Golden Gate National Recreation Area Final Drainage Report

CA NP GOGA 469(1)

China Beach Access Road

San Francisco, CA

Federal Highway Administration, Central Federal Lands Highway Division

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Acronyms

Atkins	Atkins North America, Inc.
Caltrans	California Department of Transportation
CFLHD	Central Federal Lands Highway Division
cf	cubic feet
cfs	cubic feet per second
EISA	Energy Independence and Security Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FLH	Office of Federal Lands Highway
FVA	Fundamental vertical accuracy
GGNPC	Golden Gate National Park Conservancy
GOGA	Golden Gate National Recreation Area
IDF	Intensity-Duration-Frequency
LiDAR	Light Detection and Ranging
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NVA	Non-vegetated vertical accuracy
PDDM	*Project Development and Design Manual*
SDE	Sherwood Design Engineers
Tc	Time of Concentration
UTM	Universal Transverse Mercator
VVA	Vegetated vertical accuracy

1. Introduction

The purpose of this report is to provide the hydrologic and hydraulic (H&H) analysis at the Golden Gate National Recreation Area (GOGA) Improvements Project CA NP 469(1) China Beach Access Road (Figure 1.1), located at China Beach in San Francisco County. Major improvements to this site include site grading, retaining wall rehabilitation, new u-channels, pavement replacement, and drainage infrastructure. This report will explain the China Beach project's existing drainage conditions and infrastructure, and present the proposed drainage improvement designs.

Figure 1.1: GOGA China Beach Project Location

2. Project Criteria

The *GOGA Hydrologic and Hydraulic Criteria and Computational Methods Memo* (see Appendix A) outlines the proposed design criteria and methodologies used for the project. Drainage criteria were developed using methods, guidelines, and standards set forth in the Federal Highway Administration (FHWA), Office of Federal Lands Highway (FLH), *Project Development and Design Manual* (PDDM), the American Association of State Highway and Transportation Officials (AASHTO), and the California Department of Transportation (Caltrans) *Highway Design Manual.* This memo references equations and factors used to evaluate the existing drainage and design the proposed infrastructure.

3. China Beach

3.1. Project Background

China Beach is within San Francisco County, located approximately two miles southwest of the Golden Gate Bridge. The improvements include redesign and reconstruction of retaining walls along the trail and parking lot, as well as architectural improvements to the gathering areas adjacent to the parking lot. This project will also include new drainage infrastructure and improvements to the current u-channels (drainage channels). The proposed drainage analyses and design for this site was performed by Sherwood Design Engineers. The goals of this report are to: (1) analyze and identify any existing retaining wall drainage capacity issues, (2) assess the changes to existing drainage patterns due to proposed improvements, and (3) describe the proposed design. All drainage related documentation for China Beach is contained in Appendix D and Appendix E.

3.2. Existing Hydrology and Hydraulics

This section summarizes the existing drainage patterns and the analyses used to identify existing retaining wall drainage inlet capacity.

3.2.1. Drainage Patterns

The China Beach Trail originates at Sea Cliff Avenue and ends at China Beach. The high relief between the origin and end of the trail causes grade breaks that require retaining walls (see Figure 3.1). The upper parking area is level with Sea Cliff Avenue, and stormwater flows collect at a catch basin drainage inlet depression. A pipe routes the flow down and through the wall, and stormflows collect in a short, steep, concrete u-channel ditch. A concrete structure that resembles a headwall halts flow and allows it to drop into an inlet (see Figure 3.2) and is conveyed downhill.

Figure 3.1: Trail and Retaining Walls

Figure 3.2: Parking Lot Runoff Outfall and Downstream Inlet

The rest of the trail's drainage pattern follows a similar system: u-channels with curb to inlet and/or pipe culverts (see Figure 3.3). The flow is eventually routed underground to three existing outfalls located at the promenade seawall (see Figure 3.4). The current survey and routing for the underground system is unknown. The seawall also contains weepholes that collect runoff from the existing Bathhouse and adjacent pavement.

Figure 3.3: V-Ditch Along Roadside Edge

Figure 3.4: Seawall Outfalls

3.2.2. Drainage Infrastructure

The China Beach Trail contains pipes varying in diameter from 8 inches to 12 inches. See Appendix D, Exhibit D.1.1 for the exact locations.

3.2.3. Data Sources

3.2.3.1. Elevation Data

Elevation data sources onsite and offsite are summarized in Table 3.1. Offsite contours are not used for design; their use is for drainage area delineations only.

Table 3.1: China Beach Elevation Data Sources

Location	Onsite	Offsite	Raw Elevation Data Set (Produced For, Year)	Projected Coordinate System	Vertical Datum	NVA	VVA
China Beach	X		Site Survey (Atkins by R.E.Y. Engineers LLC, 2020)	NAD83 California State Plane, Zone III US foot	NAVD88		
		X	West Coast El Nino Lidar (USGS, 2016)	NAD83 (2011) UTM Zone 10 Meters	NAVD88	11.4 cm	21.1 cm

Abbreviations: NVA = Non-vegetated vertical accuracy; VVA = Vegetated vertical accuracy

3.2.3.2. Rainfall Data

Precipitation intensity and precipitation depth data for Latitude 37.7885 degrees, Longitude -122.4884 degrees was obtained from NOAA Atlas 14, Volume 6, Version 2, respectively. Precipitation depth for the 2-year, 24-hour event is used in the computation for sheet flow (Table 3.3). Precipitation intensity is used to develop an IDF curve using a best-fit power equation. The 10-year storm precipitation intensity was used to design the management of site runoff (Table 3.2). Rainfall data tables obtained from NOAA are referenced in Appendix C. The rainfall intensity is determined by the time of concentration, and is applied to the rational formula, which will be described below. For time of concentration below 5 minutes, the rainfall intensity is 3.13 inches per hour to meet local City and County of San Francisco ordinances and codes.

Table 3.2: China Beach Precipitation Intensity for a 10-Year Storm Event

Duration (minutes)	Duration (hours)	Intensity (inches/hour)
5	0.083	3.06
10	0.167	2.20
15	0.250	1.77
30	0.500	1.22
60	1.000	0.86
120	2.000	0.61
180	3.000	0.50

Table 3.3: China Beach Precipitation Depth for a 2-Year, 24-Hour Storm Event

Event	Precipitation Depth (inches)
2-year, 24-hour	2.53

3.2.3.3. Soil Data

China Beach soil data were obtained from the NRCS Web Soil Survey (Appendix B). The sub-project area and its contributing uphill area consist of rock crop orthents and do not have an assigned hydrologic soil group. Orthents typically are shallow soils on steep slopes with no distinguishable soil horizon.

3.2.4. Drainage Area Calculations

3.2.4.1. Drainage Area Delineation

Existing conditions drainage area delineations are shown in Appendix D, 0.

3.2.4.2. Rational Method

The Rational Method was used to estimate a watershed's peak flow rate based on inputs that include a dimensionless runoff coefficient (C), rainfall intensity (i), and the drainage area acreage (A). The C values and drainage areas are summarized in Appendix D. Existing peak flows are summarized in Table 3.4, and calculations are provided in 0.

The rational formula is: $Q = CiA$

Table 3.4: Existing China Beach 10-Year Peak Flows

Drainage Area ID	Peak Flow (cfs)
DMA 1 (E)	1.62
DMA 2 (E)	0.01
DMA 3 (E)	0.48
DMA 4 (E)	0.17
DMA 5 (E)	0.48
DMA 6 (E)	0.47
DMA 7 (E)	0.17
DMA 8 (E)	1.36
DMA 9 (E)	0.40

3.2.4.3. Time of Concentration

The rainfall intensity is determined by the time of concentration, which is the time required for runoff to travel from the hydraulically most distant point in the watershed to the furthest outlet. The time of concentration is broken down via sheet flow, shallow concentrated flow, and open channel flow regimes. For sheet flow conditions, sheet flow is calculated to a maximum length of 100 feet, which then becomes shallow concentrated flow. If the total calculated time of concentration was below 5 minutes, local City and County of San Francisco Ordinances were followed, which requires an intensity of 3.13 inches per hour to be used. When the calculated Time of Concentration was greater than 5 minutes, National Oceanic and Atmospheric Administration (NOAA) data was used, which is referenced in Appendix C.

Time of concentration calculations are shown in Appendix D, Exhibit D.1.2 and Appendix E, Exhibit E.1.2, Exhibit E.1.4, and Exhibit E.1.6.

Assumptions made when calculating the time of concentration include:

- Sheet flow:
  - Precipitation depth of 2.53 inches for 2 year, 24 hour event
  - Roughness coefficient for sheet flow of smooth surfaces n = 0.011
  - Roughness coefficient for sheet flow of dense grass n = 0.24
- Shallow Concentrated Flow
  - Coefficient Cp = 6.962 for short pasture surfaces
- Open Channel Flow
  - Roughness Coeff for concrete channel n=0.012

Calculations are shown in Appendix D, Exhibit D.1.2 and Appendix E, Exhibit E.1.2, Exhibit E.1.4, and Exhibit E.1.6.

3.2.4.4. Hydraulics

The runoff from the parking lot, Drainage Area 1(E), flows into Inlet 1(E), which is collected by Pipe P1(E). Pipe 1(E) connects to Pipe P2(E), which drains the flow to an outfall at the retaining wall. No detailed dimensions or photos of Inlet 1(E) were obtained from the field survey. The assumption is the depressedd inlet (a.k.a. catch basin) is substantially similar to FLH Standard 604-1-Catch Basin Type 1. Subsequently, the grate dimensions used to calculate spread at 50% clogging are 2-foot, 6-inch length and 2-foot, 6-inch width. The result is a spread of 2.83 feet at the existing inlet. These pipes and inlet will be demolished when the retaining wall is replaced.

The flow from the outfall at the retaining wall, along with Drainage Area 2(E), drains into Inlet 2(E) and routes through Pipe P3(E), which is connected to Inlet 3(E). The flow from Drainage Area 3(E) also drains into Inlet 3(E). The combined flow at Inlet 3(E) runs through Pipe P4(E) to a culvert and leads into a u-channel, EX C2. This u-channel also collects runoff from Drainage Area 4(E), which all flows to Inlet 4(E). There are no survey details for the pipe routing from Inlet 4(E). It is assumed that the flow eventually makes its way down to one of the three seawall outfalls.

Remaining runoff from the road and hillsides for Drainage Area 5(E), Drainage Area 6(E), Drainage Area 7(E), and Drainage Area 8(E) lead into a series of u-channels and inlets, which eventually make their way to the seawall outfalls. See Appendix D, Exhibit D.1.1 for existing drainage routing. The runoff from the promenade walk against the face of the wall, Drainage Area 9(E), drains through the seawall weepholes. See Appendix D, Exhibit D.1.2 for calculations pertaining to existing conditions.

3.3. Project Improvements

Proposed improvements include redesign and reconstruction of retaining walls along the China Beach Trail. There will be a new site entry with concrete seat walls and regrading along the parking lot, parking lot sidewalk, and the top portion of the roadway. New catch basins and u-channels will replace the existing inlets and u-channels for stormwater management. Hydrodynamic separators will be deployed to account for water quality. Updates to the Bathhouse facilities at the base of the China Beach Trail are being designed and addressed under a separate project.

3.3.1. Impacts to Existing Drainage Patterns

The drainage pattern from the parking lot will be similar in routing, with improvements to the pipe network and water quality aspect. The parking lot originally drains through the existing parking lot inlet, eventually to the u-channel, and down to an existing seawall outfall. The new schematic for the parking lot drainage

instead flows through two catch basins at the parking lot depression and connects directly to a main pipe network. The catch basins will contain trash capture devices to remove potential trash from the stormwater stream. The runoff will eventually flow to the West Outfall located at the seawall. See Appendix E, Exhibit E.1.3 and Exhibit E1.4 for delineation of the parking lot routing and respective calculations.

The drainage pattern for the driveway/trail and along the road from the entrance to the promenade will follow a similar schematic to existing conditions – flowing into adjacent u-channels. The proposed u-channels have been widened compared to existing conditions to address vehicular conflict concerns and allow for metal grates to be integrated. The existing storm drain pipe routing for the v-ditches is unknown per gathered survey. The road runoff will sheet flow into proposed u-channels, which will each flow to a respective terminal inlet catch basin. The runoff stream from the driveway/trail catchment areas will also be treated via a hydrodynamic separator. These inlets are connected to the main West Outfall storm drain pipe alignment, which is piped to the seawall outfall located at the West promenade. This outfall will increase from an 8” outfall to a 12” outfall per peak runoff calculations for the 10-year and 100-year storm.

The vegetated hillside runoff of the site originally sheet flows onto the road and into the u-channels. The proposed design will capture the hillside runoff in swales behind the walls, which flow to an atrium grate and collect into a back of wall drain. These drains will be piped and connected to one of the three major storm drain alignments that least to the seawall outfalls.

There will be two proposed hydrodynamic separators for the West Outfall and Center Outfall storm drain alignments, located at the promenade. The hydrodynamic separators will improve water quality by removing suspended solids, sediments, and trash collected in the stream before the runoff drains to the seawall outfalls.

See Appendix E for proposed project improvements for site runoff design and schematic.

3.3.2. Proposed Drainage Calculations

Drainage areas in the proposed and existing conditions mainly follow similar separation, however the proposed areas separated into smaller catchments and routed to different outfalls dependent on the type and location of runoff. Proposed peak flows are summarized in Table 3.5. See Appendix E, Exhibit E.1.1, Exhibit E.1.3, and Exhibit E.1.5 for drainage management area delineation and Appendix E, Exhibit E.1.2, Exhibit E.1.4, and Exhibit E.1.6 for calculations.

Table 3.5: Proposed China Beach 10-Year Peak Flows

Drainage Area ID	Peak Flow (cfs)
1	0.37
2	0.39
3	0.26
4	0.22
5	0.20
6	0.07
7	0.08
8	0.53
9	0.26
10	0.11
11	0.19
12	0.19

13	0.09
14	0.09
15	0.08
16	0.12
17	0.13

3.3.3. Proposed Hydraulic Calculations

There are three main proposed storm drain alignments, which collect runoff from the site and eventually lead to the three seawall outfalls. The West Outfall alignment will mainly collect runoff from the parking lot and entrance area, u-channels, and partial West hillside runoff. The Center Outfall alignment will convey hillside runoff that drains to the retaining wall inlets. The East Outfall alignment will mainly collect the very East hillside runoff, and the treated water from a portion of the future Promenade runoff and biotreatment. The u-channels along the site will be increased in width and size based on sizing calculation results displayed in Table 3.8. Stormwater conveyance sizing has been computed to accommodate the 10-year and 100-year storm.

To adequately size the conveyance system in accordance with FHWA standards, the Rational Method was used based on the methodology described in the FHWA Urban Drainage Design Manual. The runoff coefficient was calculated based on the varying amounts of land cover of each drainage area. The rainfall intensity used varied based on the calculated Time of Concentration, which is referenced in Appendix E, Exhibit E.1.2, Exhibit E.1.4, and Exhibit E.1.6. When the calculated Time of Concentration was greater than 5 minutes, National Oceanic and Atmospheric Administration (NOAA) data was used. If the calculated Time of Concentration was less than 5 minutes, local City and County of San Francisco Ordinances were followed, which requires an intensity of 3.13 inches per hour to be used. Compared to NOAA data, this was a slightly more conservative value. Hydraulic routing and delineation is shown in Appendix E, Exhibit E.1.1, Exhibit E.1.3, and Exhibit E.1.5 and calculations are shown in Appendix E, Exhibit E.1.2, Exhibit E.1.4, and Exhibit E.1.6.

The existing depressed catch in the parking lot has the following information:

- Inlet dimensions: 2.6’ W x 2.2’ L x 2.4’ depth
- Assumed percent clogging: 50%
- Resulting spread: 1.74’

The proposed catch basin in the parking lot has the following information:

- Inlet dimensions: 2’ W x 2’ L x 5.00’ and 22.75’ depth respectively (Inlet 1 and 2)
- Assumed percent clogging: 50%
- Resulting spread: 3.20’ and 2.89’ respectively (Inlet 1 and 2)

In the case of intense rainfalls, there is potential of inlet spread. Partial amounts of water are not captured by the inlet, flowing outside of the gutter pan and into the road. For cases where the catch basins are located at the tail of the u-channels with the transverse slope sloping away from the catch basin, there will be no inlet spread. The water is contained in the u-channel and will not experience overtopping.

The u-channel and pipe capacity were sized using Manning’s equation. See Appendix A for design criteria and constraints.

- Manning’s Equation: $Q = VA = \frac{1..49}{n} * A * R^{\frac{2}{3}} * S^{\frac{1}{2}}$

Proposed inlet data, storm drainage pipe data and u-channel data are summarized in Table 3.6, Table 3.7, and Table 3.8 respectively. See Appendix E for calculations and routing exhibits

Table 3.6: Proposed Inlet Data

Inlet ID	Basin ID	10-yr Flow (cfs)	Spread (feet)	Depth (feet)
1	1	0.37	3.20	5.00
2	2	0.39	2.89	22.75
3	9	0.26	2.13	18.79
4	10	0.11	1.46	4.66
5	11	0.19	1.67	8.55
6	3	0.26	1.11	3.79
7	4	0.22	3.81	4.00
8	5	0.20	1.58	4.00
9	6	0.07	1.64	4.00
10	12	0.19	2.15	8.67
11	14	0.09	1.71	10.12
12	17	0.13	1.63	7.93
13	15	0.08	1.09	7.50
14	16	0.12	1.28	8.55

Table 3.7: Proposed Pipe Data

Pipe ID	Size	10-yr Flow (cfs)	HGL (feet)	Velocity (f/s)
P1	8	0.37	85.75	1.06
P2	8	0.75	69.15	1.10
P3	8	0.26	46.96	0.75
P4a	8	0.76	32.39	2.18
P4b	8	0.76	23.97	2.18
P5	8	0.34	28.15	0.98
P6	8	0.11	21.14	0.32
P7	10	0.58	20.32	1.05
P8	8	0.19	19.97	0.56
P9	10	0.77	19.42	1.41
P10	8	0.08	18.87	0.22
P11	10	0.85	18.90	1.55
P12	8	1.09	67.19	3.13
P13	8	0.22	39.21	0.63
P14	8	1.31	37.98	3.77
P15	8	0.20	29.62	0.58
P16	8	1.52	29.62	4.35
P17	8	0.07	21.51	0.20
P18	10	1.59	21.46	2.91

P19	12	2.20	19.38	2.81
P20a	10	0.34	20.82	0.62
P20b	10	0.53	20.58	0.97
P20c	10	0.62	19.93	1.13
P21	10	0.62	19.65	1.13
P22	10	0.53	18.71	0.97
P23	10	0.65	17.67	1.20
P24	8	0.13	18.61	0.36
P25	8	0.08	33.28	0.23
P26	8	0.45	28.16	0.83
P27	8	0.75	67.79	2.16
P28	8	0.08	85.16	0.23
P29	8	0.08	83.06	0.23
P30	8	0.26	67.65	0.74
P31	8	0.34	67.43	0.97
P32	8	0.12	21.86	0.35

The proposed u-channels will also utilize Manning's equation to calculate the peak flow rate of the channels. The u-channels will have a ditch geometry of a semi-circle with a channel width of 1.0-feet and a channel depth of 0.5 feet, which is used in finding the hydraulic radius, R, and area of the channel, A. The longitudinal slope, S, of the channel will be consistent with the adjacent road slopes relative to the channels. The u-channel will be of concrete surface material and will use a Manning's roughness coefficient of n = 0.013. See Table 3.8 for a summary of the u-channels and Appendix E, Exhibit E.1.7 for u-channel routing and Appendix E, Exhibit E.1.8 for u-channel sizing calculations.

