSE
194	MH-134	24.92	MH-133	20.45	172	0.026	Concrete	Box	1		3	10	607.6	450.9	18.08	22.69	FALSE
196	MH-133	20.45	MH-132	20.15	46	0.006	Concrete	Box	1		3	10	303.2	451.2	15.04	20.32	FALSE
198	MH-132	20.15	MH-131	18	213	0.01	Concrete	Box	1		3	10	379	451.2	15.04	19.08	FALSE
200	MH-131	18	MH-130	18.06	49	-0.001	Concrete	Box	1		3	10	132.5	481.7	16.06	18.07	FALSE
202	MH-130	18.06	MH-124	17	194	0.005	Concrete	Box	1		3	10	279	542.1	18.07	17.53	FALSE
221	MH-165	57.75	MH-166	52.76	217	0.023	Concrete	Circle	1	27			46.9	0	0	55.31	FALSE
223	MH-164	58.67	MH-165	57.75	93	0.01	Concrete	Circle	1	24			22.5	0	0.62	58.21	FALSE
225	MH-163	65.6	MH-164	58.67	228	0.03	Concrete	Circle	1	24			39.5	0	0	62.21	FALSE
227	MH-162	67.45	MH-163	65.6	95	0.019	Concrete	Circle	1	24			31.5	0	0	66.57	FALSE
229	MH-161	72	MH-162	67.45	226	0.02	Concrete	Circle	1	24			32.1	0	0	69.78	FALSE
231	MH-160	75.5	MH-161	72	142	0.025	Concrete	Circle	1	24			35.5	0	0	73.75	FALSE
233	MH-159	85.11	MH-160	75.5	236	0.041	Concrete	Circle	1	24			45.6	0	0	80.41	FALSE
235	MH-158	89.5	MH-159	85.11	155	0.028	Concrete	Circle	1	21			26.7	0	0	87.31	FALSE
237	MH-157	91.94	MH-158	89.5	138	0.018	Concrete	Circle	1	21			21.1	0	0	90.77	FALSE
240	MH-168	53.29	MH-167	49.71	430	0.008	Concrete	Circle	1	60			237.6	320.6	16.33	51.5	FALSE
242	MH-169	57.35	MH-168	53.29	45	0.091	Concrete	Circle	1	60			785.9	302.4	15.4	55.32	FALSE
244	MH-170	58	MH-169	57.35	117	0.006	Concrete	Circle	1	60			194.4	302.4	15.4	57.69	FALSE
246	MH-171	75	MH-170	58	1,082.00	0.016	Concrete	Circle	1	60			326.5	302.4	16.14	66.5	FALSE
248	MH-172	95.05	MH-171	75	476	0.042	Concrete	Circle	1	60			534.3	257.4	26.94	85.13	FALSE
254	MH-179	216.02	MH-178	211	107	0.047	Concrete	Circle	1	36			144.6	171.4	24.25	213.63	FALSE
256	MH-180	220.3	MH-179	216.02	266	0.016	Concrete	Circle	1	36			84.7	136.4	19.3	218.2	FALSE
258	MH-183	264.16	MH-180	220.3	390	0.113	Concrete	Circle	1	30			137.6	126.3	31.73	242.51	FALSE
260	MH-184	272	MH-183	264.16	136	0.058	Concrete	Circle	1	30			98.4	126.3	25.8	268.23	FALSE
262	MH-185	274.2	MH-184	272	45	0.048	Concrete	Circle	1	27			68.1	126.3	31.75	273.22	FALSE
264	MH-186	289.2	MH-185	274.2	477	0.031	Concrete	Circle	1	27			54.9	23.4	13.32	281.78	FALSE
266	MH-187	297.4	MH-186	289.2	297	0.028	Concrete	Circle	1	21			26.3	0	0	293.37	FALSE
268	MH-188	339	MH-187	297.4	363	0.115	Concrete	Circle	1	21			53.7	0	0	318.2	FALSE
270	MH-189	396.5	MH-188	339	356	0.162	Concrete	Circle	1	21			63.7	0	0	368.15	FALSE
272	MH-190	402.13	MH-189	396.5	116	0.049	Concrete	Circle	1	21			34.9	0	0	399.44	FALSE
274	MH-191	228.7	MH-180	220.3	539	0.016	Concrete	Circle	1	36			83.2	56	7.93	224.54	FALSE
276	MH-192	234.25	MH-191	228.7	281	0.02	Concrete	Circle	1	36			93.8	58.7	8.3	231.48	FALSE
278	MH-193	237.05	MH-192	234.25	92	0.031	Concrete	Circle	1	24			39.6	58.7	18.69	235.65	FALSE
280	MH-194	261.9	MH-193	237.05	386	0.064	Concrete	Circle	1	21			40.2	0	0.96	249.64	FALSE
282	MH-195	276	MH-194	261.9	495	0.028	Concrete	Circle	1	15			10.9	0	0	269.02	FALSE
285	MH-31	5.5	CS-10	5	62	0.008	Concrete	Box	1		6	6.5	539	519.6	14.3	5.25	FALSE
287	CB-65	6	MH-31	5.5	323	0.002	Concrete	Box	1		6	6.5	235.9	519.8	13.33	5.75	FALSE
289	MH-34	6.55	CB-65	6	133	0.004	Concrete	Box	1		6	6.5	385.8	519.7	13.33	6.28	FALSE
291	MH-35	7.81	MH-34	6.55	139	0.009	Concrete	Box	1		6	6.5	570.7	519.6	13.32	7.2	FALSE
293	MH-36	8.94	MH-35	7.81	355	0.003	Concrete	Box	1		6	6.5	338.3	519.5	13.32	8.38	FALSE
295	MH-37	14.04	MH-36	8.94	476	0.011	Concrete	Box	1		6	6.5	620.9	484.6	12.7	11.52	FALSE
297	MH-38	17.29	MH-37	14.04	429	0.008	Concrete	Box	1		6	6.5	521.6	447.1	14.96	15.68	FALSE
299	MH-39	20.78	MH-38	17.29	103	0.034	Concrete	Box	1		4	6	569.3	447	21.05	19.03	FALSE
301	MH-40	21.12	MH-39	20.78	89	0.004	Concrete	Box	1		4	6	191.9	447	18.62	20.96	FALSE
303	MH-41	30.07	MH-40	21.12	757	0.012	Concrete	Box	1		4	6	336.9	422.9	17.62	25.62	FALSE
305	CH-7	46.64	MH-41	30.07	706	0.023	Concrete	Box	1		4	6	474.5	351.7	21.98	38.41	FALSE
331	MH-42	11.22	MH-111	11	84	0.003	Concrete	Box	2		4	12	368.8	886.7	9.24	11.12	FALSE
333	MH-57	11.5	MH-42	11.22	52	0.005	Concrete	Box	2		4	12	528.1	843.8	8.79	11.36	FALSE
335	MH-45	11.65	MH-57	11.5	151	0.001	Concrete	Box	1		3.5	8.5	123.5	370.7	12.46	11.57	FALSE
337	MH-46	11.85	MH-45	11.65	61	0.003	Concrete	Box	1		3	10	218.4	370.6	12.35	11.75	FALSE
339	MH-47	15.74	MH-46	11.85	234	0.017	Concrete	Box	1		3	10	486.5	370.4	12.35	13.8	FALSE

Id	Start-node Id	Invert (Start) (ft)	Stop-node Id	Invert (Stop) (ft)	Length (ft)	Constructed Slope (ft/ft)	Material	Section Type	Number of Barrels	Diameter (in)	Rise (ft)	Span (ft)	Full Capacity (cfs)	Flow (Maximum) (cfs)	Velocity (Maximum) (ft/s)	Hydraulic Grade (ft)	Is Overflowing/ Surcharged?
341	MH-48	15.74	MH-47	15.74	36	0	Concrete	Box	1		3	10	0	369.4	12.31	15.76	FALSE
343	MH-49	17.14	MH-48	15.74	229	0.006	Concrete	Box	1		3	10	295.1	369.2	12.31	16.46	FALSE
345	MH-50	17.52	MH-49	17.14	41	0.009	Concrete	Box	1		3	10	362.7	368.5	12.28	17.33	FALSE
347	MH-51	19.8	MH-50	17.52	226	0.01	Concrete	Box	1		3	10	379.3	367.8	12.26	18.69	FALSE
349	MH-52	20	MH-51	19.8	64	0.003	Concrete	Box	1		3	10	210.8	367.5	12.25	19.9	FALSE
351	MH-53	21	MH-52	20	226	0.004	Concrete	Box	1		3	10	250.7	366.9	12.23	20.51	FALSE
353	MH-54	21.76	MH-53	21	62	0.012	Concrete	Box	1		3	10	416.8	366.7	12.22	21.38	FALSE
363	MH-77	50.3	MH-59	33	1,137.00	0.015	Concrete	Circle	1	72			522.4	588.1	20.8	41.69	FALSE
365	MH-78	54.5	MH-77	50.3	664	0.006	Concrete	Circle	1	72			336.8	539.7	19.09	52.4	FALSE
367	MH-79	75	MH-78	54.5	1,182.00	0.017	Concrete	Circle	1	72			557.8	549.5	19.43	64.75	FALSE
369	CH-1	87	MH-79	75	218	0.055	Concrete	Circle	1	72			994.7	723.2	25.58	81.14	FALSE
376	MH-81	112	MH-80	84.56	1,786.00	0.015	Concrete	Circle	1	72			525	532.3	18.83	98.32	FALSE
378	MH-82	180.13	MH-81	112	919	0.074	Concrete	Circle	1	72			1,152.90	644.3	41.88	146.25	FALSE
380	CH-3	206	MH-82	180.13	1,207.00	0.021	Concrete	Circle	1	72			620.1	552.1	24.78	193.12	FALSE
390	MH-86	339.6	MH-85	339.5	260	0	Concrete	Circle	1	60			51.1	323.2	16.46	339.55	FALSE
392	MH-87	339.63	MH-86	339.6	234	0	Concrete	Circle	1	60			29.5	301.3	15.35	339.61	FALSE
394	MH-88	390.55	MH-87	339.63	674	0.076	Concrete	Circle	1	56			595.6	532.2	31.11	365.09	FALSE
396	MH-89	393.85	MH-88	390.55	318	0.01	Concrete	Circle	1	56			220.6	532.3	31.12	392.23	FALSE
400	MH-91	414.8	MH-90	393.85	410	0.051	Concrete	Circle	1	66			759.4	370.7	15.6	404.45	FALSE
402	MH-96	430.8	MH-91	414.8	303	0.053	Concrete	Circle	1	36			153.4	65.7	9.3	422.8	FALSE
404	MH-97	436.55	MH-96	430.8	183	0.031	Concrete	Circle	1	36			118.2	65.7	17.18	433.67	FALSE
406	MH-98	483.3	MH-97	436.55	340	0.138	Concrete	Circle	1	36			247.4	65.7	29.69	459.92	FALSE
408	MH-99	532.11	MH-98	483.3	578	0.084	Concrete	Circle	1	20			40.4	59.4	27.24	507.92	FALSE
410	MH-100	630.19	MH-99	532.11	780	0.126	Concrete	Circle	1	20			49.3	0	0	581.47	FALSE
412	MH-101	681.54	MH-100	630.19	321	0.16	Concrete	Circle	1	12			14.3	0	0	655.86	FALSE
414	MH-102	707	MH-101	681.54	284	0.09	Concrete	Circle	1	12			10.7	0	0	694.27	FALSE
416	MH-103	719.83	MH-102	707	107	0.12	Concrete	Circle	1	12			12.4	0	0	713.72	FALSE
418	MH-92	483.4	MH-91	414.8	441	0.156	Concrete	Circle	1	54			775.9	264	44.67	449.1	FALSE
424	MH-95	580.6	MH-94	561.05	691	0.028	Concrete	Circle	1	54			330.8	264.1	23.09	570.82	FALSE
435	MH-65	33.19	MH-59	33	93	0.002	Concrete	Circle	1	18			4.7	20.4	11.55	33.1	FALSE
437	MH-67	40.3	MH-65	33.19	797	0.009	Concrete	Circle	1	36			63	39.1	5.53	36.77	FALSE
439	MH-66	44.7	MH-67	40.3	307	0.014	Concrete	Circle	1	30			49.1	34.9	10.63	42.54	FALSE
441	MH-68	45.2	MH-66	44.7	131	0.004	Concrete	Circle	1	24			14	25	7.95	44.95	FALSE
443	MH-69	46.2	MH-68	45.2	159	0.006	Concrete	Circle	1	24			17.9	25	7.95	45.72	FALSE
445	MH-70	46.6	MH-69	46.2	107	0.004	Concrete	Circle	1	24			13.8	25.1	7.99	46.41	FALSE
447	MH-71	48	MH-70	46.6	164	0.009	Concrete	Circle	1	20			12.8	25.1	11.51	47.3	FALSE
449	MH-72	49.2	MH-71	48	316	0.004	Concrete	Circle	1	20			8.6	5.5	2.54	48.61	FALSE
455	MH-75	50.4	MH-74	50.3	119	0.001	Concrete	Circle	1	18			3	3.7	2.12	50.35	FALSE
457	MH-76	53.6	MH-75	50.4	385	0.008	Concrete	Circle	1	18			9.6	1.4	1.59	52.02	FALSE
472	MH-60	12	MH-57	11.5	216	0.002	Concrete	Box	1		4	8	213.2	575.7	17.99	11.76	FALSE
479	MH-177	210	MH-176	209	585	0.002	Concrete	Circle	1	60			107.7	171.4	9.1	209.5	FALSE
482	MH-178	211	MH-177	210	386	0.003	Concrete	Circle	1	60			132.6	171.4	8.73	210.51	FALSE
507	MH-94	561.05	MH-92	483.4	981	0.079	Concrete	Circle	1	54			553.2	263.8	34.35	522.22	FALSE
508	MH-85	339.5	CH-6	338	423	0.004	Concrete	Circle	1	54			117.2	323.2	20.32	338.75	FALSE
514	MH-59	33	MH-54	21.76	409	0.027	Concrete	Box	1		7	10	2,145.40	655.2	26.47	27.45	FALSE
515	MH-54	21.76	MH-60	12	1,784.00	0.005	Concrete	Ellipse	1		4	6.3	191.5	423.4	5.32	16.88	FALSE
517	MH-124	17	MH-120	15.51	229	0.007	Concrete	Box	1		4	5	197.9	146.3	7.32	16.27	FALSE
521	MH-120	15.51	MH-60	12	765	0.005	Concrete	Box	1		4	5	166.1	147.3	7.37	13.77	FALSE
524	MH-111	11	MH-15	7.72	449	0.007	Concrete	Box	2		4	12	614.3	956.3	9.96	9.39	FALSE
526	MH-15	7.72	MH-19	4.97	742	0.004	Concrete	Box	2		5	9	429.7	1,230.70	13.67	7.63	FALSE
529	MH-19	4.97	MH-22	2.62	780	0.003	Concrete	Box	2		5	9	387.3	1,231.90	13.69	7.61	FALSE
530	MH-196	17.05	MH-111	11	674	0.009	Concrete	Circle	1	36			63.2	69.5	9.84	14.02	FALSE
531	MH-104	31.9	MH-196	17.05	1,296.00	0.011	Concrete	Circle	1	15			6.9	0	0	24.5	FALSE
532	MH-74	50.3	MH-72	49.2	67	0.016	Concrete	Circle	1	18			13.5	4.7	2.63	49.79	FALSE
534	MH-124	17	MH-126	13.86	274	0.011	Concrete	Box	1		4	6	331.8	250.2	10.43	15.43	FALSE
536	MH-126	13.86	MH-50	9	897	0.005	Concrete	Box	1		4	9	376.2	250.9	6.97	11.46	FALSE
538	MH-50	9	MH-58	8.5	59	0.008	Concrete	Box	2		4	11	595.5	353.9	4.02	8.78	FALSE
539	MH-58	8.5	MH-15	7.72	280	0.003	Concrete	Box	2		4	7	198.5	281.6	5.03	8.12	FALSE
541	MH-124	17	MH-125	13.86	277	0.011	Concrete	Box	2		4	6	330.1	172.1	3.59	15.47	FALSE
543	MH-125	13.86	MH-127	10.28	295	0.012	CMP	Pipe-Arch	1		4	10	(N/A)	118	3.69	12.12	FALSE
545	MH-127	10.28	MH-129	9.77	158	0.003	CMP	Pipe-Arch	1		4	10	(N/A)	112.1	3.5	10.05	FALSE
547	MH-129	9.77	MH-128	9.5	103	0.003	CMP	Pipe-Arch	1		4	10	(N/A)	102.6	3.21	9.64	FALSE
548	MH-128	9.5	MH-50	9	199	0.003	Concrete	Box	1		4	10.7	313.7	102.7	2.41	9.26	FALSE
549	MH-125	13.86	MH-42	11.22	963	0.003	Concrete	Circle	1	44			59.6	47.8	4.52	12.54	FALSE
551	MH-137	29	MH-136	25.21	589	0.006	Concrete	Box	1		5	9	566.1	451	11.42	27.13	FALSE
552	MH-138	29.61	MH-137	29	179	0.003	Concrete	Box	1		3	10	220.4	451	15.03	29.31	FALSE
553	MH-142	38.24	MH-139	29.89	472	0.018	Concrete	Box	1		3	10	501.5	421.6	18.93	34.07	FALSE
554	MH-166	52.76	MH-167	49.71	309	0.01	Concrete	Circle	1	27			30.8	0	0.63	51.26	FALSE
555	MH-167	49.71	MH-142	38.24	537	0.021	Concrete	Box	1		3	10	551.4	345.7	19.8	44.03	FALSE
560	MH-176	209	MH-172	95.05	1,592.00	0.072	Concrete	Circle	1	60			696.7	171.4	29.33	152.02	FALSE
566	MH-80	84.56	CH-2	88	438	-0.008	Concrete	Circle	1	72			375.4	689.9	24.4	88.07	FALSE
577	OS-2	87	CH-9	86.38	84	0.007	CMP	Circle	2	30			19.1	179.8	18.31	86.69	FALSE
733	MH-90	393.85	MH-89	393.85	153	0	Concrete	Circle	1	66			0	501.4	21.11	393.9	FALSE