Table 3.8: Proposed U-channels

Ditch ID	10-yr Flow (cfs)	Velocity (fps)	Shear Stress	Freeboard
C1	0.28	0.66	0.60	0.24'
C2	0.48	0.56	0.89	0.20'
C3	0.52	0.52	0.89	0.29'
C4	0.07	0.18	1.00	0.36'

3.3.4. Permanent Water Quality

3.3.4.1. Design Criteria

As this project is located on federal land, FHWA standards were implemented in the stormwater design. According to the FHWA Urban Drainage Design Manual, minor systems are normally designed to carry runoff from 10-year frequency storm events and major systems are typically designed to carry more infrequent events, such as 25-, 50-, and 100-year storms. Based on the definitions of minor systems and major systems, the site conveyance systems are entirely comprised of minor systems up to the existing outfalls. This includes the site underground piping and U-Channels. The existing outfalls can be defined as the major systems. Therefore, the future upgrades were designed per the 10-year frequency storm and the existing outfalls were checked by the 100-year storm.

The permanent water quality aspect of the conveyance system will be treated with two hydrodynamic separators, located at the bottom of the driveway/trail for each major storm drain pipe system at the promenade level. See Appendix E, Exhibit E.1.1 and Exhibit E.1.3 for hydrodynamic separator locations and inflow peak flowrates for the respective devices. These hydrodynamic separators are stormwater management devices that utilize cyclonic separation to control water pollution by mechanically removing suspended solids and floatables. These devices can treat the 100-year storms and would be able to withstand potential additional flows originating from Seacliff Ave. run-on. The device will function as an inline unit capable of conveying 100% of the design peak flows and is designed to remove at least 80% of the suspended solids on an annual aggregate removal basis.

3.3.4.2. Water Quality Improvements

The current stormwater conveyance system has no formal treatment, which will be improved by the addition of hydrodynamic separators at the downstream promenade area to treat stormwater streams before draining to the beach outfalls. There will also be trash capture systems at each catch basin to remove solids and trash from pedestrian and vehicular areas before routing the runoff to the main pipe systems.

3.3.5. Recommended Maintenance

The maintenance activity and frequency required is summarized in Table 3.9.

Table 3.9: Maintenance Activity and Frequency

Structure Type	Maintenance/Details	Frequency
Cleanouts	Remove trash and debris and clogging in piping	As Needed
Inlets	Remove sediment and trash from sump	Twice Annually (More frequently for heavily travelled areas)
Hydrodynamic Separator	Remove sediment and trash	Monitored twice annually for two years. After two years, monitoring can be reduced to once annyally and cleaning out can be adjusted based on sediment and debris loading observed during the first two years. Anticipated cleaning approximately once per year.

3.3.6 Outfall Protection

There will be riprap placed on the sand at the beach level in front of the seawall outfalls. This will provide energy dissipation and prevent erosion potential. Riprap will be 4 ft Length x 4 ft Width x 1 ft Depth, filled with 4”-6” rocks. Reference Appendix A and the rip rap detail in Appendix F for additional outfall protection information and criteria.

3.4. Drainage Design Summary

China Beach drainage improvements include removal and replacement of inlet 1(E) at the parking lot and replaced with two proposed inlets. The runoff will flow through a series of inlets, in which the second inlet has a 22.75’ drop. This inlet will directly connect into the West Outfall storm drain alignment via piping. The existing u-channels will be removed and reconstructed to a widened u-channel. There will be swales and back of wall drains to prevent runoff from the hillside from overflowing onto the road. The roadway and hillside drainage are being improved in a way that meets pre-existing conditions but treat a higher level of runoff. From a drainage perspective, flow is controlled at the surface and the runoff from the site and hillside areas drain to and are routed via piping to three separate storm drain alignments that lead to the seawall outfalls

4. References

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Appendices

Appendix A. GOGA Hydrologic and Hydraulic Criteria and Computational Methods Memo

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GOGA Hydrologic and Hydraulic Criteria and Computational Methods Memo

1. H&H Criteria Reference

H&H analysis and design work for the China Beach Access Road Project associated with the proposed improvements are in accordance with the methods, guidelines, and criteria set forth by the Federal Highway Administration (FHWA), Office of Federal Lands Highway (FLH), *Project Development and Design Manual* (PDDM), the American Association of State Highway and Transportation Officials (AASHTO), and the California Department of Transportation (Caltrans) *Highway Design Manual*. Among these agencies, FLH and Caltrans have developed manuals establishing guidance for H&H design. The design manuals used for this project include:

- FLH *Project Development and Design Manual* (PDDM) (2018)

2. Hydrology

The hydrologic approach to determine peak flows using the Rational Method.

2.1 Rational Method

The Rational Method is used to calculate the peak flow, Q, for the drainage management areas and watersheds within the site. The main assumptions are: (1) the storm duration equals the time of concentration, (2) the rainfall intensity is uniform for the storm duration, and (3) the peak flow frequency is equal to the rainfall intensity frequency. The rational formula is:

$$Q = CiA$$

where,

Q = peak flow (cubic feet per second)

i = the rainfall intensity for the design storm (inches per hour)

A = the drainage area (acres)

C = dimensionless runoff coefficient based on land cover

Statistical rainfall data from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 WAS be used to create an intensity-duration frequency (IDF) curve. Time of concentration (TOC) for each watershed is the sum of travel times for segments along the hydraulically most distant flow path, via a summation of travel times for sheet flow, shallow concentrated flow, and channelized flow. The approach to solving for the TOC is explained in detail in Chapter 816 of the HDM. Runoff coefficient C values will be obtained from HDM Table 819.2A and HDM Table 819.2B, and the runoff coefficient will be area-weighted where multiple land covers exist within a watershed. Watershed basin delineations will use project survey, 2019 LiDAR data, and aerial image

3. Roadway Hydraulics

Hydraulics design within GOGA property limits of the China Beach Access Road Project will be governed by FHL PDDM design criteria.

3.1 Ditches

Ditches will be analyzed using inputs of ditch geometry (e.g., bedslope, side slopes, bottom width) and design discharge. Manning's equation is applied to find the channel flow rates. Table 1 summarizes the ditch requirements per the FLH PDDM, unless otherwise noted.

Table 1. Ditch Design Criteria

Design Component	Design Standard
Storm Event	▪ 10-year, design ▪ 100-year, check
Depth	▪ Existing Ditches: no greater than the shoulder hinge point ▪ Proposed Ditches: no greater than the bottom of the aggregate sub-base layer of the roadway pavement
Slope	▪ Desired Minimum: 1.0% ▪ Allowable Minimum: 0.5%
Freeboard Height	▪ Varies as a function of channel shape and flow regime, per HDM Table 868.2 (Caltrans, specific to SR 35)
Cross Section Shape	▪ Vee, trapezoidal, rectangular, parabolic, or triangular
Stability	▪ 10-year design storm event ▪ Hydraulic Engineering Circular 15 (HEC-15) outlines acceptable channel linings to include: vegetation, cobble, rock riprap, gabion, wire-enclosed riprap, turf reinforcement
Erosion Protection	▪ Lined with rock, stone, concrete, vegetation ▪ Permissible shear and velocity for selected linings per HDM Table 865.2 (Caltrans)

Mannings Equation is:

$$Q = VA = \frac{1..49}{n} * A * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

where,

Q = flow rate (cubic feet per second)

V = velocity (feet per second)

n = Manning's roughness coefficient (unitless)

A = drainage area (acres)

R = hydraulic radius (feet)

S = channel slope (feet/feet)

* Under the assumption of uniform flow conditions, the bottom slope is the same as the slope of the energy grade line and the water surface slope

3.2 Pavement Drainage

Pavement for this project includes high-standard and low-standard roadway pavement, pedestrian concrete, and parking areas. The China Beach Access Road project will be graded to drain using ditches, inlets, and pipes, as needed. Table 2 summarizes the pavement drainage requirements per the FLH PDDM, unless otherwise noted.

Table 2. Pavement Drainage Criteria

Design Component	Design Standard
Storm Event	On-grade, Sag, and Parking Areas: ▪ 10-year Sumps (deep roadway sags) where storm drain system is the only outlet: ▪ 50-year
Spread	▪ 3 feet of one travel lane for gutter flow (High-Standard Road) ▪ one-half the width of one travel lane for gutter flow (Low-Standard Road) ▪ one-half the width of one travel lane for gutter flow (roadway with less than 3 feet of pavement width outside the travel lane)
Depth	▪ Less than curb height (on-grade, sag, and parking area) ▪ 6 inches (roadway sumps and parking area sumps)
Inlet Clogging Factor	▪ 0% unless clogging known to be a problem (on-grade) ▪ 50% (sump and sag grate inlets) ▪ 0% unless clogging known to be a problem (sump and sag curb inlets)
Inlet Efficiency	▪ 70% minimum (on-grade)

3.3 Storm Drains

Table 3 summarizes the criteria for storm drain pipe design per FLH's PDDM, unless otherwise noted.

Table 3. Storm Drain Design Criteria

Design Component	Design Standard
Storm Event Capacity Design	On-grade: ▪ 10-year Sumps: 50-year ▪ Design storm drains to flow full whenever possible
Minimum Size	▪ 15 inches
Minimum Slope	▪ 3 fps to ensure self-cleansing when flowing full ▪ 0.5% as a minimum for constructability

Hydraulic Grade Line (HGL)	▪ Needs to be calculated over the full length of storm drains with four or more inlets connected in a series ▪ If the design flood creates pressure flow, the HGL must remain below ground elevation at all inlets an access structures and watertight gaskets would be specified for the pipe joints ▪ HGL must remain ≥ 0.75 feet below lip of the intake (Caltrans)
Energy Grade Line (EGL)	▪ Energy gradient should not rise above the lip of the intake (Caltrans)
Spacing Between Structures	▪ 15 inches to 24 inches: 300 feet ▪ 27 inches to 36 inches: 400 feet ▪ 42 inches to 54 inches: 600 feet ▪ 60 inches and up: 1,000 feet ▪ If self-cleansing velocity of 3 fps is unobtainable, spacing of 300 feet should be used (Caltrans)
Overside Drains	▪ Location based on roadway drainage criteria (Caltrans) ▪ Sideslopes 4:1 or steeper (Caltrans) ▪ Minimum pipe diameter: 8 inches (Caltrans)

Manning's equation was applied to calculate the pipe capacity of all pipe sizes to determine which pipe size would be sufficient to manage incoming flow rates

3.4 Outlet Protection

As stated in the FLH PDDM, entrance and outlet treatments for new structures are recommended to have flared end sections for pipes 48 inches in diameter and smaller. Where possible, all proposed outlets will be designed to include scour protection. For areas with no scour potential or where expected scour can be tolerated, no protection is required. For standard outlet treatment, typical riprap outlet protection that is properly designed to CFLHD Detail C-251-50 will be sufficient. Minimal outlet protection should consist of bedding, filter material, or geotextile. If additional protection is required, the design methods in HEC-11 and HEC-14 will be applied.

4. Summary

The information contained in this memorandum is only a summary of the applicable criteria, which outlines criteria from FLH PDDM.

During the design process, all criteria will be adhered to by the project engineer. The review process will check adherence to these criteria during the quality assurance/quality control process. Any changes to the design criteria during the design process will be discussed with the project team and noted in future memoranda. Drainage analysis and design work associated with the proposed improvements will be in accordance with the methods, guidelines, and criteria set forth in the FLH PDDM, FHWA HEC and Hydraulic Design Series (HDS) publications, and the Caltrans HDM.

5. References

Federal Highway Administration, Office of Federal Lands Highway. (2018). *Project Development and Design Manual*. Washington, D.C.: FHWA.

Federal Highway Administration, Office of Federal Lands Highway. (2012). *Hydraulic Engineering Circular No. 20: Stream Stability at Highway Structures (HEC-20), Fourth Edition*. Washington, D.C.: FHWA.

Federal Highway Administration, Office of Federal Lands Highway. (2009a). *Hydraulic Engineering Circular No. 23: Bridge Scour and Stream Instability Countermeasures: Experience, Section and Design Guidance (HEC-23). Third Edition.* Washington, D.C.: FHWA.

Federal Highway Administration, Office of Federal Lands Highway. (2009b). *Hydraulic Engineering Circular No. 14: Hydraulic Design of Energy Dissipators for Culverts and Channels (HEC-14). Third Edition.* Washington, D.C.: FHWA.

Federal Highway Administration, Office of Federal Lands Highway. (2002). *Hydraulic Design Series No.2 (HDS 2), Second Edition*. Washington, D.C.: FHWA.

Federal Highway Administration, Office of Planning, Environment, and Realty. (2001). *Designing Sidewalk and Trails for Access, Part II of II: Best Practices Design Guide*. Washington, D.C.: FHWA.

U.S. Department of the Interior, National Park Service. (2006). *Management Policies 2006 - The Guide to Managing the National Park System.* Washington, D.C.: NPS

Appendix B. NRCS Web Soil Survey

Map Scale: 1:1,070 if printed on B landscape (17" x 11") sheet.

N

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Mateo County, Eastern Part, and San Francisco County, California
Survey Area Data: Version 16, May 29, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 29, 2019—Jun 5, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
127	Rock outcrop-Orthents complex, 30 to 75 percent slopes	4.7	93.6%
136	Urban land-Sirdrak complex, 2 to 50 percent slopes	0.2	3.5%
138	Beaches	0.1	2.9%
Totals for Area of Interest		**5.0**	**100.0%**

Appendix C. Rainfall Data

SHERWOOD DESIGN ENGINEERS

NOAA Atlas 14, Volume 6, Version 2
Location name: San Francisco, California, USA*
Latitude: 37.7874°, Longitude: -122.4905°
Elevation: 92.24 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.142** (0.127-0.161)	**0.174** (0.154-0.197)	**0.217** (0.192-0.247)	**0.253** (0.223-0.291)	**0.305** (0.257-0.366)	**0.347** (0.285-0.427)	**0.391** (0.312-0.495)	**0.438** (0.338-0.574)	**0.505** (0.370-0.695)	**0.558** (0.393-0.802)
10-min	**0.204** (0.181-0.231)	**0.249** (0.221-0.282)	**0.311** (0.276-0.354)	**0.363** (0.319-0.418)	**0.438** (0.369-0.524)	**0.497** (0.409-0.612)	**0.561** (0.447-0.710)	**0.628** (0.484-0.823)	**0.723** (0.530-0.996)	**0.800** (0.563-1.15)
15-min	**0.246** (0.219-0.279)	**0.301** (0.268-0.341)	**0.376** (0.333-0.428)	**0.439** (0.386-0.505)	**0.529** (0.446-0.634)	**0.602** (0.494-0.740)	**0.678** (0.541-0.859)	**0.759** (0.585-0.995)	**0.875** (0.641-1.21)	**0.968** (0.681-1.39)
30-min	**0.339** (0.302-0.384)	**0.414** (0.369-0.470)	**0.517** (0.459-0.589)	**0.605** (0.531-0.696)	**0.729** (0.614-0.873)	**0.828** (0.681-1.02)	**0.933** (0.744-1.18)	**1.05** (0.806-1.37)	**1.20** (0.883-1.66)	**1.33** (0.938-1.91)
60-min	**0.478** (0.426-0.542)	**0.584** (0.520-0.663)	**0.730** (0.647-0.831)	**0.853** (0.749-0.981)	**1.03** (0.866-1.23)	**1.17** (0.960-1.44)	**1.32** (1.05-1.67)	**1.48** (1.14-1.93)	**1.70** (1.25-2.34)	**1.88** (1.32-2.70)
2-hr	**0.685** (0.611-0.777)	**0.832** (0.741-0.944)	**1.03** (0.916-1.18)	**1.20** (1.06-1.38)	**1.44** (1.21-1.73)	**1.63** (1.34-2.00)	**1.83** (1.46-2.32)	**2.04** (1.58-2.68)	**2.34** (1.72-3.23)	**2.58** (1.82-3.71)
3-hr	**0.853** (0.761-0.967)	**1.03** (0.921-1.18)	**1.28** (1.14-1.46)	**1.49** (1.31-1.72)	**1.79** (1.51-2.14)	**2.02** (1.66-2.48)	**2.27** (1.81-2.87)	**2.53** (1.95-3.32)	**2.90** (2.13-3.99)	**3.20** (2.25-4.59)
6-hr	**1.17** (1.05-1.33)	**1.43** (1.27-1.62)	**1.78** (1.58-2.03)	**2.07** (1.82-2.38)	**2.48** (2.09-2.98)	**2.81** (2.31-3.46)	**3.16** (2.52-4.00)	**3.52** (2.72-4.62)	**4.04** (2.96-5.56)	**4.45** (3.13-6.39)
12-hr	**1.53** (1.36-1.73)	**1.89** (1.69-2.15)	**2.39** (2.12-2.72)	**2.81** (2.47-3.24)	**3.41** (2.88-4.09)	**3.89** (3.20-4.78)	**4.39** (3.50-5.56)	**4.93** (3.80-6.46)	**5.68** (4.17-7.83)	**6.29** (4.43-9.03)
24-hr	**1.99** (1.79-2.25)	**2.50** (2.25-2.83)	**3.20** (2.87-3.64)	**3.80** (3.38-4.35)	**4.64** (4.01-5.48)	**5.33** (4.51-6.41)	**6.05** (5.01-7.45)	**6.82** (5.50-8.62)	**7.91** (6.14-10.4)	**8.80** (6.62-11.9)
2-day	**2.52** (2.27-2.86)	**3.15** (2.84-3.57)	**4.01** (3.60-4.56)	**4.74** (4.22-5.42)	**5.76** (4.98-6.80)	**6.58** (5.58-7.93)	**7.45** (6.17-9.17)	**8.37** (6.76-10.6)	**9.67** (7.51-12.7)	**10.7** (8.06-14.5)
3-day	**2.88** (2.60-3.26)	**3.58** (3.22-4.06)	**4.52** (4.06-5.14)	**5.32** (4.74-6.09)	**6.44** (5.57-7.61)	**7.34** (6.22-8.84)	**8.28** (6.86-10.2)	**9.27** (7.48-11.7)	**10.7** (8.29-14.0)	**11.8** (8.87-16.0)
4-day	**3.20** (2.89-3.63)	**3.98** (3.58-4.51)	**5.02** (4.50-5.70)	**5.89** (5.25-6.74)	**7.11** (6.14-8.39)	**8.07** (6.84-9.72)	**9.08** (7.52-11.2)	**10.1** (8.19-12.8)	**11.6** (9.04-15.3)	**12.8** (9.65-17.4)
7-day	**3.98** (3.59-4.51)	**4.97** (4.47-5.64)	**6.28** (5.64-7.14)	**7.36** (6.56-8.43)	**8.83** (7.63-10.4)	**9.98** (8.46-12.0)	**11.2** (9.24-13.7)	**12.4** (9.99-15.6)	**14.1** (10.9-18.5)	**15.4** (11.6-20.9)
10-day	**4.52** (4.07-5.12)	**5.68** (5.11-6.44)	**7.19** (6.45-8.16)	**8.41** (7.49-9.63)	**10.1** (8.69-11.9)	**11.3** (9.59-13.6)	**12.6** (10.4-15.5)	**13.9** (11.2-17.6)	**15.7** (12.2-20.6)	**17.0** (12.8-23.1)
20-day	**5.95** (5.36-6.74)	**7.56** (6.80-8.57)	**9.59** (8.61-10.9)	**11.2** (9.97-12.8)	**13.3** (11.5-15.7)	**14.8** (12.6-17.9)	**16.4** (13.6-20.2)	**17.9** (14.4-22.6)	**19.9** (15.4-26.1)	**21.4** (16.1-29.0)
30-day	**7.26** (6.54-8.22)	**9.25** (8.33-10.5)	**11.7** (10.5-13.3)	**13.6** (12.2-15.6)	**16.1** (13.9-19.0)	**17.9** (15.2-21.6)	**19.7** (16.3-24.2)	**21.4** (17.2-27.0)	**23.6** (18.3-31.0)	**25.2** (18.9-34.2)
45-day	**8.92** (8.04-10.1)	**11.4** (10.2-12.9)	**14.3** (12.9-16.3)	**16.6** (14.8-19.0)	**19.5** (16.8-23.0)	**21.6** (18.3-26.0)	**23.5** (19.5-29.0)	**25.4** (20.5-32.1)	**27.8** (21.6-36.5)	**29.5** (22.2-40.1)
60-day	**10.7** (9.67-12.2)	**13.6** (12.3-15.5)	**17.1** (15.4-19.5)	**19.8** (17.6-22.6)	**23.0** (19.9-27.2)	**25.4** (21.5-30.5)	**27.6** (22.8-34.0)	**29.7** (24.0-37.5)	**32.3** (25.1-42.4)	**34.2** (25.7-46.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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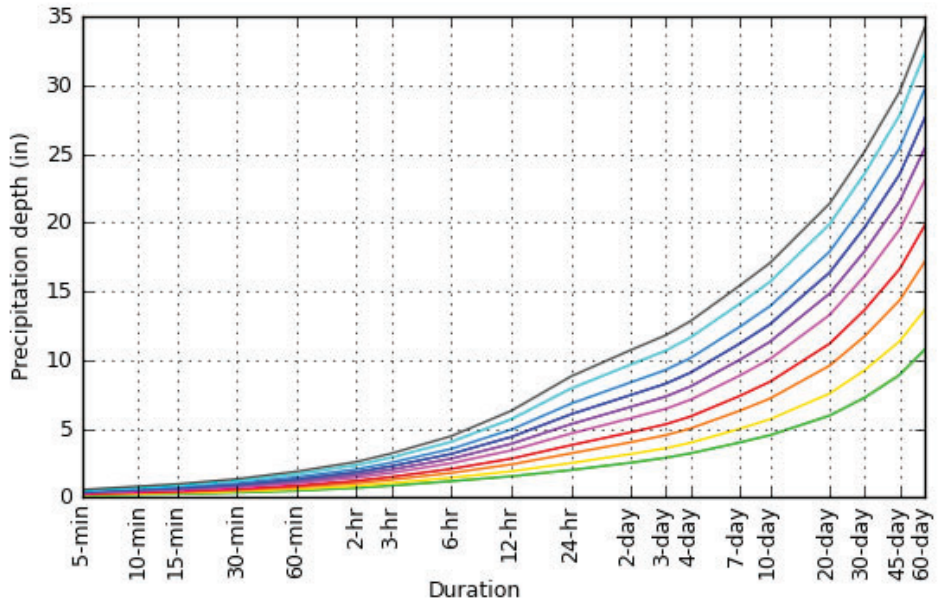
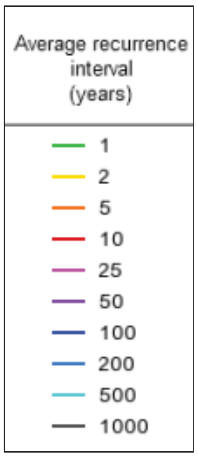
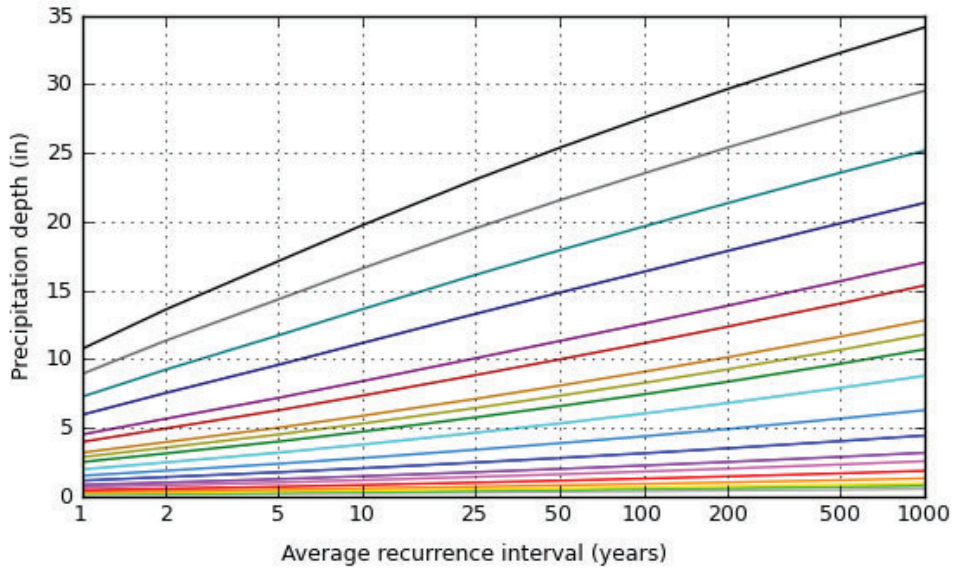
PF graphical

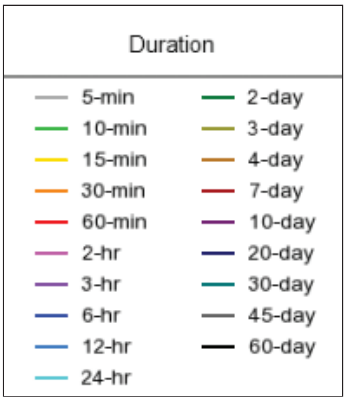
SHERWOOD DESIGN ENGINEERS

PDS-based depth-duration-frequency (DDF) curves
Latitude: 37.7874°, Longitude: -122.4905°









NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Tue Nov 17 17:01:54 2020

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Maps & aerials

Small scale terrain

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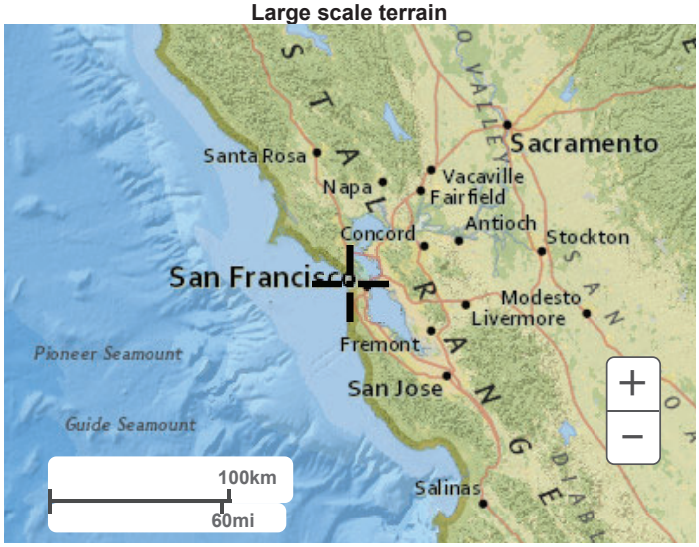
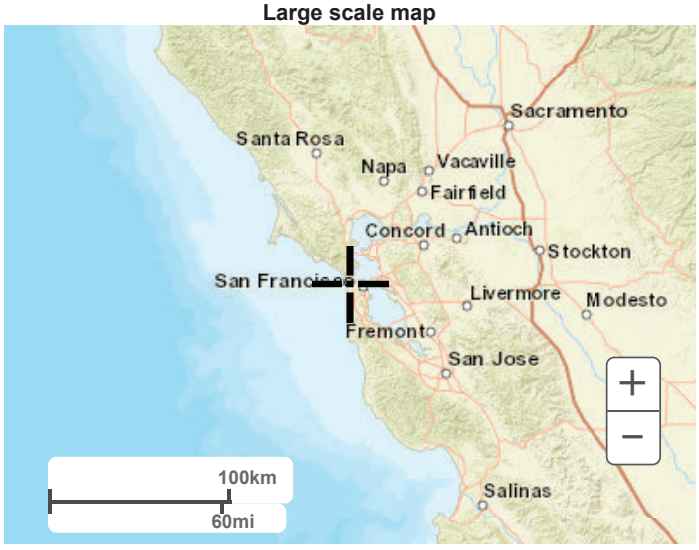
Large scale terrain



Large scale map



Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

SHERWOOD DESIGN ENGINEERS

NOAA Atlas 14, Volume 6, Version 2
Location name: San Francisco, California, USA*
Latitude: 37.7874°, Longitude: -122.4905°
Elevation: 92.24 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.70** (1.52-1.93)	**2.09** (1.85-2.36)	**2.60** (2.30-2.96)	**3.04** (2.68-3.49)	**3.66** (3.08-4.39)	**4.16** (3.42-5.12)	**4.69** (3.74-5.94)	**5.26** (4.06-6.89)	**6.06** (4.44-8.34)	**6.70** (4.72-9.62)
10-min	**1.22** (1.09-1.39)	**1.49** (1.33-1.69)	**1.87** (1.66-2.12)	**2.18** (1.91-2.51)	**2.63** (2.21-3.14)	**2.98** (2.45-3.67)	**3.37** (2.68-4.26)	**3.77** (2.90-4.94)	**4.34** (3.18-5.98)	**4.80** (3.38-6.89)
15-min	**0.984** (0.876-1.12)	**1.20** (1.07-1.36)	**1.50** (1.33-1.71)	**1.76** (1.54-2.02)	**2.12** (1.78-2.54)	**2.41** (1.98-2.96)	**2.71** (2.16-3.44)	**3.04** (2.34-3.98)	**3.50** (2.56-4.82)	**3.87** (2.72-5.56)
30-min	**0.678** (0.604-0.768)	**0.828** (0.738-0.940)	**1.03** (0.918-1.18)	**1.21** (1.06-1.39)	**1.46** (1.23-1.75)	**1.66** (1.36-2.04)	**1.87** (1.49-2.36)	**2.09** (1.61-2.74)	**2.41** (1.77-3.32)	**2.67** (1.88-3.83)
60-min	**0.478** (0.426-0.542)	**0.584** (0.520-0.663)	**0.730** (0.647-0.831)	**0.853** (0.749-0.981)	**1.03** (0.866-1.23)	**1.17** (0.960-1.44)	**1.32** (1.05-1.67)	**1.48** (1.14-1.93)	**1.70** (1.25-2.34)	**1.88** (1.32-2.70)
2-hr	**0.342** (0.306-0.388)	**0.416** (0.370-0.472)	**0.516** (0.458-0.588)	**0.600** (0.528-0.690)	**0.720** (0.606-0.862)	**0.815** (0.670-1.00)	**0.915** (0.730-1.16)	**1.02** (0.788-1.34)	**1.17** (0.859-1.61)	**1.29** (0.909-1.85)
3-hr	**0.284** (0.253-0.322)	**0.345** (0.307-0.391)	**0.427** (0.379-0.486)	**0.497** (0.436-0.571)	**0.594** (0.501-0.712)	**0.673** (0.553-0.827)	**0.755** (0.602-0.956)	**0.842** (0.649-1.10)	**0.966** (0.708-1.33)	**1.07** (0.749-1.53)
6-hr	**0.196** (0.175-0.222)	**0.239** (0.213-0.271)	**0.297** (0.264-0.338)	**0.346** (0.304-0.398)	**0.415** (0.350-0.497)	**0.470** (0.386-0.577)	**0.527** (0.421-0.668)	**0.589** (0.454-0.771)	**0.675** (0.495-0.929)	**0.744** (0.523-1.07)
12-hr	**0.127** (0.113-0.144)	**0.157** (0.140-0.178)	**0.199** (0.176-0.226)	**0.234** (0.205-0.269)	**0.283** (0.239-0.339)	**0.323** (0.265-0.397)	**0.365** (0.291-0.462)	**0.409** (0.315-0.536)	**0.472** (0.346-0.650)	**0.522** (0.368-0.750)
24-hr	**0.083** (0.075-0.094)	**0.104** (0.094-0.118)	**0.133** (0.120-0.152)	**0.158** (0.141-0.181)	**0.194** (0.167-0.229)	**0.222** (0.188-0.267)	**0.252** (0.209-0.310)	**0.284** (0.229-0.359)	**0.330** (0.256-0.433)	**0.367** (0.276-0.498)
2-day	**0.053** (0.047-0.060)	**0.066** (0.059-0.074)	**0.084** (0.075-0.095)	**0.099** (0.088-0.113)	**0.120** (0.104-0.142)	**0.137** (0.116-0.165)	**0.155** (0.129-0.191)	**0.174** (0.141-0.220)	**0.201** (0.156-0.265)	**0.223** (0.168-0.303)
3-day	**0.040** (0.036-0.045)	**0.050** (0.045-0.056)	**0.063** (0.056-0.071)	**0.074** (0.066-0.085)	**0.089** (0.077-0.106)	**0.102** (0.086-0.123)	**0.115** (0.095-0.142)	**0.129** (0.104-0.163)	**0.148** (0.115-0.195)	**0.164** (0.123-0.222)
4-day	**0.033** (0.030-0.038)	**0.041** (0.037-0.047)	**0.052** (0.047-0.059)	**0.061** (0.055-0.070)	**0.074** (0.064-0.087)	**0.084** (0.071-0.101)	**0.095** (0.078-0.117)	**0.106** (0.085-0.134)	**0.121** (0.094-0.159)	**0.134** (0.101-0.181)
7-day	**0.024** (0.021-0.027)	**0.030** (0.027-0.034)	**0.037** (0.034-0.042)	**0.044** (0.039-0.050)	**0.053** (0.045-0.062)	**0.059** (0.050-0.072)	**0.066** (0.055-0.082)	**0.074** (0.059-0.093)	**0.084** (0.065-0.110)	**0.091** (0.069-0.124)
10-day	**0.019** (0.017-0.021)	**0.024** (0.021-0.027)	**0.030** (0.027-0.034)	**0.035** (0.031-0.040)	**0.042** (0.036-0.049)	**0.047** (0.040-0.057)	**0.052** (0.043-0.065)	**0.058** (0.047-0.073)	**0.065** (0.051-0.086)	**0.071** (0.053-0.096)
20-day	**0.012** (0.011-0.014)	**0.016** (0.014-0.018)	**0.020** (0.018-0.023)	**0.023** (0.021-0.027)	**0.028** (0.024-0.033)	**0.031** (0.026-0.037)	**0.034** (0.028-0.042)	**0.037** (0.030-0.047)	**0.041** (0.032-0.054)	**0.045** (0.033-0.060)
30-day	**0.010** (0.009-0.011)	**0.013** (0.012-0.015)	**0.016** (0.015-0.019)	**0.019** (0.017-0.022)	**0.022** (0.019-0.026)	**0.025** (0.021-0.030)	**0.027** (0.023-0.034)	**0.030** (0.024-0.037)	**0.033** (0.025-0.043)	**0.035** (0.026-0.047)
45-day	**0.008** (0.007-0.009)	**0.011** (0.009-0.012)	**0.013** (0.012-0.015)	**0.015** (0.014-0.018)	**0.018** (0.016-0.021)	**0.020** (0.017-0.024)	**0.022** (0.018-0.027)	**0.024** (0.019-0.030)	**0.026** (0.020-0.034)	**0.027** (0.021-0.037)
60-day	**0.007** (0.007-0.008)	**0.009** (0.009-0.011)	**0.012** (0.011-0.014)	**0.014** (0.012-0.016)	**0.016** (0.014-0.019)	**0.018** (0.015-0.021)	**0.019** (0.016-0.024)	**0.021** (0.017-0.026)	**0.022** (0.017-0.029)	**0.024** (0.018-0.032)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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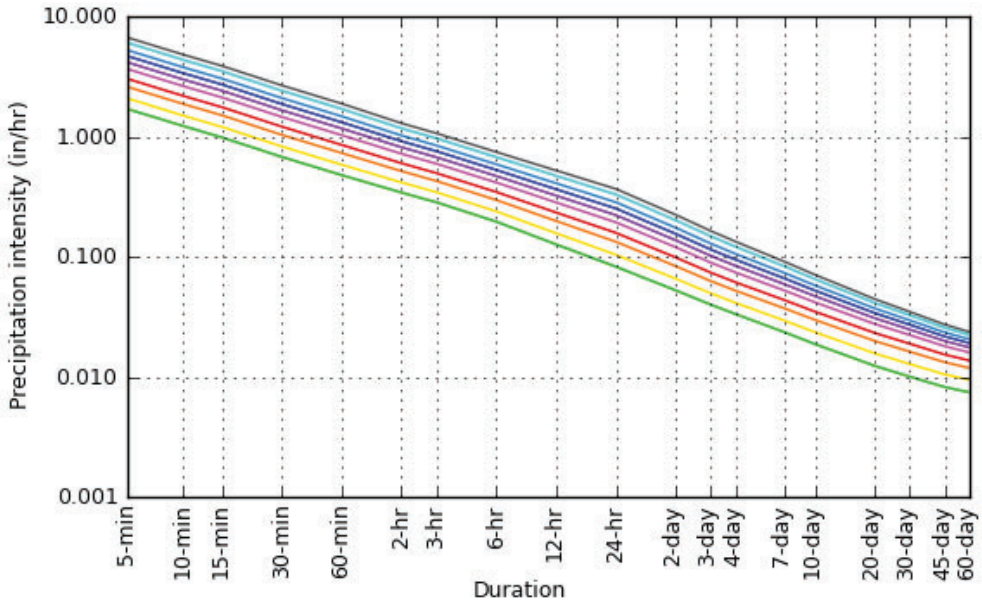
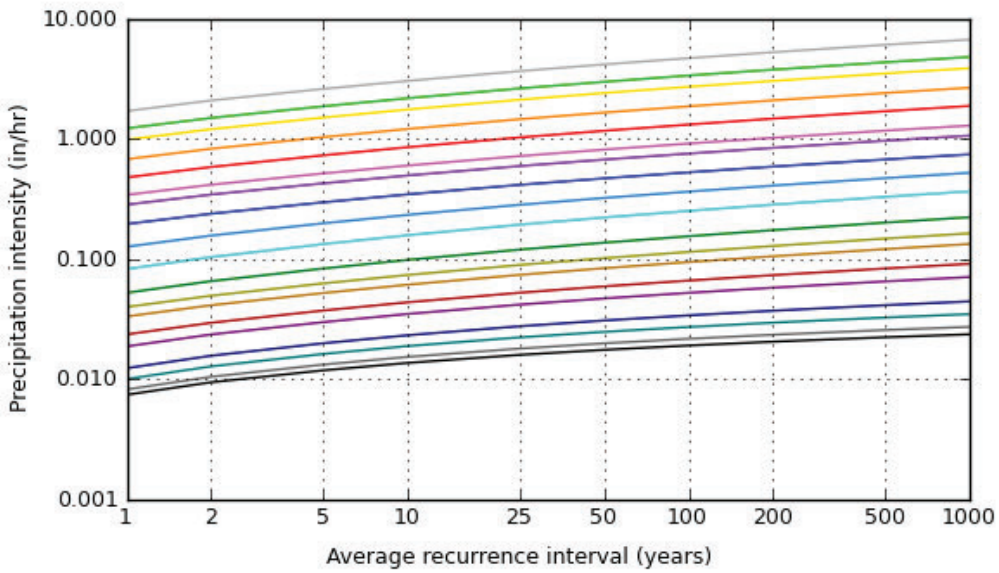
PF graphical