MANHOLE TABLE

Id	Label	Ground Elevation (ft)	Rim Elevation (ft)	Invert Elevation (ft)	Is Bolted	Hydraulic Grade (ft)	Is Flooded Ever?	Flow (Overflow Maximum) (cfs)	Flow (Total In Maximum) (cfs)
92	MH-12	22.5	22.5	17.5	FALSE	17.5	FALSE	0	0
93	MH-11	22.15	22.15	17.15	FALSE	17.15	FALSE	0	0.7
116	MH-15	13.22	13.22	7.72	FALSE	7.73	TRUE	8.4	1,235.40
123	MH-19	10.47	10.47	4.97	FALSE	7.62	FALSE	0	1,230.70
129	MH-22	9.4	9.4	2.62	FALSE	7.59	FALSE	0	1,231.90
131	MH-14	9.17	9.17	0.82	FALSE	7.58	FALSE	0	1,232.00
135	MH-23	3.05	3.05	0	FALSE	0	TRUE	12.3	33.1
138	MH-33	7.94	7.94	4.94	FALSE	4.94	FALSE	0	0
139	MH-32	6.28	6.28	1.78	FALSE	1.78	FALSE	0	0
141	MH-31	4.54	4.54	-0.46	FALSE	-0.46	FALSE	0	0.4
144	MH-30	4	4	-1.5	FALSE	-1.5	FALSE	0	50.9
175	MH-142	42.87	42.87	38.24	FALSE	38.24	FALSE	0	421.6
201	MH-124	24.27	24.27	17	FALSE	17	FALSE	0	542.1
238	MH-167	55	55	49.71	FALSE	49.71	FALSE	0	345.7
249	MH-176	214	214	209	FALSE	209	FALSE	0	171.4
251	MH-178	220.5	220.5	211	FALSE	211	FALSE	0	171.4
253	MH-179	220.9	220.9	216.02	FALSE	216.02	TRUE	44	215.5
255	MH-180	232	232	220.3	FALSE	220.3	TRUE	45.8	182.3
284	MH-31	14.2	14.2	5.5	FALSE	5.5	FALSE	0	519.9
330	MH-42	17.58	17.58	11.22	FALSE	11.23	FALSE	0	886.5
352	MH-54	29.76	29.76	21.76	FALSE	21.76	FALSE	0	697.9
368	CH-1	94	94	87	FALSE	87	FALSE	0	723.2
375	MH-81	126.92	126.92	112	FALSE	113.3	TRUE	150.1	679.4
379	CH-3	212	212	206	FALSE	206	FALSE	0	552.2
478	MH-177	220.57	220.57	210	FALSE	210	FALSE	0	171.4
516	MH-120	19.51	19.51	15.51	FALSE	15.51	FALSE	0	146.9
533	MH-126	19.06	19.06	13.86	FALSE	13.87	FALSE	0	250.4
535	MH-50	15.47	15.47	9	FALSE	9.01	FALSE	0	353.6
540	MH-125	19.06	19.06	13.86	FALSE	13.88	FALSE	0	172.2
542	MH-127	15.29	15.29	10.28	FALSE	10.3	FALSE	0	117.8
544	MH-129	14.57	14.57	9.77	FALSE	9.78	FALSE	0	112.1
546	MH-128	14.2	14.2	9.5	FALSE	9.51	FALSE	0	102.6
550	MH-137	34	34	29	FALSE	29	FALSE	0	451
649	MH-57	16.23	16.23	11.5	FALSE	11.5	FALSE	0	843.3
650	MH-58	12.5	12.5	8.5	FALSE	8.51	TRUE	75.1	353.9