SHERWOOD DESIGN ENGINEERS

PDS-based intensity-duration-frequency (IDF) curves
Latitude: 37.7874°, Longitude: -122.4905°





NOAA Atlas 14, Volume 6, Version 2

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Maps & aerials

Small scale terrain

SHERWOOD
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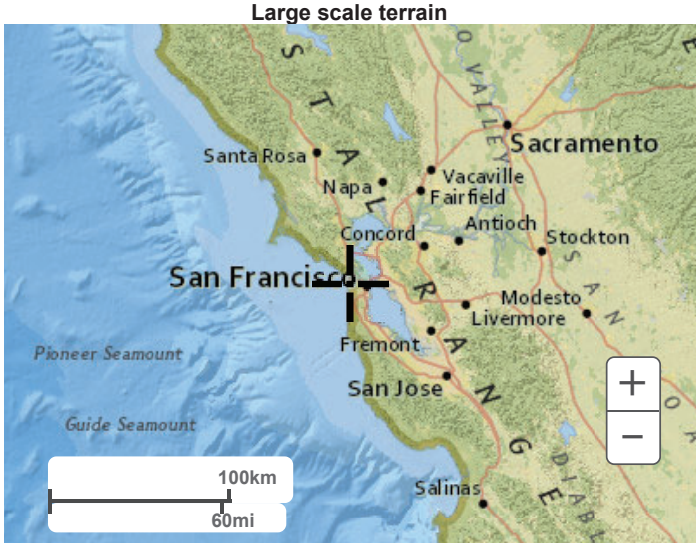
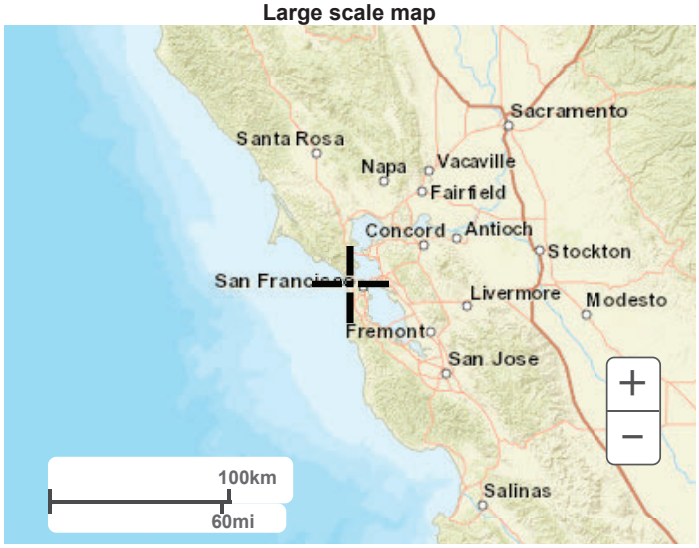
Large scale terrain



Large scale map



Large scale aerial

SHERWOOD
DESIGN ENGINEERS

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Appendix D. Existing Conditions

CHINA BEACH

320 SEA CLIFF AVE

330 SEA CLIFF AVE

Existing 8" SD Outfall
(INV: 18.86)

Drainage Area 9(E)
Impervious Area: 0.13 acres
Pervious Area: 0.01 acres
C: 0.92
i: 3.13 in/hr
Q: 0.40 cfs
Outfalls to seawall weepholes

Existing 12" SD Outfall
(Inv: 16.67)

Existing 12" SD Outfall
(Inv: 16.82)

FL 23.25

EX C4
V-ditch
D: 1.1'
US FL: 23.88
DS FL: 11.28

P6(E)
D: 8"
10 LF
US Inv 19.48
DS Inv 20.57

Inlet 6(E)
RIM: 22.59
8" INV OUT: 20.57
T: 2.10'

Inlet 7(E)
TOP 26.27
8" Inv Out: 25.64
T: 2.09'

P5(E)
D: 8"
6.8 LF
US Inv 33.31
DS Inv 32.52

EX C4
V-ditch
D: unknown
US FL: 23.25
DS FL: 22.59

Drainage Area 6(E)
Impervious Area: 0.08 acres
Pervious Area: 0.36 acres
C: 0.37
i: 2.87 in/hr
Q: 0.47 cfs

MH(E)
Rim: 23.95
8" Inv In: 19.48 (NE)
8" Inv In: 21.48 (E)
T: 3.11'

Inlet 5(E)
4" Pipe Culv
FL/Inv: 33.31
T: 1.33'

EX C3
V-ditch
D: 15"
US FL: 48.55
DS FL: 33.52

P7(E)
D: 8"
20 LF
US Inv 25.64
DS Inv 20.82

EX C4
V-ditch
D: 1.1'
US FL: 32.52
DS FL: 26.52

Drainage Area 8(E)
Impervious Area: 0.21 acres
Pervious Area: 1.30 acres
C: 0.34
i: 2.65 in/hr
Q: 1.36 cfs

Drainage Area 7(E)
Impervious Area: 0.02 acres
Pervious Area: 0.14 acres
C: 0.34
i: 3.13 in/hr
Q: 0.17 cfs

Inlet 4(E) - 3
Rim: 43.11
8" Inv Out: 40.70
Q: 2.28 cfs
T: 0.00'

EX C2
V-Ditch
D: 15"
US FL: 68.93
DS FL 44.17

Culvert
FL 69.11
8" INV OUT: 68.39

Inlet 3(E)
Rim: 71.75
8" Inv Out: 69.33
T: 0.11'

P4(E)
D: 8"
23.5 LF

P3(E)
D: 8"
10 LF

Drainage Area 2(E)
Impervious Area: 0.002 acres
Pervious Area: 0 acres
C: 0.95
i: 3.13 in/hr
Q: 0.01 cfs

Drainage Area 5(E)
Impervious Area: 0.08 acres
Pervious Area: 0.32 acres
C: 0.38
i: 3.13 in/hr
Q: 0.48 cfs

Drainage Area 4(E)
Impervious Area: 0.04 acres
Pervious Area: 0.08 acres
C: 0.87
i: 3.13 in/hr
Q: 0.17 cfs

Inlet 2(E)
RIM: 72.10
8" INV OUT: 69.53
T: 0.29'

EX C1
V-ditch
D: 15"
US FL: 89.77
DS FL: 71.75

P2(E)
D: 10"
3 LF

V-Ditch
3' Width
US FL: 75.64
DS FL: 71.07
8.6 LF

P1(E)
D: 12"
7 LF

Outfall
10" Inv Out: 77.33
FL: 75.64

Drainage Area 3(E)
Impervious Area: 0.16 acres
Pervious Area: 0 acres
C: 0.95
i: 3.13 in/hr
Q: 0.48 cfs

Inlet 1(E)
Rim: 88.10
12" Inv Out: 85.72
T50% Clogging : 1.74'

Drainage Area 1(E)
Impervious Area: 0.54 acres
Pervious Area: 0.01 acres
C: 0.94
i: 3.13 in/hr
Q: 1.62 cfs

LAND COVER LEGEND

IMPERVIOUS AREA

PERVIOUS AREA

NORTH

0 10' 20' 40'

EXISTING DRAINAGE AREAS

REHABILITATION OF CHINA BEACH
SAN FRANCISCO, CA

December 3, 2021

Exhibit D.1.1

SHERWOOD DESIGN ENGINEERS
2548 Mission Street
San Francisco, CA 94110
www.sherwoodengineers.com

SHERWOOD
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Drainage Area 1(E) - P1(E) and P2(E)
Existing Conditions

C =	0.94	
i =	3.13	in/hr
A =	0.55	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	23562	0.54
Perv. Area	0.25	500	0.01

Design Flow (Q,cfs): 1.62
Q=CiA

pipe slope = 0.840
n = 0.012

Percent Full 1

Time of Concentration	
P_2	2.53
n	0.011
L	350
S	0.06
T_c	2.39

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.840	1.00	12.57	0.012	1430.06	1430.06	113.8	ACCEPTABLE
36	0.840	0.75	7.07	0.012	664.03	664.03	93.9	ACCEPTABLE
30	0.840	0.63	4.91	0.012	408.35	408.35	83.2	ACCEPTABLE
24	0.840	0.50	3.14	0.012	225.22	225.22	71.7	ACCEPTABLE
20	0.840	0.42	2.18	0.012	138.50	138.50	63.5	ACCEPTABLE
18	0.840	0.38	1.77	0.012	104.58	104.58	59.2	ACCEPTABLE
15	0.840	0.31	1.23	0.012	64.31	64.31	52.4	ACCEPTABLE
12	0.840	0.25	0.79	0.012	35.47	35.47	45.2	ACCEPTABLE
10	0.840	0.21	0.55	0.012	21.81	21.81	40.0	ACCEPTABLE
8	0.840	0.17	0.35	0.012	12.03	12.03	34.5	ACCEPTABLE
6	0.840	0.13	0.20	0.012	5.59	5.59	28.5	ACCEPTABLE
4	0.840	0.08	0.09	0.012	1.89	1.89	21.7	ACCEPTABLE
3	0.840	0.06	0.05	0.012	0.880	0.88	17.9	FAILED
2	0.840	0.04	0.02	0.012	0.298	0.30	13.7	FAILED

Velocity (V,fps): 2.06 V=Q/A

Inlet 1(E)		
Depth	2.38	ft
Spread, $T_{50\% \text{ Clogging}}$	1.74	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 2(E) - P3(E)
Existing Conditions

C =	0.94	
i =	3.13	in/hr
A =	0.55	aces

Weighted C Factor				
	C factor	*Previous Area [AC]	Area [SF]	Area [AC]
Imperv. Area	0.95	0.54	81	0.54
Perv. Area	0.25	0.01	0	0.01

Design Flow (Q,cfs): 0.01 DMA2 Flow
Q=CiA 1.62 Inlet Flow

pipe slope = 0.41
n = 0.012

Percent Full 1

Time of Concentration	
P_2	2.53
n	0.011
L	10
S	0.4
T_c	0.07

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.410	1.00	12.57	0.012	999.10	999.10	79.5	ACCEPTABLE
36	0.410	0.75	7.07	0.012	463.91	463.91	65.6	ACCEPTABLE
30	0.410	0.63	4.91	0.012	285.29	285.29	58.1	ACCEPTABLE
24	0.410	0.50	3.14	0.012	157.35	157.35	50.1	ACCEPTABLE
20	0.410	0.42	2.18	0.012	96.76	96.76	44.4	ACCEPTABLE
18	0.410	0.38	1.77	0.012	73.06	73.06	41.3	ACCEPTABLE
15	0.410	0.31	1.23	0.012	44.93	44.93	36.6	ACCEPTABLE
12	0.410	0.25	0.79	0.012	24.78	24.78	31.6	ACCEPTABLE
10	0.410	0.21	0.55	0.012	15.24	15.24	27.9	ACCEPTABLE
8	0.410	0.17	0.35	0.012	8.40	8.40	24.1	ACCEPTABLE
6	0.410	0.13	0.20	0.012	3.90	3.90	19.9	ACCEPTABLE
4	0.410	0.08	0.09	0.012	1.32	1.32	15.2	ACCEPTABLE
3	0.410	0.06	0.05	0.012	0.615	0.61	12.5	ACCEPTABLE
2	0.410	0.04	0.02	0.012	0.208	0.21	9.6	ACCEPTABLE

Velocity (V,fps): 0.02 V=Q/A

Inlet 2(E)		
Depth	2.57	ft
Spread, T	0.29	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 3(E)
Existing Conditions

C =	0.95	
i =	3.13	in/hr
A =	0.16	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	7023	0.16
Perv. Area	0.25	0	0.00

Design Flow (Q,cfs): 0.48 Q=CiA

pipe slope = 0.040
n = 0.012

Percent Full 1

Time of Concentration	
P_2	2.53
n	0.011
L	230
S	0.13
T_c	1.25

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.040	1.00	12.57	0.012	312.06	312.06	24.8	ACCEPTABLE
36	0.040	0.75	7.07	0.012	144.90	144.90	20.5	ACCEPTABLE
30	0.040	0.63	4.91	0.012	89.11	89.11	18.2	ACCEPTABLE
24	0.040	0.50	3.14	0.012	49.15	49.15	15.6	ACCEPTABLE
20	0.040	0.42	2.18	0.012	30.22	30.22	13.9	ACCEPTABLE
18	0.040	0.38	1.77	0.012	22.82	22.82	12.9	ACCEPTABLE
15	0.040	0.31	1.23	0.012	14.03	14.03	11.4	ACCEPTABLE
12	0.040	0.25	0.79	0.012	7.74	7.74	9.9	ACCEPTABLE
10	0.040	0.21	0.55	0.012	4.76	4.76	8.7	ACCEPTABLE
8	0.040	0.17	0.35	0.012	2.63	2.63	7.5	ACCEPTABLE
6	0.040	0.13	0.20	0.012	1.22	1.22	6.2	ACCEPTABLE
4	0.040	0.08	0.09	0.012	0.41	0.41	4.7	FAILED
3	0.040	0.06	0.05	0.012	0.192	0.19	3.9	FAILED
2	0.040	0.04	0.02	0.012	0.065	0.07	3.0	FAILED

Velocity (V,fps): 1.37 V=Q/A

Inlet 3(E)		
Depth	2.42	ft
Spread, T	0.11	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

P4(E)
Existing Conditions

C =	0.94	
i =	3.13	in/hr
A =	0.72	aces

Weighted C Factor				
	C factor	*Previous Area [AC]	Area [SF]	Area [AC]
Imperv. Area	0.95	0.70	0	0.70
Perv. Area	0.25	0.01	0	0.01

Design Flow (Q,cfs): 2.10
Q=CiA

pipe slope = 0.40
n = 0.012

Percent Full 1

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.400	1.00	12.57	0.012	986.84	986.84	78.5	ACCEPTABLE
36	0.400	0.75	7.07	0.012	458.22	458.22	64.8	ACCEPTABLE
30	0.400	0.63	4.91	0.012	281.79	281.79	57.4	ACCEPTABLE
24	0.400	0.50	3.14	0.012	155.42	155.42	49.5	ACCEPTABLE
20	0.400	0.42	2.18	0.012	95.58	95.58	43.8	ACCEPTABLE
18	0.400	0.38	1.77	0.012	72.17	72.17	40.8	ACCEPTABLE
15	0.400	0.31	1.23	0.012	44.38	44.38	36.2	ACCEPTABLE
12	0.400	0.25	0.79	0.012	24.48	24.48	31.2	ACCEPTABLE
10	0.400	0.21	0.55	0.012	15.05	15.05	27.6	ACCEPTABLE
8	0.400	0.17	0.35	0.012	8.30	8.30	23.8	ACCEPTABLE
6	0.400	0.13	0.20	0.012	3.85	3.85	19.6	ACCEPTABLE
4	0.400	0.08	0.09	0.012	1.31	1.31	15.0	FAILED
3	0.400	0.06	0.05	0.012	0.607	0.61	12.4	FAILED
2	0.400	0.04	0.02	0.012	0.206	0.21	9.4	FAILED

Velocity (V,fps): 6.02 V=Q/A

Exhibit D.1.2

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Drainage Area 4(E)
Existing Conditions

C =	0.87	
i =	3.13	in/hr
A =	0.83	aces

Weighted C Factor				
	C factor	*Previous Area [AC]	Area [SF]	Area [AC]
Imperv. Area	0.95	0.70	1603	0.74
Perv. Area	0.25	0.01	3539	0.09

Design Flow (Q,cfs): 0.17 DMA3 Flow
Q=CiA 2.28 Inlet Flow

pipe slope = 0.130
n = 0.012

Percent Full 1

Time of Concentration	Hillside	Road
P_2	2.53	2.53
n	0.24	0.011
L	101	205
S	0.5	0.13
T_c	4.46	1.14
Avg Tc		2.80

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.130	1.00	12.57	0.012	562.58	562.58	44.8	ACCEPTABLE
36	0.130	0.75	7.07	0.012	261.23	261.23	37.0	ACCEPTABLE
30	0.130	0.63	4.91	0.012	160.64	160.64	32.7	ACCEPTABLE
24	0.130	0.50	3.14	0.012	88.60	88.60	28.2	ACCEPTABLE
20	0.130	0.42	2.18	0.012	54.49	54.49	25.0	ACCEPTABLE
18	0.130	0.38	1.77	0.012	41.14	41.14	23.3	ACCEPTABLE
15	0.130	0.31	1.23	0.012	25.30	25.30	20.6	ACCEPTABLE
12	0.130	0.25	0.79	0.012	13.95	13.95	17.8	ACCEPTABLE
10	0.130	0.21	0.55	0.012	8.58	8.58	15.7	ACCEPTABLE
8	0.130	0.17	0.35	0.012	4.73	4.73	13.6	ACCEPTABLE
6	0.130	0.13	0.20	0.012	2.20	2.20	11.2	FAILED
4	0.130	0.08	0.09	0.012	0.75	0.75	8.5	FAILED
3	0.130	0.06	0.05	0.012	0.346	0.35	7.1	FAILED
2	0.130	0.04	0.02	0.012	0.117	0.12	5.4	FAILED

Velocity (V,fps): 6.52 V=Q/A

Inlet 4(E)		
Depth	2.41	ft
Spread, T	0.00	ft

*No transverse slope, flow contained within u-channel. Assume no spread or bypass.

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 5(E) - P5(E)
Existing Conditions

C =	0.38	
i =	3.13	in/hr
A =	0.40	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	3322	0.08
Perv. Area	0.25	14149	0.32

Design Flow (Q,cfs): 0.48
Q=CiA

pipe slope = 0.116
n = 0.012

Percent Full 1

Time of Concentration	Hillside	Road
P_2	2.53	2.53
n	0.24	0.011
L	186	225
S	0.6	0.13
T_c	6.76	1.23
Avg Tc	4.00	

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.116	1.00	12.57	0.012	531.43	531.43	42.3	ACCEPTABLE
36	0.116	0.75	7.07	0.012	246.76	246.76	34.9	ACCEPTABLE
30	0.116	0.63	4.91	0.012	151.75	151.75	30.9	ACCEPTABLE
24	0.116	0.50	3.14	0.012	83.69	83.69	26.6	ACCEPTABLE
20	0.116	0.42	2.18	0.012	51.47	51.47	23.6	ACCEPTABLE
18	0.116	0.38	1.77	0.012	38.86	38.86	22.0	ACCEPTABLE
15	0.116	0.31	1.23	0.012	23.90	23.90	19.5	ACCEPTABLE
12	0.116	0.25	0.79	0.012	13.18	13.18	16.8	ACCEPTABLE
10	0.116	0.21	0.55	0.012	8.11	8.11	14.9	ACCEPTABLE
8	0.116	0.17	0.35	0.012	4.47	4.47	12.8	ACCEPTABLE
6	0.116	0.13	0.20	0.012	2.08	2.08	10.6	ACCEPTABLE
4	0.116	0.08	0.09	0.012	0.70	0.70	8.1	ACCEPTABLE
3	0.116	0.06	0.05	0.012	0.327	0.33	6.7	FAILED
2	0.116	0.04	0.02	0.012	0.111	0.11	5.1	FAILED

Velocity (V,fps): 1.38 V=Q/A

Inlet 5 (E)		
Depth	0.00	ft
Spread, T	1.33	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 6(E) - P6(E)
Existing Conditions

C =	0.37	
i =	2.87	in/hr
A =	0.44	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	3372	0.08
Perv. Area	0.25	15709	0.36

Design Flow (Q,cfs): 0.47 Q=CiA

pipe slope = 0.003
n = 0.012

Percent Full 0.8

Time of Concentration	Hillside	Hardscape
P_2	2.53	2.53
n	0.24	0.011
L	300	268
S	0.4	0.02
T_c	11.66	3.00
Avg Tc	7.33	

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.003	1.00	12.57	0.012	85.46	68.37	6.8	ACCEPTABLE
36	0.003	0.75	7.07	0.012	39.68	31.75	5.6	ACCEPTABLE
30	0.003	0.63	4.91	0.012	24.40	19.52	5.0	ACCEPTABLE
24	0.003	0.50	3.14	0.012	13.46	10.77	4.3	ACCEPTABLE
20	0.003	0.42	2.18	0.012	8.28	6.62	3.8	ACCEPTABLE
18	0.003	0.38	1.77	0.012	6.25	5.00	3.5	ACCEPTABLE
15	0.003	0.31	1.23	0.012	3.84	3.07	3.1	ACCEPTABLE
12	0.003	0.25	0.79	0.012	2.12	1.70	2.7	ACCEPTABLE
10	0.003	0.21	0.55	0.012	1.30	1.04	2.4	ACCEPTABLE
8	0.003	0.17	0.35	0.012	0.72	0.58	2.1	ACCEPTABLE
6	0.003	0.13	0.20	0.012	0.33	0.27	1.7	FAILED
4	0.003	0.08	0.09	0.012	0.11	0.09	1.3	FAILED
3	0.003	0.06	0.05	0.012	0.053	0.04	1.1	FAILED
2	0.003	0.04	0.02	0.012	0.018	0.01	0.8	FAILED

Velocity (V,fps): 1.35 V=Q/A

Inlet 6 (E)		
Depth	2.02	ft
Spread, T	2.10	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 7(E) - P7(E)
Existing Conditions

C =	0.37	
i =	3.13	in/hr
A =	0.56	aces

Weighted C Factor				
	C factor	*Previous Area [AC]	Area [SF]	Area [AC]
Imperv. Area	0.95	0.08	884	0.10
Perv. Area	0.25	0.32	6104	0.46

Design Flow (Q,cfs): 0.17 DMA7 Flow
Q=CiA 0.65 Inlet Flow

pipe slope = 0.41
n = 0.012

Percent Full 1

Time of Concentration	Hillside	Road
P_2	2.53	2.53
n	0.24	0.011
L	114	91
S	0.33	0.13
T_c	5.81	0.60
Avg Tc		3.20

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.410	1.00	12.57	0.012	999.10	999.10	79.5	ACCEPTABLE
36	0.410	0.75	7.07	0.012	463.91	463.91	65.6	ACCEPTABLE
30	0.410	0.63	4.91	0.012	285.29	285.29	58.1	ACCEPTABLE
24	0.410	0.50	3.14	0.012	157.35	157.35	50.1	ACCEPTABLE
20	0.410	0.42	2.18	0.012	96.76	96.76	44.4	ACCEPTABLE
18	0.410	0.38	1.77	0.012	73.06	73.06	41.3	ACCEPTABLE
15	0.410	0.31	1.23	0.012	44.93	44.93	36.6	ACCEPTABLE
12	0.410	0.25	0.79	0.012	24.78	24.78	31.6	ACCEPTABLE
10	0.410	0.21	0.55	0.012	15.24	15.24	27.9	ACCEPTABLE
8	0.410	0.17	0.35	0.012	8.40	8.40	24.1	ACCEPTABLE
6	0.410	0.13	0.20	0.012	3.90	3.90	19.9	ACCEPTABLE
4	0.410	0.08	0.09	0.012	1.32	1.32	15.2	ACCEPTABLE
3	0.410	0.06	0.05	0.012	0.615	0.61	12.5	ACCEPTABLE
2	0.410	0.04	0.02	0.012	0.208	0.21	9.6	ACCEPTABLE

Velocity (V,fps): 0.49 V=Q/A

Inlet 7(E)		
Depth	0.63	ft
Spread, T	2.09	ft

Exhibit D.1.2

SHERWOOD
DESIGN ENGINEERS

Drainage Area 8(E)
Existing Conditions

C =	0.34	
i =	2.65	in/hr
A =	1.51	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	9301	0.21
Perv. Area	0.24	56591	1.30

Design Flow (Q,cfs): 1.36 Q=CiA

pipe slope = 0.080
n = 0.012

Percent Full 1

Time of Concentration	Hillside	Hardscape
P_2	2.53	2.53
n	0.24	0.011
L	289	309
S	0.33	0.0025
T_c	12.22	7.72
Avg Tc	9.97	

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.080	1.00	12.57	0.012	441.33	441.33	35.1	ACCEPTABLE
36	0.080	0.75	7.07	0.012	204.92	204.92	29.0	ACCEPTABLE
30	0.080	0.63	4.91	0.012	126.02	126.02	25.7	ACCEPTABLE
24	0.080	0.50	3.14	0.012	69.50	69.50	22.1	ACCEPTABLE
20	0.080	0.42	2.18	0.012	42.74	42.74	19.6	ACCEPTABLE
18	0.080	0.38	1.77	0.012	32.27	32.27	18.3	ACCEPTABLE
15	0.080	0.31	1.23	0.012	19.85	19.85	16.2	ACCEPTABLE
12	0.080	0.25	0.79	0.012	10.95	10.95	13.9	ACCEPTABLE
10	0.080	0.21	0.55	0.012	6.73	6.73	12.3	ACCEPTABLE
8	0.080	0.17	0.35	0.012	3.71	3.71	10.6	ACCEPTABLE
6	0.080	0.13	0.20	0.012	1.72	1.72	8.8	ACCEPTABLE
4	0.080	0.08	0.09	0.012	0.58	0.58	6.7	FAILED
3	0.080	0.06	0.05	0.012	0.272	0.27	5.5	FAILED
2	0.080	0.04	0.02	0.012	0.092	0.09	4.2	FAILED

Exhibit D.1.2

SHERWOOD
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Drainage Area 9(E)
Existing Conditions

C =	0.92	
i =	3.13	in/hr
A =	0.14	aces

Weighted C Factor			
	C factor	Area [SF]	Area [AC]
Imperv. Area	0.95	5816	0.13
Perv. Area	0.25	275	0.01

Design Flow (Q,cfs): 0.40 Q=CiA

pipe slope = 0.080
n = 0.012

Percent Full 1

Time of Concentration	
P_2	2.53
n	0.011
L	250
S	0.02
T_c	2.84

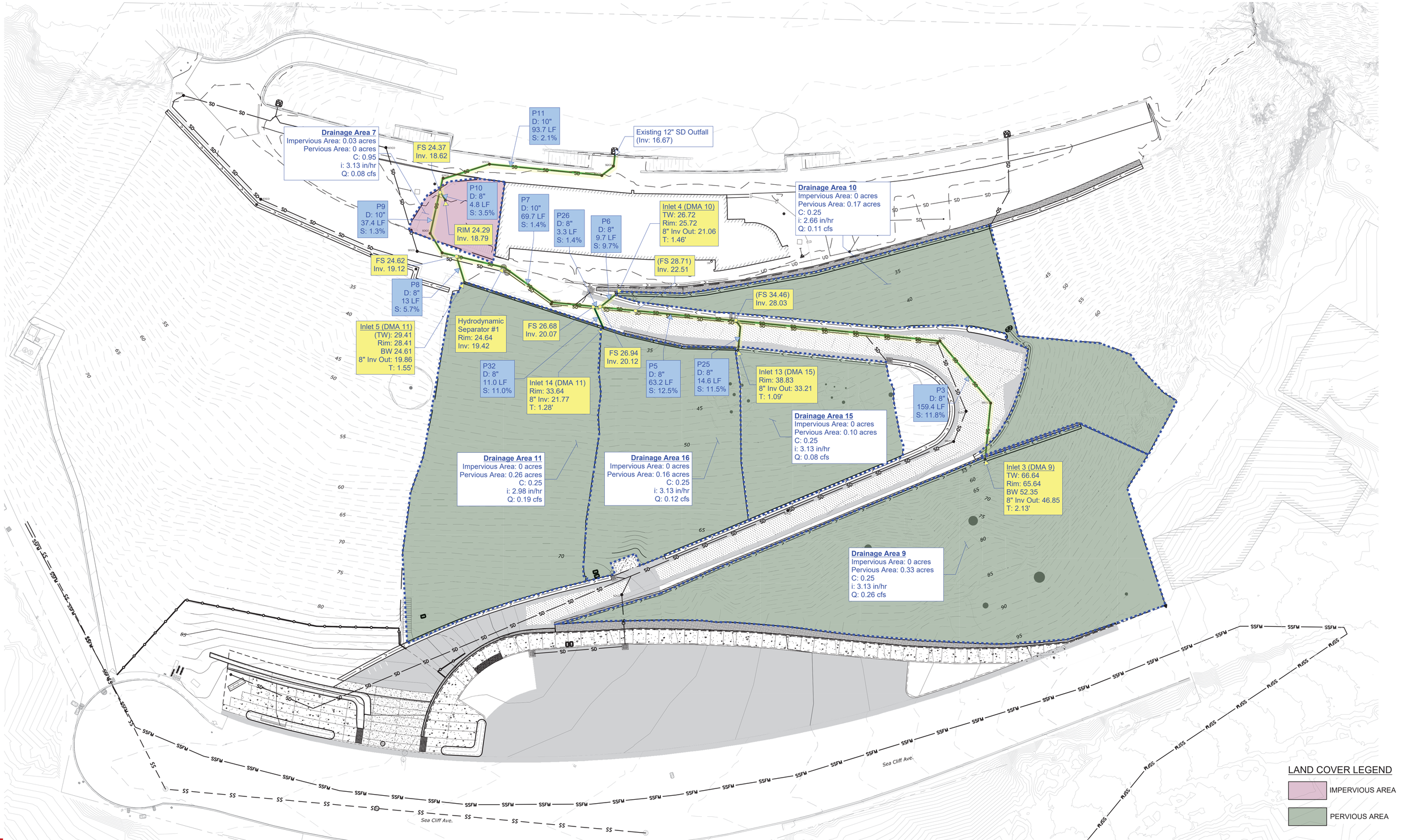
PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.080	1.00	12.57	0.012	441.33	441.33	35.1	ACCEPTABLE
36	0.080	0.75	7.07	0.012	204.92	204.92	29.0	ACCEPTABLE
30	0.080	0.63	4.91	0.012	126.02	126.02	25.7	ACCEPTABLE
24	0.080	0.50	3.14	0.012	69.50	69.50	22.1	ACCEPTABLE
20	0.080	0.42	2.18	0.012	42.74	42.74	19.6	ACCEPTABLE
18	0.080	0.38	1.77	0.012	32.27	32.27	18.3	ACCEPTABLE
15	0.080	0.31	1.23	0.012	19.85	19.85	16.2	ACCEPTABLE
12	0.080	0.25	0.79	0.012	10.95	10.95	13.9	ACCEPTABLE
10	0.080	0.21	0.55	0.012	6.73	6.73	12.3	ACCEPTABLE
8	0.080	0.17	0.35	0.012	3.71	3.71	10.6	ACCEPTABLE
6	0.080	0.13	0.20	0.012	1.72	1.72	8.8	ACCEPTABLE
4	0.080	0.08	0.09	0.012	0.58	0.58	6.7	ACCEPTABLE
3	0.080	0.06	0.05	0.012	0.272	0.27	5.5	FAILED
2	0.080	0.04	0.02	0.012	0.092	0.09	4.2	FAILED

*Drains to seawall weepholes

Exhibit D.1.2

Appendix E. Proposed Conditions



CENTER OUTFALL STORM DRAIN CAPACITY

REHABILITATION OF CHINA BEACH
SAN FRANCISCO, CA

December 3, 2021

Exhibit E.1.1

SHERWOOD DESIGN ENGINEERS
2548 Mission Street
San Francisco, CA 94110
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SHERWOOD
DESIGN ENGINEERS

Pipe 3 - Drainage Area 9
Center Outfall

DMA

C =	0.25	
i =	3.13	in/hr
A =	0.33	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	14569	0.334

Design Flow (Q,cfs): 0.26 Pipe
Q=CiA 0.26 DMA

pipe slope = 0.118
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	103
S	0.7
T_c	3.96

T_c Total	**3.98**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	17
S	0.08
Across-Sect	0.25
Pw	0.59
Rh	0.42
V	19.81
T_c	0.01

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.118	1.00	12.57	0.012	535.99	428.79	42.7	ACCEPTABLE
36	0.118	0.75	7.07	0.012	248.88	199.10	35.2	ACCEPTABLE
30	0.118	0.63	4.91	0.012	153.05	122.44	31.2	ACCEPTABLE
24	0.118	0.50	3.14	0.012	84.41	67.53	26.9	ACCEPTABLE
20	0.118	0.42	2.18	0.012	51.91	41.53	23.8	ACCEPTABLE
18	0.118	0.38	1.77	0.012	39.20	31.36	22.2	ACCEPTABLE
15	0.118	0.31	1.23	0.012	24.10	19.28	19.6	ACCEPTABLE
12	0.118	0.25	0.79	0.012	13.29	10.64	16.9	ACCEPTABLE
10	0.118	0.21	0.55	0.012	8.18	6.54	15.0	ACCEPTABLE
8	0.118	0.17	0.35	0.012	4.51	3.61	12.9	ACCEPTABLE
6	0.118	0.13	0.20	0.012	2.09	1.67	10.7	ACCEPTABLE
4	0.118	0.08	0.09	0.012	0.71	0.57	8.1	ACCEPTABLE
3	0.118	0.06	0.05	0.012	0.330	0.26	6.7	ACCEPTABLE
2	0.118	0.04	0.02	0.012	0.112	0.09	5.1	FAILED

Velocity (V,fps): 0.75 V=Q/A

Inlet 3 (DMA 9)		
Depth	18.79	ft
Spread, T	2.13	ft

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.06	0.16	0.11	46.85	46.96	0.01	46.97	Upstream
			28.03	28.14		28.15	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 25 - Drainage Area 15
Center Outfall

DMA

C =	0.25	
i =	3.13	in/hr
A =	0.10	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	4498	0.103

Design Flow (Q,cfs): 0.08 Pipe
Q=CiA 0.08 DMA

pipe slope = 0.115
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	79.6
S	0.33
T_c	4.36

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.115	1.00	12.57	0.012	529.13	423.31	42.1	ACCEPTABLE
36	0.115	0.75	7.07	0.012	245.69	196.55	34.8	ACCEPTABLE
30	0.115	0.63	4.91	0.012	151.09	120.87	30.8	ACCEPTABLE
24	0.115	0.50	3.14	0.012	83.33	66.67	26.5	ACCEPTABLE
20	0.115	0.42	2.18	0.012	51.25	41.00	23.5	ACCEPTABLE
18	0.115	0.38	1.77	0.012	38.69	30.96	21.9	ACCEPTABLE
15	0.115	0.31	1.23	0.012	23.80	19.04	19.4	ACCEPTABLE
12	0.115	0.25	0.79	0.012	13.12	10.50	16.7	ACCEPTABLE
10	0.115	0.21	0.55	0.012	8.07	6.46	14.8	ACCEPTABLE
8	0.115	0.17	0.35	0.012	4.45	3.56	12.8	ACCEPTABLE
6	0.115	0.13	0.20	0.012	2.07	1.65	10.5	ACCEPTABLE
4	0.115	0.08	0.09	0.012	0.70	0.56	8.0	ACCEPTABLE
3	0.115	0.06	0.05	0.012	0.326	0.26	6.6	ACCEPTABLE
2	0.115	0.04	0.02	0.012	0.110	0.09	5.1	ACCEPTABLE

Velocity (V,fps): 0.23 V=Q/A

Inlet 3 (DMA 15)		
Depth	7.50	ft
Spread, T	1.09	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.02	0.1	0.07	33.21	33.28	0.00	33.28	Upstream
			28.03	28.10		28.10	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 5
Center Outfall

Cummulative

C =	-	
i =	-	in/hr
A =	-	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.000
Perv. Area	0.25	0.438

Design Flow (Q,cfs): 0.34
Q=CiA

pipe slope = 0.125
n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P3 and P25

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.125	1.00	12.57	0.012	551.66	441.33	43.9	ACCEPTABLE
36	0.125	0.75	7.07	0.012	256.15	204.92	36.2	ACCEPTABLE
30	0.125	0.63	4.91	0.012	157.53	126.02	32.1	ACCEPTABLE
24	0.125	0.50	3.14	0.012	86.88	69.50	27.7	ACCEPTABLE
20	0.125	0.42	2.18	0.012	53.43	42.74	24.5	ACCEPTABLE
18	0.125	0.38	1.77	0.012	40.34	32.27	22.8	ACCEPTABLE
15	0.125	0.31	1.23	0.012	24.81	19.85	20.2	ACCEPTABLE
12	0.125	0.25	0.79	0.012	13.68	10.95	17.4	ACCEPTABLE
10	0.125	0.21	0.55	0.012	8.41	6.73	15.4	ACCEPTABLE
8	0.125	0.17	0.35	0.012	4.64	3.71	13.3	ACCEPTABLE
6	0.125	0.13	0.20	0.012	2.15	1.72	11.0	ACCEPTABLE
4	0.125	0.08	0.09	0.012	0.73	0.58	8.4	ACCEPTABLE
3	0.125	0.06	0.05	0.012	0.339	0.27	6.9	FAILED
2	0.125	0.04	0.02	0.012	0.115	0.09	5.3	FAILED

Velocity (V,fps): 0.98 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.07	0.18	0.12	28.03	28.15	0.01	28.16	Upstream
			20.12	20.24		20.25	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 6 - Drainage Area 10
Center Outfall

DMA

C =	0.25	
i =	2.66	in/hr
A =	0.17	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	7249	0.166

Design Flow (Q,cfs): 0.11 Pipe
Q=CiA 0.11 DMA

pipe slope = 0.097
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	75
S	0.333
T_c	4.13
T_c Total	**7.32**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	21
S	0.05
Across-Sect	0.5
Pw	0.85
Rh	0.59
V	19.49
T_c	0.02

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	48
S	0.333
T_c	2.90

Time of Concentration	
Open Channel Flow	
n	0.012
L	175
S	0.025
Across-Sect	0.25
Pw	0.62
Rh	0.40
V	10.72
T_c	0.27

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.097	1.00	12.57	0.012	485.96	388.77	38.7	ACCEPTABLE
36	0.097	0.75	7.07	0.012	225.65	180.52	31.9	ACCEPTABLE
30	0.097	0.63	4.91	0.012	138.77	111.01	28.3	ACCEPTABLE
24	0.097	0.50	3.14	0.012	76.53	61.23	24.4	ACCEPTABLE
20	0.097	0.42	2.18	0.012	47.07	37.65	21.6	ACCEPTABLE
18	0.097	0.38	1.77	0.012	35.54	28.43	20.1	ACCEPTABLE
15	0.097	0.31	1.23	0.012	21.85	17.48	17.8	ACCEPTABLE
12	0.097	0.25	0.79	0.012	12.05	9.64	15.3	ACCEPTABLE
10	0.097	0.21	0.55	0.012	7.41	5.93	13.6	ACCEPTABLE
8	0.097	0.17	0.35	0.012	4.09	3.27	11.7	ACCEPTABLE
6	0.097	0.13	0.20	0.012	1.90	1.52	9.7	ACCEPTABLE
4	0.097	0.08	0.09	0.012	0.64	0.52	7.4	ACCEPTABLE
3	0.097	0.06	0.05	0.012	0.299	0.24	6.1	ACCEPTABLE
2	0.097	0.04	0.02	0.012	0.101	0.08	4.6	FAILED