DETENTION - CATCH BASINS

Id	Label	Rim Elevation (ft)	Invert Elevation (ft)	Hydraulic Grade (ft)	Is Flooded Ever?	Depth (Flooding) (ft)	Flow (Overflow Maximum) (cfs)	Flow (Total In Maximum) (cfs)	Flow (Out to Links Maximum) (cfs)
96	MH-10	22.29	17	17	FALSE	-5.3	0	0	0
98	MH-9	18.8	13.8	13.8	FALSE	-5	0	0	0
100	MH-8	16.5	11.5	11.5	FALSE	-5	0	44.8	44.3
102	MH-7	13.31	7.31	7.31	FALSE	-6	0	44.3	44.2
104	MH-5	9.04	4.54	4.54	FALSE	-4.5	0	44.2	44.2
106	MH-4	7.52	3.02	3.02	FALSE	-4.5	0	44	44
108	MH-3	5.62	1.62	1.62	FALSE	-4	0	43.9	43.9
110	MH-2	5	0.6	0.6	FALSE	-4.4	0	43.8	43.8
112	MH-1	3.83	0.43	0.43	FALSE	-3.4	0	43.8	43.8
136	MH-29	2.92	-2	-2	FALSE	-4.9	0	45.7	45.6
148	MH-156	160	147	147	FALSE	-13	0	0	0
149	MH-155	153.49	145.03	145.03	FALSE	-8.5	0	0	0
151	MH-154	138.24	132.4	132.43	FALSE	-5.8	0	23.5	23.4
153	MH-153	138.24	130.49	130.51	FALSE	-7.7	0	41.5	41.4
155	MH-152	115.94	106.69	106.69	FALSE	-9.2	0	49.6	49.6
157	MH-151	97.18	91	91	FALSE	-6.2	0	57.5	57.4
159	MH-150	100.47	90	90	FALSE	-10.5	0	63.4	63.2
161	MH-149	111.2	88.98	88.98	FALSE	-22.2	0	63.3	63.2
163	MH-148	100	85	85	FALSE	-15	0	63.2	63.2
165	MH-147	69.8	61.8	61.8	FALSE	-8	0	63.1	63
167	MH-146	47.4	42.23	42.23	FALSE	-5.2	0	62.9	62.9
169	MH-145	47.33	41.66	41.66	FALSE	-5.7	0	62.2	62.2
171	MH-144	43.27	38.77	38.77	FALSE	-4.5	0	88.1	88.2
173	MH-143	49.03	38.5	38.5	FALSE	-10.5	0	88.2	88.2
181	MH-139	34.51	29.89	29.89	FALSE	-4.6	0	491.9	492
183	MH-138	34.51	29.61	29.61	FALSE	-4.9	0	492	492
187	MH-136	32.86	25.21	25.22	FALSE	-7.6	0	491.6	491.6
189	MH-135	29.38	24.98	24.99	FALSE	-4.4	0	491.6	491.6
191	MH-134	30.32	24.92	24.93	FALSE	-5.4	0	491.6	491.6
193	MH-133	24.25	20.45	20.46	FALSE	-3.8	0	491.4	489.7
195	MH-132	24.25	20.15	20.15	FALSE	-4.1	0	489.7	489
197	MH-131	22.1	18	18.11	FALSE	-4	0	512.4	511.7
199	MH-130	21.96	18.06	18.06	FALSE	-3.9	0	558.1	557.8
218	MH-166	58.96	52.76	52.76	FALSE	-6.2	0	18.6	18.6
220	MH-165	63.95	57.75	57.75	FALSE	-6.2	0	18.6	18.6
222	MH-164	64.37	58.67	58.67	FALSE	-5.7	0	18.6	18.6
224	MH-163	71	65.6	65.6	FALSE	-5.4	0	18.6	18.6
226	MH-162	73.38	67.45	67.45	FALSE	-5.9	0	18.6	18.6
228	MH-161	77	72	72	FALSE	-5	0	18.6	18.6
230	MH-160	82.5	75.5	75.5	FALSE	-7	0	18.6	18.6
232	MH-159	89.81	85.11	85.11	FALSE	-4.7	0	18.8	18.6
234	MH-158	94.09	89.5	89.5	FALSE	-4.6	0	0	0
236	MH-157	99.48	91.94	91.94	FALSE	-7.5	0	0	0
239	MH-168	58.5	53.29	53.29	FALSE	-5.2	0	355.2	355.2
241	MH-169	62.75	57.35	57.35	FALSE	-5.4	0	319.7	319.7
243	MH-170	66.9	58	58	FALSE	-8.9	0	319.7	319.7
245	MH-171	81.47	75	75	FALSE	-6.5	0	319.2	319.3
247	MH-172	101.05	95.05	95.05	FALSE	-6	0	286	286.1

DETENTION - CATCH BASINS

Id	Label	Rim Elevation (ft)	Invert Elevation (ft)	Hydraulic Grade (ft)	Is Flooded Ever?	Depth (Flooding) (ft)	Flow (Overflow Maximum) (cfs)	Flow (Total In Maximum) (cfs)	Flow (Out to Links Maximum) (cfs)
257	MH-183	270	264.16	264.16	FALSE	-5.8	0	89.5	89.5
259	MH-184	282.5	272	272	FALSE	-10.5	0	89.5	89.5
261	MH-185	281.95	274.2	274.2	FALSE	-7.7	0	89.5	89.5
263	MH-186	295.63	289.2	289.2	FALSE	-6.4	0	17.6	17.6
265	MH-187	303	297.4	297.4	FALSE	-5.6	0	0	0
267	MH-188	344.3	339	339	FALSE	-5.3	0	0	0
269	MH-189	401.16	396.5	396.5	FALSE	-4.7	0	0	0
271	MH-190	418	402.13	402.13	FALSE	-15.9	0	0	0
273	MH-191	237.54	228.7	228.7	FALSE	-8.8	0	78.5	78.5
275	MH-192	242.36	234.25	234.25	FALSE	-8.1	0	78.5	78.5
277	MH-193	243.3	237.05	237.05	FALSE	-6.2	0	78.7	78.6
279	MH-194	266	261.9	261.9	FALSE	-4.1	0	79.2	78.8
281	MH-195	284	276	276	FALSE	-8	0	0	0
286	CB-65	12.5	6	12.1	FALSE	-0.4	0	287	287
288	MH-34	13	6.55	12.39	FALSE	-0.6	0	287	287
290	MH-35	14	7.81	13.38	FALSE	-0.6	0	286.9	286.9
292	MH-36	15.24	8.94	14.54	FALSE	-0.7	0	286.7	286.8
294	MH-37	20.44	14.04	19.51	FALSE	-0.9	0	259.9	260
296	MH-38	29.98	17.29	21.95	FALSE	-8	0	231.4	231.4
298	MH-39	30.28	20.78	24.24	FALSE	-6	0	231.4	231.4
300	MH-40	34.32	21.12	24.96	FALSE	-9.4	0	231.3	231.4
302	MH-41	41.01	30.07	32.41	FALSE	-8.6	0	212.6	212.8
304	CH-7	54.12	46.64	48.97	FALSE	-5.1	0	158.9	158.9
312	MH-111	16.75	11	11.01	FALSE	-5.7	0	811.8	810.1
316	MH-196	20.05	17.05	17.05	FALSE	-3	0	52.7	51.9
328	MH-104	34.5	31.9	31.9	FALSE	-2.6	0	0	0
334	MH-45	16.25	11.65	11.65	FALSE	-4.6	0	346.6	346.6
336	MH-46	16.3	11.85	11.85	FALSE	-4.4	0	346.6	346.6
338	MH-47	19.64	15.74	15.74	FALSE	-3.9	0	347	347
340	MH-48	20.2	15.74	15.76	FALSE	-4.4	0	347.1	347
342	MH-49	22.24	17.14	17.14	FALSE	-5.1	0	347.5	347.5
344	MH-50	22.31	17.52	17.52	FALSE	-4.8	0	347.6	347.6
346	MH-51	24.5	19.8	19.8	FALSE	-4.7	0	348	347.9
348	MH-52	24.6	20	20	FALSE	-4.6	0	348	348
350	MH-53	29.82	21	21.01	FALSE	-8.8	0	347.8	347.8
360	MH-59	40	33	33.01	FALSE	-7	0	559.4	551.1
362	MH-77	55.8	50.3	50.3	FALSE	-5.5	0	471.3	471.7
364	MH-78	66.4	54.5	54.69	FALSE	-11.7	0	404.2	404.2
366	MH-79	85.23	75	75.11	FALSE	-10.1	0	391.4	391.4
372	MH-80	101.15	88	88.28	FALSE	-12.9	0	356.3	356.1
387	MH-85	354.73	339.5	339.5	FALSE	-15.2	0	318.2	318.2
389	MH-86	355.98	339.6	339.6	FALSE	-16.4	0	318.1	318.2
391	MH-87	354.74	339.63	339.63	TRUE	-15.1	154.2	457.6	301.4
393	MH-88	413.05	390.55	390.55	FALSE	-22.5	0	448	448
395	MH-89	418.85	393.85	393.85	FALSE	-25	0	448	448
397	MH-90	418.85	393.85	393.91	FALSE	-24.9	0	426.9	424.1
399	MH-91	426.8	414.8	414.8	FALSE	-12	0	261.5	261.6
401	MH-96	438.8	430.8	430.8	FALSE	-8	0	48	48