Velocity (V,fps): 0.32 V=Q/A

Inlet 4 (DMA 10)		
Depth	4.66	ft
Spread, T	1.46	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.03	0.12	0.08	21.06	21.14	0.00	21.14	Upstream
			20.12	20.20		20.20	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 26
Center Outfall

Cummulative

C =	-	
i =	-	in/hr
A =	-	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.000
Perv. Area	0.25	0.604

Design Flow (Q,cfs): 0.45 Pipe

Q=CiA

pipe slope = 0.117

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P5 and P6

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.117	1.00	12.57	0.012	533.71	426.97	42.5	ACCEPTABLE
36	0.117	0.75	7.07	0.012	247.82	198.26	35.1	ACCEPTABLE
30	0.117	0.63	4.91	0.012	152.40	121.92	31.0	ACCEPTABLE
24	0.117	0.50	3.14	0.012	84.05	67.24	26.8	ACCEPTABLE
20	0.117	0.42	2.18	0.012	51.69	41.35	23.7	ACCEPTABLE
18	0.117	0.38	1.77	0.012	39.03	31.22	22.1	ACCEPTABLE
15	0.117	0.31	1.23	0.012	24.00	19.20	19.6	ACCEPTABLE
12	0.117	0.25	0.79	0.012	13.24	10.59	16.9	ACCEPTABLE
10	0.117	0.21	0.55	0.012	8.14	6.51	14.9	ACCEPTABLE
8	0.117	0.17	0.35	0.012	4.49	3.59	12.9	ACCEPTABLE
6	0.117	0.13	0.20	0.012	2.08	1.67	10.6	ACCEPTABLE
4	0.117	0.08	0.09	0.012	0.71	0.57	8.1	ACCEPTABLE
3	0.117	0.06	0.05	0.012	0.328	0.26	6.7	FAILED
2	0.117	0.04	0.02	0.012	0.111	0.09	5.1	FAILED

Velocity (V,fps): 0.83 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.06	0.16	0.13	28.03	28.16	0.01	28.17	Upstream
			22.51	22.64		22.65	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 32 - Drainage Area 16
Center Outfall

DMA

C =	0.25	
i =	3.13	in/hr
A =	0.16	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	6,793	0.156

Design Flow (Q,cfs): 0.12 Pipe
Q=CiA 0.12 DMA

pipe slope = 0.057
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	80
S	0.33
T_c	4.36

T_c Total	**4.40**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	61
S	0.083
Across-Sect	0.25
Pw	0.45
Rh	0.56
V	24.17
Tc	0.04

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.057	1.00	12.57	0.012	372.52	298.02	29.6	ACCEPTABLE
36	0.057	0.75	7.07	0.012	172.97	138.38	24.5	ACCEPTABLE
30	0.057	0.63	4.91	0.012	106.37	85.10	21.7	ACCEPTABLE
24	0.057	0.50	3.14	0.012	58.67	46.93	18.7	ACCEPTABLE
20	0.057	0.42	2.18	0.012	36.08	28.86	16.5	ACCEPTABLE
18	0.057	0.38	1.77	0.012	27.24	21.79	15.4	ACCEPTABLE
15	0.057	0.31	1.23	0.012	16.75	13.40	13.7	ACCEPTABLE
12	0.057	0.25	0.79	0.012	9.24	7.39	11.8	ACCEPTABLE
10	0.057	0.21	0.55	0.012	5.68	4.55	10.4	ACCEPTABLE
8	0.057	0.17	0.35	0.012	3.13	2.51	9.0	ACCEPTABLE
6	0.057	0.13	0.20	0.012	1.46	1.16	7.4	ACCEPTABLE
4	0.057	0.08	0.09	0.012	0.49	0.39	5.7	ACCEPTABLE
3	0.057	0.06	0.05	0.012	0.229	0.18	4.7	ACCEPTABLE
2	0.057	0.04	0.02	0.012	0.078	0.06	3.6	FAILED

Velocity (V,fps): 0.35 V=Q/A

Inlet 14 (DMA 16)		
Depth	8.55	ft
Spread, T	1.28	ft

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.04	0.13	0.09	21.77	21.86	0.00	21.86	Upstream
			20.07	20.16		20.16	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 7
Center Outfall

Cummulative

C =	-	
i =	-	in/hr
A =	-	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.000
Perv. Area	0.25	0.760

Design Flow (Q,cfs): 0.58 Pipe

Q=CiA

pipe slope = 0.014

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P26 and P32

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.014	1.00	12.57	0.012	184.62	147.70	14.7	ACCEPTABLE
36	0.014	0.75	7.07	0.012	85.73	68.58	12.1	ACCEPTABLE
30	0.014	0.63	4.91	0.012	52.72	42.17	10.7	ACCEPTABLE
24	0.014	0.50	3.14	0.012	29.08	23.26	9.3	ACCEPTABLE
20	0.014	0.42	2.18	0.012	17.88	14.30	8.2	ACCEPTABLE
18	0.014	0.38	1.77	0.012	13.50	10.80	7.6	ACCEPTABLE
15	0.014	0.31	1.23	0.012	8.30	6.64	6.8	ACCEPTABLE
12	0.014	0.25	0.79	0.012	4.58	3.66	5.8	ACCEPTABLE
10	0.014	0.21	0.55	0.012	2.82	2.25	5.2	ACCEPTABLE
8	0.014	0.17	0.35	0.012	1.55	1.24	4.4	ACCEPTABLE
6	0.014	0.13	0.20	0.012	0.72	0.58	3.7	ACCEPTABLE
4	0.014	0.08	0.09	0.012	0.24	0.20	2.8	FAILED
3	0.014	0.06	0.05	0.012	0.114	0.09	2.3	FAILED
2	0.014	0.04	0.02	0.012	0.039	0.03	1.8	FAILED

Velocity (V,fps): 1.05 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.20	0.3	0.25	20.07	20.32	0.02	20.34	Upstream
			19.12	19.37		19.39	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 8 - Drainage Area 11
Center Outfall

DMA

C =	0.25	
i =	2.98	in/hr
A =	0.26	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	11,391	0.261

Design Flow (Q,cfs): 0.19 Pipe
Q=CiA 0.19 DMA

pipe slope = 0.057
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	100
S	0.33
T_c	5.21

Time of Concentration	
Shallow Concentrated Flow	
L	67
S	0.333
Cp	6.962
V	4.02
T_c	0.28

T_c Total	**5.49**

*Interpolate T_c to obtain intensity

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.057	1.00	12.57	0.012	372.52	298.02	29.6	ACCEPTABLE
36	0.057	0.75	7.07	0.012	172.97	138.38	24.5	ACCEPTABLE
30	0.057	0.63	4.91	0.012	106.37	85.10	21.7	ACCEPTABLE
24	0.057	0.50	3.14	0.012	58.67	46.93	18.7	ACCEPTABLE
20	0.057	0.42	2.18	0.012	36.08	28.86	16.5	ACCEPTABLE
18	0.057	0.38	1.77	0.012	27.24	21.79	15.4	ACCEPTABLE
15	0.057	0.31	1.23	0.012	16.75	13.40	13.7	ACCEPTABLE
12	0.057	0.25	0.79	0.012	9.24	7.39	11.8	ACCEPTABLE
10	0.057	0.21	0.55	0.012	5.68	4.55	10.4	ACCEPTABLE
8	0.057	0.17	0.35	0.012	3.13	2.51	9.0	ACCEPTABLE
6	0.057	0.13	0.20	0.012	1.46	1.16	7.4	ACCEPTABLE
4	0.057	0.08	0.09	0.012	0.49	0.39	5.7	ACCEPTABLE
3	0.057	0.06	0.05	0.012	0.229	0.18	4.7	FAILED
2	0.057	0.04	0.02	0.012	0.078	0.06	3.6	FAILED

Velocity (V,fps): 0.56 V=Q/A

Inlet 15 (DMA 11)		
Depth	8.55	ft
Spread, T	1.67	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.06	0.16	0.11	19.86	19.97	0.00	19.97	Upstream
			19.12	19.23		19.23	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 9
Center Outfall

Cummulative

C =	0.25	
i =	-	in/hr
A =	1.02	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.000
Perv. Area	0.25	1.022

Design Flow (Q,cfs): 0.77 Pipe

Q=CiA

pipe slope = 0.013

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P7 and P8

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.013	1.00	12.57	0.012	177.90	142.32	14.2	ACCEPTABLE
36	0.013	0.75	7.07	0.012	82.61	66.09	11.7	ACCEPTABLE
30	0.013	0.63	4.91	0.012	50.80	40.64	10.3	ACCEPTABLE
24	0.013	0.50	3.14	0.012	28.02	22.41	8.9	ACCEPTABLE
20	0.013	0.42	2.18	0.012	17.23	13.78	7.9	ACCEPTABLE
18	0.013	0.38	1.77	0.012	13.01	10.41	7.4	ACCEPTABLE
15	0.013	0.31	1.23	0.012	8.00	6.40	6.5	ACCEPTABLE
12	0.013	0.25	0.79	0.012	4.41	3.53	5.6	ACCEPTABLE
10	0.013	0.21	0.55	0.012	2.71	2.17	5.0	ACCEPTABLE
8	0.013	0.17	0.35	0.012	1.50	1.20	4.3	ACCEPTABLE
6	0.013	0.13	0.20	0.012	0.69	0.56	3.5	FAILED
4	0.013	0.08	0.09	0.012	0.24	0.19	2.7	FAILED
3	0.013	0.06	0.05	0.012	0.109	0.09	2.2	FAILED
2	0.013	0.04	0.02	0.012	0.037	0.03	1.7	FAILED

Velocity (V,fps): 1.41 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.28	0.36	0.30	19.12	19.42	0.03	19.45	Upstream
			18.62	18.92		18.95	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 10 - Drainage Area 7
Center Outfall

DMA

C =	0.95	
i =	3.13	in/hr
A =	0.03	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	1130	0.026
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.08 Pipe
Q=CiA 0.08 DMA

pipe slope = 0.035
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	36
S	0.013
T_c	0.71

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.035	1.00	12.57	0.012	291.91	233.53	23.2	ACCEPTABLE
36	0.035	0.75	7.07	0.012	135.54	108.43	19.2	ACCEPTABLE
30	0.035	0.63	4.91	0.012	83.35	66.68	17.0	ACCEPTABLE
24	0.035	0.50	3.14	0.012	45.97	36.78	14.6	ACCEPTABLE
20	0.035	0.42	2.18	0.012	28.27	22.62	13.0	ACCEPTABLE
18	0.035	0.38	1.77	0.012	21.35	17.08	12.1	ACCEPTABLE
15	0.035	0.31	1.23	0.012	13.13	10.50	10.7	ACCEPTABLE
12	0.035	0.25	0.79	0.012	7.24	5.79	9.2	ACCEPTABLE
10	0.035	0.21	0.55	0.012	4.45	3.56	8.2	ACCEPTABLE
8	0.035	0.17	0.35	0.012	2.46	1.96	7.0	ACCEPTABLE
6	0.035	0.13	0.20	0.012	1.14	0.91	5.8	ACCEPTABLE
4	0.035	0.08	0.09	0.012	0.39	0.31	4.4	ACCEPTABLE
3	0.035	0.06	0.05	0.012	0.180	0.14	3.7	ACCEPTABLE
2	0.035	0.04	0.02	0.012	0.061	0.05	2.8	FAILED

Velocity (V,fps): 0.22 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.03	0.12	0.08	18.79	18.87	0.00	18.87	Upstream
			18.62	18.70		18.70	Downstream

Exhibit E.1.2

SHERWOOD
DESIGN ENGINEERS

Pipe 11
Center Outfall

Cummulative

C =	0.27	
i =	-	in/hr
A =	1.05	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.026
Perv. Area	0.25	1.022

Design Flow (Q,cfs): 0.85 Pipe

Q=CiA

pipe slope = 0.021

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P9 and P10

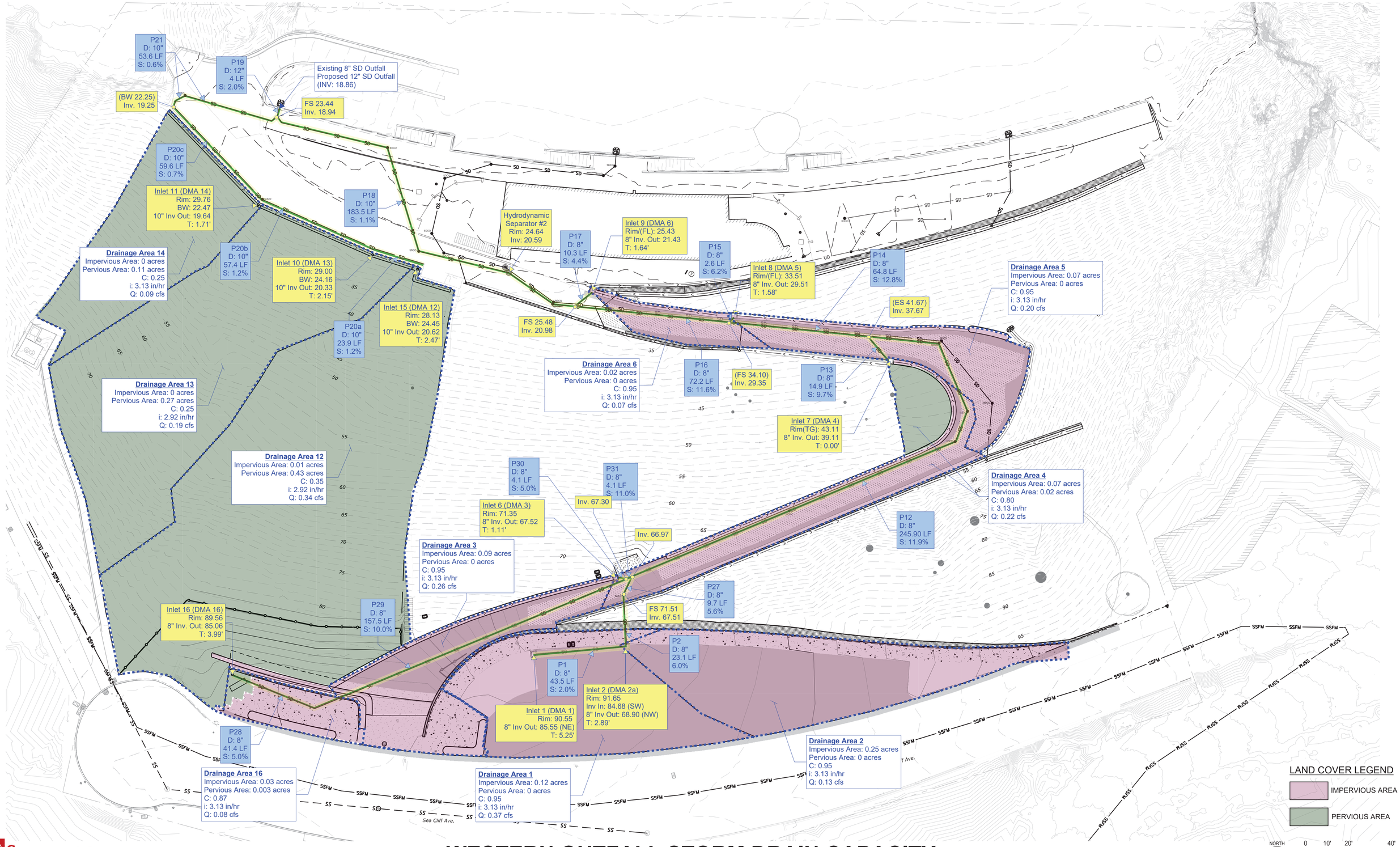
PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.021	1.00	12.57	0.012	226.11	180.89	18.0	ACCEPTABLE
36	0.021	0.75	7.07	0.012	104.99	83.99	14.9	ACCEPTABLE
30	0.021	0.63	4.91	0.012	64.57	51.65	13.2	ACCEPTABLE
24	0.021	0.50	3.14	0.012	35.61	28.49	11.3	ACCEPTABLE
20	0.021	0.42	2.18	0.012	21.90	17.52	10.0	ACCEPTABLE
18	0.021	0.38	1.77	0.012	16.54	13.23	9.4	ACCEPTABLE
15	0.021	0.31	1.23	0.012	10.17	8.13	8.3	ACCEPTABLE
12	0.021	0.25	0.79	0.012	5.61	4.49	7.1	ACCEPTABLE
10	0.021	0.21	0.55	0.012	3.45	2.76	6.3	ACCEPTABLE
8	0.021	0.17	0.35	0.012	1.90	1.52	5.4	ACCEPTABLE
6	0.021	0.13	0.20	0.012	0.88	0.71	4.5	FAILED
4	0.021	0.08	0.09	0.012	0.30	0.24	3.4	FAILED
3	0.021	0.06	0.05	0.012	0.139	0.11	2.8	FAILED
2	0.021	0.04	0.02	0.012	0.047	0.04	2.2	FAILED

Velocity (V,fps): 1.55 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.25	0.34	0.28	18.62	18.90	0.04	18.94	Upstream
			16.67	16.95		16.99	Downstream

Exhibit E.1.2



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WESTERN OUTFALL STORM DRAIN CAPACITY

REHABILITATION OF CHINA BEACH
SAN FRANCISCO, CA

December 3, 2021

Exhibit E.1.3

SHERWOOD
DESIGN ENGINEERS

Pipe 1 - Drainage Area 1
West Outfall

C =	0.95	
i =	3.13	in/hr
A =	0.12	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	5416	0.124
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.37 Pipe
Q=CiA 0.37 DMA

pipe slope = 0.020
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	75
S	0.035
T_c	0.87

Time of Concentration	
Shallow Concentrated Flow	
L	41
S	0.035
C_p	20.238
V	3.79
T_c	0.18

T_c Total	**1.05**

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.020	1.00	12.57	0.012	220.66	176.53	17.6	ACCEPTABLE
36	0.020	0.75	7.07	0.012	102.46	81.97	14.5	ACCEPTABLE
30	0.020	0.63	4.91	0.012	63.01	50.41	12.8	ACCEPTABLE
24	0.020	0.50	3.14	0.012	34.75	27.80	11.1	ACCEPTABLE
20	0.020	0.42	2.18	0.012	21.37	17.10	9.8	ACCEPTABLE
18	0.020	0.38	1.77	0.012	16.14	12.91	9.1	ACCEPTABLE
15	0.020	0.31	1.23	0.012	9.92	7.94	8.1	ACCEPTABLE
12	0.020	0.25	0.79	0.012	5.47	4.38	7.0	ACCEPTABLE
10	0.020	0.21	0.55	0.012	3.37	2.69	6.2	ACCEPTABLE
8	0.020	0.17	0.35	0.012	1.86	1.49	5.3	ACCEPTABLE
6	0.020	0.13	0.20	0.012	0.86	0.69	4.4	ACCEPTABLE
4	0.020	0.08	0.09	0.012	0.29	0.23	3.4	FAILED
3	0.020	0.06	0.05	0.012	0.136	0.11	2.8	FAILED
2	0.020	0.04	0.02	0.012	0.046	0.04	2.1	FAILED

Velocity (V,fps): 1.06 V=Q/A

Inlet 1 (DMA 1)		
Depth	5.00	ft
Spread, T	3.20	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.20	0.3	0.20	85.55	85.75	0.02	85.77	Upstream
			84.68	84.88		84.90	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 2 - Drainage Area 2
West Outfall

C =	0.95	
i =	3.13	in/hr
A =	0.13	AC

Weighted C Factor				
	C factor	DMA Area [SF]	DMA Area [AC]	Cumm. DMA Area [AC]
Imperv. Area	0.95	5642	0.13	0.254
Perv. Area	0.25	0	0.00	0.000