DETENTION - CATCH BASINS

Id	Label	Rim Elevation (ft)	Invert Elevation (ft)	Hydraulic Grade (ft)	Is Flooded Ever?	Depth (Flooding) (ft)	Flow (Overflow Maximum) (cfs)	Flow (Total In Maximum) (cfs)	Flow (Out to Links Maximum) (cfs)
403	MH-97	445.22	436.55	436.55	FALSE	-8.7	0	48	48
405	MH-98	487.63	483.3	483.3	FALSE	-4.3	0	48	48
407	MH-99	536.28	532.11	532.11	FALSE	-4.2	0	43.4	43.4
409	MH-100	633.86	630.19	630.19	FALSE	-3.7	0	0	0
411	MH-101	685.71	681.54	681.54	FALSE	-4.2	0	0	0
413	MH-102	711	707	707	FALSE	-4	0	0	0
415	MH-103	724.6	719.83	719.83	FALSE	-4.8	0	0	0
417	MH-92	489	483.4	483.4	FALSE	-5.6	0	179.2	179.2
421	MH-94	565.6	561.05	561.05	FALSE	-4.6	0	179.3	179.3
423	MH-95	584.06	580.6	580.6	FALSE	-3.5	0	180.5	179.5
434	MH-65	37	33.19	33.19	FALSE	-3.8	0	52.6	52.7
436	MH-67	47.2	40.3	40.3	FALSE	-6.9	0	49	49
438	MH-66	51.7	44.7	44.7	FALSE	-7	0	45.8	45.8
440	MH-68	49	45.2	45.2	FALSE	-3.8	0	38.6	38.6
442	MH-69	49.5	46.2	46.2	FALSE	-3.3	0	38.6	38.6
444	MH-70	51.5	46.6	46.6	FALSE	-4.9	0	38.6	38.6
446	MH-71	54	48	48	FALSE	-6	0	38.6	38.6
448	MH-72	55.7	49.2	49.2	FALSE	-6.5	0	38.7	38.6
452	MH-74	54.8	50.3	50.3	FALSE	-4.5	0	0.1	1.3
454	MH-75	55.2	50.4	50.4	FALSE	-4.8	0	0	0
456	MH-76	57.9	53.6	53.6	FALSE	-4.3	0	0	0
470	MH-60	16.75	12	12	FALSE	-4.8	0	355.4	353.7
1139	MH-82	186.13	180.13	180.3	FALSE	-5.8	0	251.1	251.1
1170	CB-147	8	0.2	0.2	FALSE	-7.8	0	150.7	149.9
1180	CB-149	2	-0.1	-0.1	FALSE	-2.1	0	0	0

ID	U/S MH	U/S MH Inv (ft)	D/S MH	D/S MH Inv (ft)	Length (ft)	Slope (%)	Material	Manning's n	Existing Conditions	Number of Barrels	Section Type	Diameter (in)	Span (ft)	Rise (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (cfs)	Depth/Rise (%)	Capacity (Excess Full) (cfs)
95	MH-12	17.5	MH-11	17.15	718	0.05	Concrete	0.013		1	Circle	12			0.51	0.2	0	-0.8
97	MH-11	17.15	MH-10	17	330	0.05	Concrete	0.013		1	Circle	12			1.09	0.4	0	-0.8
99	MH-10	17	MH-9	13.8	322	0.99	Concrete	0.013		1	Circle	12			2.99	0.5	0	-3.6
101	MH-9	13.8	MH-8	11.5	309	0.74	Concrete	0.013		1	Circle	12			1.34	0.5	0	-3.1
103	MH-8	11.5	MH-7	7.31	264	1.58	Concrete	0.013	24" Dia	1	Circle	30			11.2	55	0	-51.6
105	MH-7	7.31	MH-5	4.54	262	1.06	Concrete	0.013	24" Dia	1	Circle	30			11.18	54.9	0	-42.2
107	MH-5	4.54	MH-4	3.02	264	0.58	Concrete	0.013	24" Dia	1	Circle	36			7.75	54.8	0	-50.6
109	MH-4	3.02	MH-3	1.62	255	0.55	Concrete	0.013	24" Dia	1	Circle	36			7.74	54.7	0	-49.4
111	MH-3	1.62	MH-2	0.6	304	0.34	Concrete	0.013	24" Dia	1	Circle	36			7.73	54.7	0	-38.6
113	MH-2	0.6	MH-1	0.43	46	0.37	Concrete	0.013	24" Dia	1	Circle	36			7.73	54.7	0	-40.6
115	MH-1	0.43	Walnut PS	0	166	0.26	Concrete	0.013	24" Dia	1	Circle	36			7.98	54.7	0	-33.9
132	MH-22	2.62	MH-14	0.82	176	1.02	Concrete	0.013	2 Barrels	3	Box		9	5	9.96	1,344.80	100	-710.7
134	MH-14	0.82	OF-2	0.82	210	0	Concrete	0.013		2	Box		10	8	8.88	1,420.10	84.4	-97.8
140	MH-33	4.94	MH-32	1.78	262	1.21	Concrete	0.013		1	Circle	30			6.14	30.1	0	-45.1
142	MH-32	1.78	MH-31	-0.46	254	0.88	Concrete	0.013		1	Circle	30			6.13	30.1	0	-38.5
143	MH-31	-0.46	MH-29	-0.83	223	0.17	Concrete	0.013		1	Circle	30			6.11	30	0	-16.7
145	MH-29	-2	MH-30	-2.9	270	0.33	Concrete	0.013	30" Dia per a	1	Circle	36			8.63	61	0	-38.5
147	MH-30	-2.9	Angus PS "	-3	137	0.07	Concrete	0.013	30" Dia per a	1	Circle	36			8.63	61	0	-18
150	MH-156	147	MH-155	145.03	154	1.28	Concrete	0.013		1	Circle	18			0	0	0	-11.9
152	MH-155	145.03	MH-154	132.4	127	9.98	Concrete	0.013		1	Circle	18			0.91	0.1	0	-33.2
154	MH-154	132.4	MH-153	130.49	87	2.19	Concrete	0.013		1	Circle	24			12.09	30.5	0	-33.5
156	MH-153	130.49	MH-152	106.69	255	9.33	Concrete	0.013		1	Circle	30			24.54	53.9	0	-125.3
158	MH-152	106.69	MH-151	91	240	6.53	Concrete	0.013		1	Circle	30			13.16	64.6	0	-104.8
160	MH-151	91	MH-150	90	210	0.48	Concrete	0.013	30" Dia	1	Circle	36			8.9	62.9	0	-46
162	MH-150	90	MH-149	88.98	257	0.4	Concrete	0.013	30" Dia	1	Circle	36			9.97	70.5	0	-42
164	MH-149	88.98	MH-148	85	250	1.59	Concrete	0.013		1	Circle	30			14.36	70.5	0	-51.8
166	MH-148	85	MH-147	61.8	251	9.26	Concrete	0.013		1	Circle	30			26.18	70.5	0	-124.8
168	MH-147	61.8	MH-146	42.23	242	8.09	Concrete	0.013		1	Circle	30			24.86	70.5	0	-116.6
170	MH-146	42.23	MH-145	41.66	298	0.19	Concrete	0.013	30" Dia	1	Circle	42			7.33	70.5	0	-44
172	MH-145	41.66	MH-144	38.77	481	0.6	Concrete	0.013	30" Dia	1	Circle	42			7.33	70.5	0	-78
174	MH-144	38.77	MH-143	38.5	134	0.2	Concrete	0.013	30" Dia	1	Circle	42			10.94	105.3	0	-45.1
176	MH-143	38.5	MH-142	38.24	38	0.68	Concrete	0.013	30" Dia	1	Circle	42			10.94	105.3	0	-82.9
184	MH-139	29.89	MH-138	29.61	30	0.95	Concrete	0.013	1 Barrel, 3' R	1	Box		10	4	14.32	572.7	0	-564
190	MH-136	25.21	MH-135	24.98	216	0.11	Concrete	0.013		1	Box		9	5	12.72	572.6	0.1	-230.2
192	MH-135	24.98	MH-134	24.92	25	0.24	Concrete	0.013		1	Box		10	3	19.09	572.7	0.2	-186
194	MH-134	24.92	MH-133	20.45	173	2.58	Concrete	0.013		1	Box		10	3	19.09	572.7	0.2	-605.9
196	MH-133	20.45	MH-132	20.15	44	0.68	Concrete	0.013		1	Box		10	3	18.82	564.5	0	-312.1
198	MH-132	20.15	MH-131	18	213	1.01	Concrete	0.013		1	Box		10	3	18.82	564.6	0	-379
200	MH-131	18	MH-130	18.06	49	-0.12	Concrete	0.013		1	Box		10	3	19.84	595.1	1.4	-132.5
202	MH-130	18.06	MH-124	17	194	0.55	Concrete	0.013		1	Box		10	3	21.85	655.4	0	-279
221	MH-165	57.75	MH-166	52.76	217	2.3	Concrete	0.013		1	Circle	27			11.98	25.1	0	-46.9
223	MH-164	58.67	MH-165	57.75	93	0.99	Concrete	0.013		1	Circle	24			8.39	25.1	0	-22.5
225	MH-163	65.6	MH-164	58.67	228	3.04	Concrete	0.013		1	Circle	24			13.32	25.2	0	-39.5
227	MH-162	67.45	MH-163	65.6	95	1.94	Concrete	0.013		1	Circle	24			11.16	25.2	0	-31.5
229	MH-161	72	MH-162	67.45	226	2.01	Concrete	0.013		1	Circle	24			11.3	25.2	0	-32.1
231	MH-160	75.5	MH-161	72	142	2.47	Concrete	0.013		1	Circle	24			12.25	25.3	0	-35.5
233	MH-159	85.11	MH-160	75.5	236	4.06	Concrete	0.013		1	Circle	24			14.88	25.3	0	-45.6
235	MH-158	89.5	MH-159	85.11	155	2.84	Concrete	0.013		1	Circle	21			0	0	0	-26.7