Design Flow (Q,cfs): 0.75 Pipe
Q=CiA 0.39 DMA

pipe slope = 0.060
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	100
S	0.037
T_c	1.07

Time of Concentration	
Shallow Concentrated Flow	
L	107
S	0.037
C_p	20.238
V	3.89
T_c	0.46

T_c Total	**1.52**

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.060	1.00	12.57	0.012	382.20	305.76	30.4	ACCEPTABLE
36	0.060	0.75	7.07	0.012	177.47	141.97	25.1	ACCEPTABLE
30	0.060	0.63	4.91	0.012	109.14	87.31	22.2	ACCEPTABLE
24	0.060	0.50	3.14	0.012	60.19	48.15	19.2	ACCEPTABLE
20	0.060	0.42	2.18	0.012	37.02	29.61	17.0	ACCEPTABLE
18	0.060	0.38	1.77	0.012	27.95	22.36	15.8	ACCEPTABLE
15	0.060	0.31	1.23	0.012	17.19	13.75	14.0	ACCEPTABLE
12	0.060	0.25	0.79	0.012	9.48	7.58	12.1	ACCEPTABLE
10	0.060	0.21	0.55	0.012	5.83	4.66	10.7	ACCEPTABLE
8	0.060	0.17	0.35	0.012	3.22	2.57	9.2	ACCEPTABLE
6	0.060	0.13	0.20	0.012	1.49	1.19	7.6	ACCEPTABLE
4	0.060	0.08	0.09	0.012	0.51	0.41	5.8	ACCEPTABLE
3	0.060	0.06	0.05	0.012	0.235	0.19	4.8	FAILED
2	0.060	0.04	0.02	0.012	0.080	0.06	3.7	FAILED

Velocity (V,fps): 1.10 V=Q/A

Inlet 2 (DMA 2a)		
Depth	22.75	ft
Spread, T	2.89	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.12	0.23	0.19	68.96	69.15	0.02	69.17	Upstream
			67.57	67.76		67.78	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 27
West Outfall

Cummulative

C =	0.95	
i =	3.13	in/hr
A =	0.254	AC

Weighted C Factor			
	C factor	Cumm. Area [SF]	Cumm. DMA Area [AC]
Imperv. Area	0.95	11058	0.254
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.75 Pipe

Q=CiA

pipe slope = 0.056

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation of P2

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.056	1.00	12.57	0.012	369.24	295.39	29.4	ACCEPTABLE
36	0.056	0.75	7.07	0.012	171.45	137.16	24.3	ACCEPTABLE
30	0.056	0.63	4.91	0.012	105.44	84.35	21.5	ACCEPTABLE
24	0.056	0.50	3.14	0.012	58.15	46.52	18.5	ACCEPTABLE
20	0.056	0.42	2.18	0.012	35.76	28.61	16.4	ACCEPTABLE
18	0.056	0.38	1.77	0.012	27.00	21.60	15.3	ACCEPTABLE
15	0.056	0.31	1.23	0.012	16.61	13.28	13.5	ACCEPTABLE
12	0.056	0.25	0.79	0.012	9.16	7.33	11.7	ACCEPTABLE
10	0.056	0.21	0.55	0.012	5.63	4.51	10.3	ACCEPTABLE
8	0.056	0.17	0.35	0.012	3.11	2.49	8.9	ACCEPTABLE
6	0.056	0.13	0.20	0.012	1.44	1.15	7.3	ACCEPTABLE
4	0.056	0.08	0.09	0.012	0.49	0.39	5.6	FAILED
3	0.056	0.06	0.05	0.012	0.227	0.18	4.6	FAILED
2	0.056	0.04	0.02	0.012	0.077	0.06	3.5	FAILED

Velocity (V,fps): 2.16 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.24	0.33	0.22	67.57	67.79	0.07	67.86	Upstream
			66.97	67.19		67.26	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 28 - Drainage Area 16
Center Outfall

C =	0.87	
i =	3.13	in/hr
A =	0.03	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	1130	0.026
Perv. Area	0.25	139	0.003

Design Flow (Q,cfs): 0.08 Pipe
Q=CiA 0.08 DMA

pipe slope = 0.050
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	66
S	0.015
T_c	1.10

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.050	1.00	12.57	0.012	348.90	279.12	27.8	ACCEPTABLE
36	0.050	0.75	7.07	0.012	162.01	129.60	22.9	ACCEPTABLE
30	0.050	0.63	4.91	0.012	99.63	79.70	20.3	ACCEPTABLE
24	0.050	0.50	3.14	0.012	54.95	43.96	17.5	ACCEPTABLE
20	0.050	0.42	2.18	0.012	33.79	27.03	15.5	ACCEPTABLE
18	0.050	0.38	1.77	0.012	25.51	20.41	14.4	ACCEPTABLE
15	0.050	0.31	1.23	0.012	15.69	12.55	12.8	ACCEPTABLE
12	0.050	0.25	0.79	0.012	8.65	6.92	11.0	ACCEPTABLE
10	0.050	0.21	0.55	0.012	5.32	4.26	9.8	ACCEPTABLE
8	0.050	0.17	0.35	0.012	2.94	2.35	8.4	ACCEPTABLE
6	0.050	0.13	0.20	0.012	1.36	1.09	6.9	ACCEPTABLE
4	0.050	0.08	0.09	0.012	0.46	0.37	5.3	ACCEPTABLE
3	0.050	0.06	0.05	0.012	0.215	0.17	4.4	ACCEPTABLE
2	0.050	0.04	0.02	0.012	0.073	0.06	3.3	FAILED

Velocity (V,fps): 0.23 V=Q/A

Inlet 16 (DMA 16)		
Depth	4.50	ft
Spread, T	3.94	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.03	0.12	0.10	85.06	85.16	0.00	85.16	Upstream
			82.99	83.09		83.09	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 29
West Outfall

Cummulative

C =	0.87	
i =	3.13	in/hr
A =	0.029	AC

Weighted C Factor			
	C factor	Cumm. Area [SF]	Cumm. DMA Area [AC]
Imperv. Area	0.95	1130	0.026
Perv. Area	0.25	139	0.003

Design Flow (Q,cfs): 0.08 Pipe

Q=CiA

pipe slope = 0.100

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation of P28

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.100	1.00	12.57	0.012	493.42	394.73	39.3	ACCEPTABLE
36	0.100	0.75	7.07	0.012	229.11	183.29	32.4	ACCEPTABLE
30	0.100	0.63	4.91	0.012	140.89	112.72	28.7	ACCEPTABLE
24	0.100	0.50	3.14	0.012	77.71	62.17	24.7	ACCEPTABLE
20	0.100	0.42	2.18	0.012	47.79	38.23	21.9	ACCEPTABLE
18	0.100	0.38	1.77	0.012	36.08	28.87	20.4	ACCEPTABLE
15	0.100	0.31	1.23	0.012	22.19	17.75	18.1	ACCEPTABLE
12	0.100	0.25	0.79	0.012	12.24	9.79	15.6	ACCEPTABLE
10	0.100	0.21	0.55	0.012	7.53	6.02	13.8	ACCEPTABLE
8	0.100	0.17	0.35	0.012	4.15	3.32	11.9	ACCEPTABLE
6	0.100	0.13	0.20	0.012	1.93	1.54	9.8	ACCEPTABLE
4	0.100	0.08	0.09	0.012	0.65	0.52	7.5	ACCEPTABLE
3	0.100	0.06	0.05	0.012	0.304	0.24	6.2	ACCEPTABLE
2	0.100	0.04	0.02	0.012	0.103	0.08	4.7	ACCEPTABLE

Velocity (V,fps): 0.23 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.02	0.1	0.07	82.99	83.06	0.00	83.06	Upstream
			67.30	67.37		67.37	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 30 - Drainage Area 3
West Outfall

DMA

C =	0.95	
i =	3.13	in/hr
A =	0.087	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	3797	0.087
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.26 Pipe
Q=CiA 0.26 DMA

pipe slope = 0.050
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	61
S	0.15
T_c	0.41

T_c Total	**0.50**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	113
S	0.125
Across-Sect	0.39
Pw	1.16
Rh	0.34
V	21.23
T_c	0.09

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.050	1.00	12.57	0.012	348.90	279.12	27.8	ACCEPTABLE
36	0.050	0.75	7.07	0.012	162.01	129.60	22.9	ACCEPTABLE
30	0.050	0.63	4.91	0.012	99.63	79.70	20.3	ACCEPTABLE
24	0.050	0.50	3.14	0.012	54.95	43.96	17.5	ACCEPTABLE
20	0.050	0.42	2.18	0.012	33.79	27.03	15.5	ACCEPTABLE
18	0.050	0.38	1.77	0.012	25.51	20.41	14.4	ACCEPTABLE
15	0.050	0.31	1.23	0.012	15.69	12.55	12.8	ACCEPTABLE
12	0.050	0.25	0.79	0.012	8.65	6.92	11.0	ACCEPTABLE
10	0.050	0.21	0.55	0.012	5.32	4.26	9.8	ACCEPTABLE
8	0.050	0.17	0.35	0.012	2.94	2.35	8.4	ACCEPTABLE
6	0.050	0.13	0.20	0.012	1.36	1.09	6.9	ACCEPTABLE
4	0.050	0.08	0.09	0.012	0.46	0.37	5.3	ACCEPTABLE
3	0.050	0.06	0.05	0.012	0.215	0.17	4.4	FAILED
2	0.050	0.04	0.02	0.012	0.073	0.06	3.3	FAILED

Velocity (V,fps): 0.74 V=Q/A

Inlet 6 (DMA 3)		
Depth	3.79	ft
Spread, T	1.11	ft

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.09	0.2	0.13	67.52	67.65	0.01	67.66	Upstream
			67.30	67.43		67.44	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 31
West Outfall

Cummulative

C =	0.93	
i =	3.13	in/hr
A =	0.116	AC

Weighted C Factor			
	C factor	Cumm. Area [SF]	Cumm. DMA Area [AC]
Imperv. Area	0.95	4927	0.113
Perv. Area	0.25	139	0.003

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

Design Flow (Q,cfs): 0.34 Pipe
Q=CiA
pipe slope = 0.110
n = 0.012

Percent Full 0.8

*Continuation and combination of P29 ad P30

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.110	1.00	12.57	0.012	517.50	414.00	41.2	ACCEPTABLE
36	0.110	0.75	7.07	0.012	240.29	192.23	34.0	ACCEPTABLE
30	0.110	0.63	4.91	0.012	147.77	118.22	30.1	ACCEPTABLE
24	0.110	0.50	3.14	0.012	81.50	65.20	25.9	ACCEPTABLE
20	0.110	0.42	2.18	0.012	50.12	40.10	23.0	ACCEPTABLE
18	0.110	0.38	1.77	0.012	37.84	30.28	21.4	ACCEPTABLE
15	0.110	0.31	1.23	0.012	23.27	18.62	19.0	ACCEPTABLE
12	0.110	0.25	0.79	0.012	12.84	10.27	16.3	ACCEPTABLE
10	0.110	0.21	0.55	0.012	7.89	6.31	14.5	ACCEPTABLE
8	0.110	0.17	0.35	0.012	4.35	3.48	12.5	ACCEPTABLE
6	0.110	0.13	0.20	0.012	2.02	1.62	10.3	ACCEPTABLE
4	0.110	0.08	0.09	0.012	0.69	0.55	7.9	ACCEPTABLE
3	0.110	0.06	0.05	0.012	0.318	0.25	6.5	FAILED
2	0.110	0.04	0.02	0.012	0.108	0.09	4.9	FAILED

Velocity (V,fps): 0.97 V=Q/A

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.08	0.19	0.13	67.30	67.43	0.01	67.44	Upstream
			66.97	67.10		67.11	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 12
West Outfall

Cummulative

C =	0.94	
i =	3.13	in/hr
A =	0.370	AC

Weighted C Factor			
	C factor	Cumm. Area [SF]	Cumm. DMA Area [AC]
Imperv. Area	0.95	15985	0.367
Perv. Area	0.25	139	0.003

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P27 ad P31

Design Flow (Q,cfs): 1.09 Pipe

Q=CiA

pipe slope = 0.119

n = 0.012

Percent Full 0.8

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.119	1.00	12.57	0.012	538.26	430.60	42.8	ACCEPTABLE
36	0.119	0.75	7.07	0.012	249.93	199.94	35.4	ACCEPTABLE
30	0.119	0.63	4.91	0.012	153.70	122.96	31.3	ACCEPTABLE
24	0.119	0.50	3.14	0.012	84.77	67.82	27.0	ACCEPTABLE
20	0.119	0.42	2.18	0.012	52.13	41.70	23.9	ACCEPTABLE
18	0.119	0.38	1.77	0.012	39.36	31.49	22.3	ACCEPTABLE
15	0.119	0.31	1.23	0.012	24.21	19.36	19.7	ACCEPTABLE
12	0.119	0.25	0.79	0.012	13.35	10.68	17.0	ACCEPTABLE
10	0.119	0.21	0.55	0.012	8.21	6.57	15.1	ACCEPTABLE
8	0.119	0.17	0.35	0.012	4.53	3.62	13.0	ACCEPTABLE
6	0.119	0.13	0.20	0.012	2.10	1.68	10.7	ACCEPTABLE
4	0.119	0.08	0.09	0.012	0.71	0.57	8.2	FAILED
3	0.119	0.06	0.05	0.012	0.331	0.26	6.7	FAILED
2	0.119	0.04	0.02	0.012	0.112	0.09	5.1	FAILED

Velocity (V,fps): 3.13 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.24	0.33	0.22	66.97	67.19	0.15	67.34	Upstream
			37.67	37.89		38.04	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 13 - Drainage Area 4
West Outfall

DMA

C =	0.80	
i =	3.13	in/hr
A =	0.088	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	3022	0.069
Perv. Area	0.25	820	0.019

Design Flow (Q,cfs): 0.22 Pipe
Q=CiA 0.22 DMA

pipe slope = 0.097
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	38.11
S	0.12
T_c	0.31
T_c Total	**0.47**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	196
S	0.115
Across-Sect	0.39
Pw	1.16
Rh	0.34
V	20.36
Tc	0.16

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.097	1.00	12.57	0.012	485.96	388.77	38.7	ACCEPTABLE
36	0.097	0.75	7.07	0.012	225.65	180.52	31.9	ACCEPTABLE
30	0.097	0.63	4.91	0.012	138.77	111.01	28.3	ACCEPTABLE
24	0.097	0.50	3.14	0.012	76.53	61.23	24.4	ACCEPTABLE
20	0.097	0.42	2.18	0.012	47.07	37.65	21.6	ACCEPTABLE
18	0.097	0.38	1.77	0.012	35.54	28.43	20.1	ACCEPTABLE
15	0.097	0.31	1.23	0.012	21.85	17.48	17.8	ACCEPTABLE
12	0.097	0.25	0.79	0.012	12.05	9.64	15.3	ACCEPTABLE
10	0.097	0.21	0.55	0.012	7.41	5.93	13.6	ACCEPTABLE
8	0.097	0.17	0.35	0.012	4.09	3.27	11.7	ACCEPTABLE
6	0.097	0.13	0.20	0.012	1.90	1.52	9.7	ACCEPTABLE
4	0.097	0.08	0.09	0.012	0.64	0.52	7.4	ACCEPTABLE
3	0.097	0.06	0.05	0.012	0.299	0.24	6.1	ACCEPTABLE
2	0.097	0.04	0.02	0.012	0.101	0.08	4.6	FAILED

Velocity (V,fps): 0.63 V=Q/A

Inlet 7		
Depth	4.00	ft
Spread, T	0.00	ft

*No transverse slope, flow contained within u-channel. Assume no spread or bypass.

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.05	0.15	0.10	39.11	39.21	0.01	39.22	Upstream
			37.67	37.77		37.78	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 14
West Outfall

Cummulative

C =	0.92	
i =	-	in/hr
A =	0.458	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.44
Perv. Area	0.25	0.02

Design Flow (Q,cfs): 1.31 Pipe

Q=CiA

pipe slope = 0.128

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P12 ad P13

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.128	1.00	12.57	0.012	558.24	446.59	44.4	ACCEPTABLE
36	0.128	0.75	7.07	0.012	259.21	207.37	36.7	ACCEPTABLE
30	0.128	0.63	4.91	0.012	159.40	127.52	32.5	ACCEPTABLE
24	0.128	0.50	3.14	0.012	87.92	70.33	28.0	ACCEPTABLE
20	0.128	0.42	2.18	0.012	54.07	43.25	24.8	ACCEPTABLE
18	0.128	0.38	1.77	0.012	40.82	32.66	23.1	ACCEPTABLE
15	0.128	0.31	1.23	0.012	25.10	20.08	20.5	ACCEPTABLE
12	0.128	0.25	0.79	0.012	13.85	11.08	17.6	ACCEPTABLE
10	0.128	0.21	0.55	0.012	8.51	6.81	15.6	ACCEPTABLE
8	0.128	0.17	0.35	0.012	4.70	3.76	13.5	ACCEPTABLE
6	0.128	0.13	0.20	0.012	2.18	1.74	11.1	ACCEPTABLE
4	0.128	0.08	0.09	0.012	0.74	0.59	8.5	FAILED
3	0.128	0.06	0.05	0.012	0.343	0.27	7.0	FAILED
2	0.128	0.04	0.02	0.012	0.116	0.09	5.3	FAILED

Velocity (V,fps): 3.77 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.28	0.36	0.31	37.67	37.98	0.22	38.20	Upstream
			29.35	29.66		29.88	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 15 - Drainage Area 5
West Outfall

DMA

C =	0.95	
i =	3.13	in/hr
A =	0.068	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	2964	0.068
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.20 Pipe
Q=CiA 0.20 DMA

pipe slope = 0.062
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	70
S	0.128
T_c	0.49

T_c Total	**0.55**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	82
S	0.128
Across-Sect	0.39
Pw	1.14
Rh	0.34
V	21.73
Tc	0.06

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.062	1.00	12.57	0.012	388.52	310.81	30.9	ACCEPTABLE
36	0.062	0.75	7.07	0.012	180.40	144.32	25.5	ACCEPTABLE
30	0.062	0.63	4.91	0.012	110.94	88.75	22.6	ACCEPTABLE
24	0.062	0.50	3.14	0.012	61.19	48.95	19.5	ACCEPTABLE
20	0.062	0.42	2.18	0.012	37.63	30.10	17.2	ACCEPTABLE
18	0.062	0.38	1.77	0.012	28.41	22.73	16.1	ACCEPTABLE
15	0.062	0.31	1.23	0.012	17.47	13.98	14.2	ACCEPTABLE
12	0.062	0.25	0.79	0.012	9.64	7.71	12.3	ACCEPTABLE
10	0.062	0.21	0.55	0.012	5.93	4.74	10.9	ACCEPTABLE
8	0.062	0.17	0.35	0.012	3.27	2.61	9.4	ACCEPTABLE
6	0.062	0.13	0.20	0.012	1.52	1.21	7.7	ACCEPTABLE
4	0.062	0.08	0.09	0.012	0.51	0.41	5.9	ACCEPTABLE
3	0.062	0.06	0.05	0.012	0.239	0.19	4.9	FAILED
2	0.062	0.04	0.02	0.012	0.081	0.06	3.7	FAILED

Velocity (V,fps): 0.58 V=Q/A

Inlet 8 (DMA 5)		
Depth	4.00	ft
Spread, T	1.58	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.06	0.16	0.11	29.51	29.62	0.01	29.62	Upstream
			29.35	29.46		29.46	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 16
West Outfall