DETENTION - CONDUIT

ID	U/S MH	U/S MH Inv (ft)	D/S MH	D/S MH Inv (ft)	Length (ft)	Slope (%)	Material	Manning's n	Existing Conditions	Number of Barrels	Section Type	Diameter (in)	Span (ft)	Rise (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (cfs)	Depth/Rise (%)	Capacity (Excess Full) (cfs)
237	MH-157	91.94	MH-158	89.5	138	1.77	Concrete	0.013		1	Circle	21			0	0	0	-21.1
240	MH-168	53.29	MH-167	49.71	430	0.83	Concrete	0.013	60" Dia	1	Box		6	4	16.75	401.9	0.1	-282.6
242	MH-169	57.35	MH-168	53.29	45	9.11	Concrete	0.013		1	Circle	60			25.4	354.5	0	-785.9
244	MH-170	58	MH-169	57.35	117	0.56	Concrete	0.013		1	Circle	60			18.06	354.5	0	-194.4
246	MH-171	75	MH-170	58	1,082.00	1.57	Concrete	0.013		1	Circle	60			18.06	354.5	0	-326.5
248	MH-172	95.05	MH-171	75	476	4.21	Concrete	0.013		1	Circle	60			21.88	353.5	0	-534.3
254	MH-179	213.02	MH-178	211	107	1.89	Concrete	0.013	36" Dia	1	Circle	66			11.33	269.2	0	-461.7
256	MH-180	220.3	MH-179	213.02	266	2.74	Concrete	0.013	36" Dia	1	Circle	42			20.56	197.8	0	-166.6
258	MH-183	264.16	MH-180	220.3	390	11.26	Concrete	0.013		1	Circle	30			31.74	126.3	0	-137.6
260	MH-184	272	MH-183	264.16	136	5.75	Concrete	0.013		1	Circle	30			25.8	126.3	0	-98.4
262	MH-185	274.2	MH-184	272	45	4.84	Concrete	0.013		1	Circle	27			31.76	126.3	0	-68.1
264	MH-186	289.2	MH-185	274.2	477	3.14	Concrete	0.013		1	Circle	27			13.32	23.4	0	-54.9
266	MH-187	297.4	MH-186	289.2	297	2.76	Concrete	0.013		1	Circle	21			0	0	0	-26.3
268	MH-188	339	MH-187	297.4	363	11.47	Concrete	0.013		1	Circle	21			0	0	0	-53.7
270	MH-189	396.5	MH-188	339	356	16.15	Concrete	0.013		1	Circle	21			0	0	0	-63.7
272	MH-190	402.13	MH-189	396.5	116	4.85	Concrete	0.013		1	Circle	21			0	0	0	-34.9
274	MH-191	228.7	MH-180	220.3	539	1.56	Concrete	0.013		1	Circle	36			11.02	77.9	0	-83.2
276	MH-192	234.25	MH-191	228.7	281	1.98	Concrete	0.013		1	Circle	36			12.08	85.4	0	-93.8
278	MH-193	237.05	MH-192	234.25	92	3.06	Concrete	0.013	24" Dia	1	Circle	36			12.95	91.5	0	-116.6
280	MH-194	261.9	MH-193	237.05	386	6.43	Concrete	0.013	21" Dia	1	Circle	36			20.03	114.2	0	-169.1
282	MH-195	276	MH-194	261.9	495	2.85	Concrete	0.013		1	Circle	15			0	0	0	-10.9
285	MH-31	5.5	CS-10	5	62	0.81	Concrete	0.013		1	Box		6.5	6	11.16	373.4	100	-512.1
287	CB-65	6	MH-31	5.5	323	0.15	Concrete	0.013		1	Box		6.5	6	10.64	372.2	100	-207.3
289	MH-34	6.55	CB-65	6	133	0.41	Concrete	0.013		1	Box		6.5	6	10.16	371.7	100	-357.2
291	MH-35	7.81	MH-34	6.55	139	0.91	Concrete	0.013		1	Box		6.5	6	11.21	371.6	95.6	-540.5
293	MH-36	8.94	MH-35	7.81	355	0.32	Concrete	0.013		1	Box		6.5	6	11.5	371.5	93.4	-304.9
295	MH-37	14.04	MH-36	8.94	476	1.07	Concrete	0.013		1	Box		6.5	6	13.92	336.7	90.2	-581.1
297	MH-38	17.29	MH-37	14.04	429	0.76	Concrete	0.013		1	Box		6.5	6	13.85	299.5	83	-473.5
299	MH-39	20.78	MH-38	17.29	103	3.38	Concrete	0.013		1	Box		6	4	20.88	299.5	100	-518.9
301	MH-40	21.12	MH-39	20.78	89	0.38	Concrete	0.013		1	Box		6	4	12.48	299.5	92.1	-142.3
303	MH-41	30.07	MH-40	21.12	757	1.18	Concrete	0.013		1	Box		6	4	15.76	275.5	73	-293.3
305	CH-7	46.64	MH-41	30.07	706	2.35	Concrete	0.013		1	Box		6	4	18.9	204.2	63	-440.7
331	MH-42	11.22	MH-111	11	84	0.26	Concrete	0.013	Improved by	2	Box		12	4	9.94	953.9	0.2	-368.8
333	MH-57	11.5	MH-42	11.22	52	0.54	Concrete	0.013	Improved by	2	Box		12	4	9.24	886.8	0	-528.1
335	MH-45	11.65	MH-57	11.5	151	0.1	Concrete	0.013		1	Box		8.5	3.5	12.65	376.3	0	-123.5
337	MH-46	11.85	MH-45	11.65	61	0.34	Concrete	0.013		1	Box		10	3	12.54	376.2	0	-218.4
339	MH-47	15.74	MH-46	11.85	229	1.7	Concrete	0.013		1	Box		10	3	12.5	375.1	0	-491.4
341	MH-48	15.74	MH-47	15.74	40	0	Concrete	0.013		1	Box		10	3	12.37	371	0.8	0
343	MH-49	17.14	MH-48	15.74	229	0.61	Concrete	0.013		1	Box		10	3	12.29	368.8	0	-295.2
345	MH-50	17.52	MH-49	17.14	41	0.92	Concrete	0.013		1	Box		10	3	12.22	366.7	0	-362.7
347	MH-51	19.8	MH-50	17.52	226	1.01	Concrete	0.013		1	Box		10	3	12.19	365.7	0	-379.3
349	MH-52	20	MH-51	19.8	64	0.31	Concrete	0.013		1	Box		10	3	12.13	363.8	0	-210.8
351	MH-53	21	MH-52	20	226	0.44	Concrete	0.013		1	Box		10	3	11.96	358.9	0	-250.7
353	MH-54	21.76	MH-53	21	62	1.22	Concrete	0.013		1	Box		10	3	11.88	356.5	0.2	-416.8
363	MH-77	50.3	MH-59	33	1,137.00	1.52	Concrete	0.013		1	Circle	72			20.53	580.5	0	-522.4
365	MH-78	54.5	MH-77	50.3	664	0.63	Concrete	0.013		1	Circle	72			18.05	510.4	0	-336.8
367	MH-79	75	MH-78	54.5	1,182.00	1.73	Concrete	0.013		1	Circle	72			17.74	501.6	0	-557.8
369	CH-1	87	MH-79	75	218	5.52	Concrete	0.013		1	Circle	72			19.59	488.6	1.7	-994.6

ID	U/S MH	U/S MH Inv (ft)	D/S MH	D/S MH Inv (ft)	Length (ft)	Slope (%)	Material	Manning's n	Existing Conditions	Number of Barrels	Section Type	Diameter (in)	Span (ft)	Rise (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (cfs)	Depth/Rise (%)	Capacity (Excess Full) (cfs)
376	MH-81	112	MH-80	88	1,786.00	1.34	Concrete	0.013		1	Circle	72			18.14	300.1	0	-490.9
390	MH-86	339.6	MH-85	339.5	260	0.04	Concrete	0.013		1	Circle	60			16.46	323.1	0	-51.1
392	MH-87	339.63	MH-86	339.6	234	0.01	Concrete	0.013		1	Circle	60			15.46	303.5	0	-29.5
394	MH-88	390.55	MH-87	339.63	674	7.56	Concrete	0.013		1	Circle	56			31.12	532.2	0	-595.6
396	MH-89	393.85	MH-88	390.55	318	1.04	Concrete	0.013		1	Circle	56			31.12	532.3	0	-220.6
400	MH-91	414.8	MH-90	393.85	410	5.12	Concrete	0.013		1	Circle	66			15.61	370.9	0	-759.4
402	MH-96	430.8	MH-91	414.8	303	5.29	Concrete	0.013		1	Circle	36			9.3	65.7	0	-153.4
404	MH-97	436.55	MH-96	430.8	183	3.14	Concrete	0.013		1	Circle	36			17.18	65.7	0	-118.2
406	MH-98	483.3	MH-97	436.55	340	13.76	Concrete	0.013		1	Circle	36			29.69	65.7	0	-247.4
408	MH-99	532.11	MH-98	483.3	578	8.44	Concrete	0.013		1	Circle	20			27.24	59.4	0	-40.4
410	MH-100	630.19	MH-99	532.11	780	12.58	Concrete	0.013		1	Circle	20			0	0	0	-49.3
412	MH-101	681.54	MH-100	630.19	321	16.02	Concrete	0.013		1	Circle	12			0	0	0	-14.3
414	MH-102	707	MH-101	681.54	284	8.95	Concrete	0.013		1	Circle	12			0	0	0	-10.7
416	MH-103	719.83	MH-102	707	107	12.03	Concrete	0.013		1	Circle	12			0	0	0	-12.4
418	MH-92	483.4	MH-91	414.8	441	15.57	Concrete	0.013		1	Circle	54			44.64	263.9	0	-775.9
424	MH-95	580.6	MH-94	561.05	691	2.83	Concrete	0.013		1	Circle	54			23.09	264.1	0	-330.8
435	MH-65	33.19	MH-59	33	93	0.2	Concrete	0.013	18" Dia	1	Circle	36			8.92	63	0	-30.1
437	MH-67	40.3	MH-65	33.19	797	0.89	Concrete	0.013		1	Circle	36			8.66	58.1	0	-63
439	MH-66	44.7	MH-67	40.3	307	1.43	Concrete	0.013		1	Circle	30			11.14	53.9	0	-49.1
441	MH-68	45.2	MH-66	44.7	131	0.38	Concrete	0.013	24" Dia	1	Circle	30			8.97	44	0	-25.3
443	MH-69	46.2	MH-68	45.2	159	0.63	Concrete	0.013	24" Dia	1	Circle	30			8.97	44.1	0	-32.5
445	MH-70	46.6	MH-69	46.2	107	0.37	Concrete	0.013	24" Dia	1	Circle	30			8.99	44.1	0	-25
447	MH-71	48	MH-70	46.6	164	0.85	Concrete	0.013	20" Dia	1	Circle	30			9	44.2	0	-37.8
449	MH-72	49.2	MH-71	48	316	0.38	Concrete	0.013	20" Dia	1	Circle	30			9	44.2	0	-25.3
455	MH-75	50.4	MH-74	50.3	119	0.08	Concrete	0.013		1	Circle	18			0.22	0.2	0	-3
457	MH-76	53.6	MH-75	50.4	385	0.83	Concrete	0.013		1	Circle	18			0	0	0	-9.6
472	MH-60	12	MH-57	11.5	216	0.23	Concrete	0.013		1	Box		8	4	18.98	607.5	0	-213.2
479	MH-177	210	MH-176	209	585	0.17	Concrete	0.013		1	Circle	60			13.64	267.7	0	-107.7
482	MH-178	211	MH-177	210	386	0.26	Concrete	0.013	60" Dia	1	Circle	66			11.27	267.8	0	-171
507	MH-94	561.05	MH-92	483.4	981	7.91	Concrete	0.013		1	Circle	54			34.35	263.8	0	-553.2
508	MH-85	339.5	CH-6	338	423	0.35	Concrete	0.013		1	Circle	54			20.32	323.1	0	-117.2
514	MH-59	33	MH-54	21.76	409	2.75	Concrete	0.013		1	Box		10	7	26.91	690.9	0.1	-2,145.30
517	MH-124	17	MH-120	15.51	229	0.65	Concrete	0.013		1	Box		5	4	10.91	218.2	0	-197.9
521	MH-120	15.51	MH-60	12	765	0.46	Concrete	0.013		1	Box		5	4	10.79	215.8	0	-166.1
524	MH-111	11	MH-15	7.72	449	0.73	Concrete	0.013	Improved by	2	Box		12	4	10.69	1,026.10	0.3	-614.3
526	MH-15	7.72	MH-19	4.97	742	0.37	Concrete	0.013	2 Barrels	3	Box		9	5	9.94	1,342.10	25.4	-429.7
529	MH-19	4.97	MH-22	2.62	780	0.3	Concrete	0.013	2 Barrels	3	Box		9	5	9.74	1,315.40	76.1	-387.3
530	MH-196	17.05	MH-111	11	674	0.9	Concrete	0.013		1	Circle	36			9.84	69.6	0	-63.2
531	MH-104	31.9	MH-196	17.05	1,296.00	1.15	Concrete	0.013		1	Circle	15			0	0	0	-6.9
532	MH-74	50.3	MH-72	49.2	67	1.65	Concrete	0.013		1	Circle	18			0.22	0.4	0	-13.5
534	MH-124	17	MH-126	13.86	274	1.15	Concrete	0.013		1	Box		6	4	15.61	374.7	0	-331.8
536	MH-126	13.86	MH-50	9	897	0.54	Concrete	0.013		1	Box		9	4	9.39	337.9	0.3	-376.1
538	MH-50	9	MH-58	8.5	59	0.84	Concrete	0.013		2	Box		11	4	4.48	393.9	0.2	-595.5
539	MH-58	8.5	MH-15	7.72	280	0.28	Concrete	0.013	GSP 2 Barrel:	2	Box		7	4	7.21	403.6	0.3	-198.4
541	MH-124	17	MH-125	13.86	277	1.14	Concrete	0.013		2	Box		6	4	3.76	180.6	0.2	-330.1
543	MH-125	13.86	MH-127	10.28	295	1.21	CMP	0.024		1	Pipe-Arch		10	4	3.76	120.3	0.4	(N/A)
545	MH-127	10.28	MH-129	9.77	158	0.32	CMP	0.024		1	Pipe-Arch		10	4	3.6	115.3	0.3	(N/A)
547	MH-129	9.77	MH-128	9.5	122	0.22	CMP	0.024		1	Pipe-Arch		10	4	3.54	113.4	0.2	(N/A)

ID	U/S MH	U/S MH Inv (ft)	D/S MH	D/S MH Inv (ft)	Length (ft)	Slope (%)	Material	Manning's n	Existing Conditions	Number of Barrels	Section Type	Diameter (in)	Span (ft)	Rise (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (cfs)	Depth/Rise (%)	Capacity (Excess Full) (cfs)
548	MH-128	9.5	MH-50	9	171	0.29	Concrete	0.013		1	Box		10.7	4	2.98	127.1	0.2	-338.7
549	MH-125	13.86	MH-42	11.22	963	0.27	Concrete	0.013		1	Circle	44			5.66	59.8	0	-59.6
551	MH-137	29	MH-136	25.21	589	0.64	Concrete	0.013		1	Box		9	5	12.73	572.6	0.2	-566.1
552	MH-138	29.61	MH-137	29	179	0.34	Concrete	0.013	1 Barrel, 3' R	1	Box		10	4	14.32	572.7	0.2	-338.9
553	MH-142	38.24	MH-139	29.89	472	1.77	Concrete	0.013		1	Box		10	3	18.11	543.3	0	-501.5
554	MH-166	52.76	MH-167	49.71	309	0.99	Concrete	0.013		1	Circle	27			6.56	25.1	0	-30.8
555	MH-167	49.71	MH-142	38.24	537	2.14	Concrete	0.013		1	Box		10	3	21.22	427	0.3	-551.4
560	MH-176	209	MH-172	95.05	1,592.00	7.16	Concrete	0.013		1	Circle	60			33.13	267.6	0	-696.7
566	MH-80	88	CH-2	88	438	0	Concrete	0.013		1	Circle	72			16.19	457.8	4.2	-0.1
577	OS-2	87	CH-9	86.38	84	0.74	CMP	0.024	30" Dia; 2 Ba	2	Circle	30			5.37	32.4	27.6	-19.7
733	MH-90	393.85	MH-89	393.85	153	0	Concrete	0.013		1	Circle	66			21.09	501.1	1.1	0
1136	OS-3	206	MH-82	180.13	1,169.00	2.21	Concrete	0.013		1	Circle	72			21.43	271.3	3.2	-629.7
1137	MH-82	180.13	MH-81	112	915	7.45	Concrete	0.013		1	Circle	72			33.34	271.3	1.8	-1,155.50
1153	MH-54	21.76	MH-59A	12.52	1,689.00	0.55	Concrete	0.013		1	Ellipse		6.3	4	7.11	565.8	0	-191.5
1154	MH-59A	12.52	MH-60	12	95	0.55	Concrete	0.013		1	Ellipse		6.3	4	5.76	458.2	0	-191.5
1175	CB-147	0.2	OF-11	0	203	0.1		0.013		1	Circle	144			7.49	221.3	0	-844
1177	MH-23	-0.45	MH-23A	-1.44	208	0.48	Concrete	0.013	24" Dia	1	Box		3	3	3.67	33	0	-58.6
1178	MH-23A	-1.44	MH-29	-2	118	0.48	Concrete	0.013	24" Dia	1	Box		3	3	3.45	31	0	-58.7
1182	CB-149	-0.1	MH-23A	-1.44	29	4.65		0.013		1	Circle	12			0	0	0	-7.7

DETENTION - MANHOLES

Id	Label	Rim Elevation (ft)	Is Bolted	Invert Elevation (ft)	Hydraulic Grade (ft)	Is Flooded Ever?	Flow (Out to Links Maximum) (cfs)	Flow (Overflow Maximum) (cfs)	Flow (Total In Maximum) (cfs)	Hydraulic Grade (Maximum) (ft)	Is Flooded?
92	MH-12	22.5	FALSE	17.5	17.5	FALSE	0	0	0	17.5	FALSE
93	MH-11	22.15	FALSE	17.15	17.15	FALSE	0	0	0	17.15	FALSE
116	MH-15	13.22	FALSE	7.72	7.73	FALSE	1,168.00	0	1,168.70	14.58	FALSE
123	MH-19	10.47	FALSE	4.97	5.94	FALSE	1,163.80	0	1,163.90	11.4	FALSE
129	MH-22	9.4	FALSE	2.62	5.91	FALSE	1,153.80	0	1,153.90	8.07	FALSE
131	MH-14	9.17	FALSE	0.82	5.9	FALSE	1,153.20	0	1,153.20	7.16	FALSE
135	MH-23	3.05	FALSE	-0.45	-0.45	FALSE	23.5	0	24.1	2.6	FALSE
138	MH-33	7.94	FALSE	4.94	4.94	FALSE	22.7	0	22.8	6.2	FALSE
139	MH-32	6.28	FALSE	1.78	1.78	FALSE	22.7	0	22.7	3.19	FALSE
141	MH-31	4.54	FALSE	-0.46	-0.46	FALSE	22.6	0	22.7	2.01	FALSE
144	MH-30	4	FALSE	-2.9	-2.9	FALSE	45.5	0	45.5	-0.14	FALSE
175	MH-142	42.87	FALSE	38.24	38.24	FALSE	470	0	469.5	40.53	FALSE
201	MH-124	24.27	FALSE	17	17	FALSE	547.9	0	557.8	21.09	FALSE
238	MH-167	55	FALSE	49.71	49.72	FALSE	373.5	0	373.4	51.55	FALSE
249	MH-176	214	FALSE	209	209	FALSE	222.9	0	222.9	210.95	FALSE
251	MH-178	220.5	FALSE	211	211	FALSE	223	0	223	219.47	FALSE
253	MH-179	220.9	FALSE	213.02	213.02	FALSE	223	0	223.4	220.1	FALSE
255	MH-180	232	FALSE	220.3	220.3	FALSE	165.9	0	167.9	227.11	FALSE
284	MH-31	14.2	FALSE	5.5	11.31	FALSE	287.1	0	287.1	11.31	FALSE
330	MH-42	17.74	FALSE	11.22	11.23	FALSE	761.1	0	758	16.92	FALSE
352	MH-54	29.76	FALSE	21.76	21.77	FALSE	577	0	583.1	24.82	FALSE
368	CH-1	97	FALSE	87	87.1	FALSE	380.9	0	380.7	89.58	FALSE
375	MH-81	126.92	FALSE	112	112	FALSE	257.3	0	256.8	115.09	FALSE
478	MH-177	220.57	FALSE	210	210	FALSE	222.9	0	223	217.7	FALSE
516	MH-120	19.51	FALSE	15.51	15.51	FALSE	127.8	0	127.8	20.4	FALSE
533	MH-126	19.06	FALSE	13.86	13.87	FALSE	217.9	0	217.8	19.95	FALSE
535	MH-50	13.85	FALSE	9	9.01	FALSE	363.5	0	358.8	16.33	FALSE
540	MH-125	19.06	FALSE	13.86	13.88	FALSE	201.8	0	202.1	19.99	FALSE
542	MH-127	15.15	FALSE	10.28	10.3	FALSE	142	0	142.1	18.63	FALSE
544	MH-129	14.65	FALSE	9.77	9.78	FALSE	141.4	0	141.4	17.83	FALSE
546	MH-128	14.95	FALSE	9.5	9.51	FALSE	141	0	141	17.19	FALSE
550	MH-137	34	FALSE	29	29.01	FALSE	492	0	492	32.91	FALSE
649	MH-57	17.35	FALSE	11.5	11.5	FALSE	700.2	0	700.3	17.34	FALSE
650	MH-58	13.05	FALSE	8.5	8.51	FALSE	363.2	0	363.3	15.92	FALSE
1152	MH-59A	17.67	FALSE	12.52	12.52	FALSE	227.8	0	227.8	18.55	FALSE
1179	MH-23A	3	FALSE	-1.44	-1.44	FALSE	23.3	0	23.3	1.78	FALSE

GHD Inc

2235 Mercury Way
Suite 150
Santa Rosa CA 95407-5472

T: 1 707 523 1010   F: 1 707 527 8679   E: santarosa@ghd.com

N:\US\Santa Rosa\Projects\02487 - San Bruno\0248708001 - San Bruno SDMP\FINAL SDMP REVISIONS-08-13\FINAL DOCUMENT\GHD Report.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date

www.ghd.com