Cummulative

C =	0.92	
i =	-	in/hr
A =	0.526	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.50
Perv. Area	0.25	0.02

Design Flow (Q,cfs): 1.52 Pipe

Q=CiA

pipe slope = 0.116

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P14 and P15

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.116	1.00	12.57	0.012	531.43	425.14	42.3	ACCEPTABLE
36	0.116	0.75	7.07	0.012	246.76	197.41	34.9	ACCEPTABLE
30	0.116	0.63	4.91	0.012	151.75	121.40	30.9	ACCEPTABLE
24	0.116	0.50	3.14	0.012	83.69	66.96	26.6	ACCEPTABLE
20	0.116	0.42	2.18	0.012	51.47	41.18	23.6	ACCEPTABLE
18	0.116	0.38	1.77	0.012	38.86	31.09	22.0	ACCEPTABLE
15	0.116	0.31	1.23	0.012	23.90	19.12	19.5	ACCEPTABLE
12	0.116	0.25	0.79	0.012	13.18	10.54	16.8	ACCEPTABLE
10	0.116	0.21	0.55	0.012	8.11	6.48	14.9	ACCEPTABLE
8	0.116	0.17	0.35	0.012	4.47	3.58	12.8	ACCEPTABLE
6	0.116	0.13	0.20	0.012	2.08	1.66	10.6	ACCEPTABLE
4	0.116	0.08	0.09	0.012	0.70	0.56	8.1	FAILED
3	0.116	0.06	0.05	0.012	0.327	0.26	6.7	FAILED
2	0.116	0.04	0.02	0.012	0.111	0.09	5.1	FAILED

Velocity (V,fps): 4.35 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.34	0.4	0.27	29.35	29.62	0.29	29.91	Upstream
			20.98	21.25		21.54	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 17 - Drainage Area 6
West Outfall

DMA

C =	0.95	
i =	3.13	in/hr
A =	0.023	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	1011	0.023
Perv. Area	0.25	0	0.000

Design Flow (Q,cfs): 0.07 Pipe
Q=CiA 0.07 DMA

pipe slope = 0.044
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	28
S	0.136
T_c	0.23

T_c Total	**0.27**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	58
S	0.125
Across-Sect	0.39
Pw	1.08
Rh	0.36
V	22.26
Tc	0.04

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.044	1.00	12.57	0.012	327.30	261.84	26.0	ACCEPTABLE
36	0.044	0.75	7.07	0.012	151.97	121.58	21.5	ACCEPTABLE
30	0.044	0.63	4.91	0.012	93.46	74.77	19.0	ACCEPTABLE
24	0.044	0.50	3.14	0.012	51.55	41.24	16.4	ACCEPTABLE
20	0.044	0.42	2.18	0.012	31.70	25.36	14.5	ACCEPTABLE
18	0.044	0.38	1.77	0.012	23.93	19.15	13.5	ACCEPTABLE
15	0.044	0.31	1.23	0.012	14.72	11.78	12.0	ACCEPTABLE
12	0.044	0.25	0.79	0.012	8.12	6.49	10.3	ACCEPTABLE
10	0.044	0.21	0.55	0.012	4.99	3.99	9.2	ACCEPTABLE
8	0.044	0.17	0.35	0.012	2.75	2.20	7.9	ACCEPTABLE
6	0.044	0.13	0.20	0.012	1.28	1.02	6.5	ACCEPTABLE
4	0.044	0.08	0.09	0.012	0.43	0.35	5.0	ACCEPTABLE
3	0.044	0.06	0.05	0.012	0.201	0.16	4.1	ACCEPTABLE
2	0.044	0.04	0.02	0.012	0.068	0.05	3.1	FAILED

Velocity (V,fps): 0.20 V=Q/A

Inlet 9 (DMA 6)		
Depth	4.00	ft
Spread, T	1.64	ft

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.03	0.12	0.08	21.43	21.51	0.00	21.51	Upstream
			20.98	21.06		21.06	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 18
West Outfall

Cummulative

C =	0.92	
i =	-	in/hr
A =	0.550	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.53
Perv. Area	0.25	0.02

Design Flow (Q,cfs): 1.59 Pipe

Q=CiA

pipe slope = 0.011

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P16 and P17

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.011	1.00	12.57	0.012	163.65	130.92	13.0	ACCEPTABLE
36	0.011	0.75	7.07	0.012	75.99	60.79	10.8	ACCEPTABLE
30	0.011	0.63	4.91	0.012	46.73	37.38	9.5	ACCEPTABLE
24	0.011	0.50	3.14	0.012	25.77	20.62	8.2	ACCEPTABLE
20	0.011	0.42	2.18	0.012	15.85	12.68	7.3	ACCEPTABLE
18	0.011	0.38	1.77	0.012	11.97	9.57	6.8	ACCEPTABLE
15	0.011	0.31	1.23	0.012	7.36	5.89	6.0	ACCEPTABLE
12	0.011	0.25	0.79	0.012	4.06	3.25	5.2	ACCEPTABLE
10	0.011	0.21	0.55	0.012	2.50	2.00	4.6	ACCEPTABLE
8	0.011	0.17	0.35	0.012	1.38	1.10	3.9	FAILED
6	0.011	0.13	0.20	0.012	0.64	0.51	3.3	FAILED
4	0.011	0.08	0.09	0.012	0.22	0.17	2.5	FAILED
3	0.011	0.06	0.05	0.012	0.101	0.08	2.1	FAILED
2	0.011	0.04	0.02	0.012	0.034	0.03	1.6	FAILED

Velocity (V,fps): 2.91 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.64	0.58	0.48	20.98	21.46	0.13	21.59	Upstream
			18.94	19.42		19.55	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 20a - Drainage Area 12
West Outfall

DMA

C =	0.27	
i =	2.92	in/hr
A =	0.44	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	419	0.010
Perv. Area	0.25	18538	0.426

Design Flow (Q,cfs): 0.34 Pipe
Q=CiA 0.34 DMA

pipe slope = 0.012
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	100
S	0.333
T_c	5.21

Time of Concentration	
Shallow Concentrated Flow	
L	139
S	0.333
C_p	6.962
V	4.02
T_c	0.58

T_c Total	**5.79**

*Interpolate T_c to obtain intensity

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.012	1.00	12.57	0.012	170.92	136.74	13.6	ACCEPTABLE
36	0.012	0.75	7.07	0.012	79.37	63.49	11.2	ACCEPTABLE
30	0.012	0.63	4.91	0.012	48.81	39.05	9.9	ACCEPTABLE
24	0.012	0.50	3.14	0.012	26.92	21.54	8.6	ACCEPTABLE
20	0.012	0.42	2.18	0.012	16.55	13.24	7.6	ACCEPTABLE
18	0.012	0.38	1.77	0.012	12.50	10.00	7.1	ACCEPTABLE
15	0.012	0.31	1.23	0.012	7.69	6.15	6.3	ACCEPTABLE
12	0.012	0.25	0.79	0.012	4.24	3.39	5.4	ACCEPTABLE
10	0.012	0.21	0.55	0.012	2.61	2.09	4.8	ACCEPTABLE
8	0.012	0.17	0.35	0.012	1.44	1.15	4.1	ACCEPTABLE
6	0.012	0.13	0.20	0.012	0.67	0.53	3.4	ACCEPTABLE
4	0.012	0.08	0.09	0.012	0.23	0.18	2.6	FAILED
3	0.012	0.06	0.05	0.012	0.105	0.08	2.1	FAILED
2	0.012	0.04	0.02	0.012	0.036	0.03	1.6	FAILED

Velocity (V,fps): 0.62 V=Q/A

Inlet 15 (DMA 12)		
Depth	7.51	ft
Spread, T	2.47	ft

HGL and EGL Calculations							
Q/Qfull	**d/D**	**Depth of flow, y (ft)**	**Elev. Head z (ft)**	**HGL**	**Velocity Head**	**EGL**	
0.13	0.24	0.20	20.62	20.82	0.01	20.83	Upstream
			20.33	20.53		20.54	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 20b - Drainage Area 13
West Outfall

DMA

C =	0.25	
i =	2.92	in/hr
A =	0.26	AC

Weighted C Factor				
	C factor	DMA Area [SF]	DMA Area [AC]	Cumm. Area AC
Imperv. Area	0.95	0	0.000	0.010
Perv. Area	0.25	11529	0.265	0.690

Design Flow (Q,cfs): 0.53 Pipe
Q=CiA 0.19 DMA

pipe slope = 0.012
n = 0.012

Percent Full 0.8

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	100
S	0.333
T_c	5.21

Time of Concentration	
Shallow Concentrated Flow	
L	112
S	0.333
C_p	6.962
V	4.02
T_c	0.47

Time of Concentration	
Open Channel Flow	
n	0.012
L	41
S	0.013
Across-Sect	0.25
P_w	1.14
Rh	0.22
V	5.15
T_c	0.13

T_c Total	5.81

*Interpolate T_c to obtain intensity

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.012	1.00	12.57	0.012	170.92	136.74	13.6	ACCEPTABLE
36	0.012	0.75	7.07	0.012	79.37	63.49	11.2	ACCEPTABLE
30	0.012	0.63	4.91	0.012	48.81	39.05	9.9	ACCEPTABLE
24	0.012	0.50	3.14	0.012	26.92	21.54	8.6	ACCEPTABLE
20	0.012	0.42	2.18	0.012	16.55	13.24	7.6	ACCEPTABLE
18	0.012	0.38	1.77	0.012	12.50	10.00	7.1	ACCEPTABLE
15	0.012	0.31	1.23	0.012	7.69	6.15	6.3	ACCEPTABLE
12	0.012	0.25	0.79	0.012	4.24	3.39	5.4	ACCEPTABLE
10	0.012	0.21	0.55	0.012	2.61	2.09	4.8	ACCEPTABLE
8	0.012	0.17	0.35	0.012	1.44	1.15	4.1	ACCEPTABLE
6	0.012	0.13	0.20	0.012	0.67	0.53	3.4	ACCEPTABLE
4	0.012	0.08	0.09	0.012	0.23	0.18	2.6	FAILED
3	0.012	0.06	0.05	0.012	0.105	0.08	2.1	FAILED
2	0.012	0.04	0.02	0.012	0.036	0.03	1.6	FAILED

Velocity (V,fps): 0.97 V=Q/A

Inlet 10 (DMA 12)		
Depth	8.67	ft
Spread, T	2.15	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.20	0.3	0.25	20.33	20.58	0.01	20.59	Upstream
			19.64	19.89		19.90	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 20c - Drainage Area 14
West Outfall

DMA

C =	0.25	
i =	3.13	in/hr
A =	0.112	AC

Weighted C Factor				
	C factor	DMA Area SF	DMA Area [AC]	Cumm. Area AC
Imperv. Area	0.95	0	0.00	0.010
Perv. Area	0.25	4896	0.11	0.803

Design Flow (Q,cfs):	0.62	Pipe
Q=CiA	0.09	DMA
pipe slope =	0.007	
n =	0.012	
Percent Full	0.8	

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.24
L	100
S	0.4
T_c	4.84

Time of Concentration	
Shallow Concentrated Flow	
L	23
S	0.4
C_p	6.962
V	4.40
T_c	0.09

T_c Total	**4.93**

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.007	1.00	12.57	0.012	130.55	104.44	10.4	ACCEPTABLE
36	0.007	0.75	7.07	0.012	60.62	48.49	8.6	ACCEPTABLE
30	0.007	0.63	4.91	0.012	37.28	29.82	7.6	ACCEPTABLE
24	0.007	0.50	3.14	0.012	20.56	16.45	6.5	ACCEPTABLE
20	0.007	0.42	2.18	0.012	12.64	10.11	5.8	ACCEPTABLE
18	0.007	0.38	1.77	0.012	9.55	7.64	5.4	ACCEPTABLE
15	0.007	0.31	1.23	0.012	5.87	4.70	4.8	ACCEPTABLE
12	0.007	0.25	0.79	0.012	3.24	2.59	4.1	ACCEPTABLE
10	0.007	0.21	0.55	0.012	1.99	1.59	3.7	ACCEPTABLE
8	0.007	0.17	0.35	0.012	1.10	0.88	3.1	ACCEPTABLE
6	0.007	0.13	0.20	0.012	0.51	0.41	2.6	FAILED
4	0.007	0.08	0.09	0.012	0.17	0.14	2.0	FAILED
3	0.007	0.06	0.05	0.012	0.080	0.06	1.6	FAILED
2	0.007	0.04	0.02	0.012	0.027	0.02	1.2	FAILED

Velocity (V,fps): 1.13 V=Q/A

Inlet 11 (DMA 13)		
Depth	10.12	ft
Spread, T	1.71	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.31	0.38	0.32	19.64	19.96	0.02	19.98	Upstream
			19.25	19.57		19.59	Downstream

Exhibit E.1.4

SHERWOOD
DESIGN ENGINEERS

Pipe 21
West Outfall

Cummulative

C =	0.26	
i =	-	in/hr
A =	0.81	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.010
Perv. Area	0.25	0.803

Design Flow (Q,cfs): 0.62 Pipe

Q=CiA

pipe slope = 0.006

n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

*Continuation and combination of P20a, P20b, and P20c

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.006	1.00	12.57	0.012	120.86	96.69	9.6	ACCEPTABLE
36	0.006	0.75	7.07	0.012	56.12	44.90	7.9	ACCEPTABLE
30	0.006	0.63	4.91	0.012	34.51	27.61	7.0	ACCEPTABLE
24	0.006	0.50	3.14	0.012	19.03	15.23	6.1	ACCEPTABLE
20	0.006	0.42	2.18	0.012	11.71	9.36	5.4	ACCEPTABLE
18	0.006	0.38	1.77	0.012	8.84	7.07	5.0	ACCEPTABLE
15	0.006	0.31	1.23	0.012	5.44	4.35	4.4	ACCEPTABLE
12	0.006	0.25	0.79	0.012	3.00	2.40	3.8	ACCEPTABLE
10	0.006	0.21	0.55	0.012	1.84	1.47	3.4	ACCEPTABLE
8	0.006	0.17	0.35	0.012	1.02	0.81	2.9	ACCEPTABLE
6	0.006	0.13	0.20	0.012	0.47	0.38	2.4	FAILED
4	0.006	0.08	0.09	0.012	0.16	0.13	1.8	FAILED
3	0.006	0.06	0.05	0.012	0.074	0.06	1.5	FAILED
2	0.006	0.04	0.02	0.012	0.025	0.02	1.2	FAILED

Velocity (V,fps): 1.13 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.34	0.4	0.40	19.25	19.65	0.02	19.67	Upstream
			18.94	19.34		19.36	Downstream

Exhibit E.1.4

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Pipe 19
West Outfall

Cummulative

C =	0.53	
i =	-	in/hr
A =	1.36	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.537
Perv. Area	0.25	0.825

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

Design Flow (Q,cfs): 2.20 Pipe

Q=CiA

pipe slope = 0.020

n = 0.012

Percent Full 0.8

*Continuation and combination of P18 and P21

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.020	1.00	12.57	0.012	220.66	176.53	17.6	ACCEPTABLE
36	0.020	0.75	7.07	0.012	102.46	81.97	14.5	ACCEPTABLE
30	0.020	0.63	4.91	0.012	63.01	50.41	12.8	ACCEPTABLE
24	0.020	0.50	3.14	0.012	34.75	27.80	11.1	ACCEPTABLE
20	0.020	0.42	2.18	0.012	21.37	17.10	9.8	ACCEPTABLE
18	0.020	0.38	1.77	0.012	16.14	12.91	9.1	ACCEPTABLE
15	0.020	0.31	1.23	0.012	9.92	7.94	8.1	ACCEPTABLE
12	0.020	0.25	0.79	0.012	5.47	4.38	7.0	ACCEPTABLE
10	0.020	0.21	0.55	0.012	3.37	2.69	6.2	ACCEPTABLE
8	0.020	0.17	0.35	0.012	1.86	1.49	5.3	FAILED
6	0.020	0.13	0.20	0.012	0.86	0.69	4.4	FAILED
4	0.020	0.08	0.09	0.012	0.29	0.23	3.4	FAILED
3	0.020	0.06	0.05	0.012	0.136	0.11	2.8	FAILED
2	0.020	0.04	0.02	0.012	0.046	0.04	2.1	FAILED

Velocity (V,fps): 2.81 V=Q/A

HGL and EGL Calculations

Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.40	0.44	0.44	18.94	19.38	0.12	19.50	Upstream
			18.86	19.30		19.42	Downstream

Exhibit E.1.4

Existing 12" SD Outfall
(Inv: 16.82)

P23
D: 10"
24.7 LF
2.5%

SDMH
Rim 25.31
Inv In (SW): 17.57
Inv In (S): 17.94
Inv Out (NW): 17.44

P22
D: 10"
87 LF
S: 1.0%

Drainage Area 8
Impervious Area: 0.17 acres
Pervious Area: 0.02 acres
C: 0.89
i: 3.13 in/hr
Q: 0.53 cfs

Rim 22.27
Inv. 18.44

Inlet 12
TW 32.59
Rim: 31.50
(BW): 23.57
8" Inv Out: 18.50
T: 1.75'

P24
D: 8"
18.8 LF
3.0%

Drainage Area 17
Impervious Area: 0 acres
Pervious Area: 0.16 acres
C: 0.25
i: 3.13 in/hr
Q: 0.13 cfs

Sea Cliff Ave.

Sea Cliff Ave.

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San Francisco, CA 94110
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EASTERN OUTFALL STORM DRAIN CAPACITY

REHABILITATION OF CHINA BEACH
SAN FRANCISCO, CA

NORTH

0 10' 20' 40'

December 3, 2021

Exhibit E.1.5

SHERWOOD
DESIGN ENGINEERS

Pipe 22 - Drainage Area 8
East Outfall

PIPE CAPACITY: $Q_{pipe} = (1.49/n*R2/3*S1/2)*A$

DMA

C =	0.89	
i =	3.13	in/hr
A =	0.189	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	7576	0.174
Perv. Area	0.25	668	0.015

Design Flow (Q,cfs): 0.53 Pipe
Q=CiA 0.53 DMA

pipe slope = 0.010
n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	2.53
n	0.011
L	111
S	0.02
T_c	1.48

*Min T_c = 5 min, use i=3.13in/hr

PIPE INFORMATION AND SIZE CHECK

size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.010	1.00	12.57	0.012	156.03	124.83	12.4	ACCEPTABLE
36	0.010	0.75	7.07	0.012	72.45	57.96	10.2	ACCEPTABLE
30	0.010	0.63	4.91	0.012	44.55	35.64	9.1	ACCEPTABLE
24	0.010	0.50	3.14	0.012	24.57	19.66	7.8	ACCEPTABLE
20	0.010	0.42	2.18	0.012	15.11	12.09	6.9	ACCEPTABLE
18	0.010	0.38	1.77	0.012	11.41	9.13	6.5	ACCEPTABLE
15	0.010	0.31	1.23	0.012	7.02	5.61	5.7	ACCEPTABLE
12	0.010	0.25	0.79	0.012	3.87	3.10	4.9	ACCEPTABLE
10	0.010	0.21	0.55	0.012	2.38	1.90	4.4	ACCEPTABLE
8	0.010	0.17	0.35	0.012	1.31	1.05	3.8	ACCEPTABLE
6	0.010	0.13	0.20	0.012	0.61	0.49	3.1	FAILED
4	0.010	0.08	0.09	0.012	0.21	0.17	2.4	FAILED
3	0.010	0.06	0.05	0.012	0.096	0.08	2.0	FAILED
2	0.010	0.04	0.02	0.012	0.033	0.03	1.5	FAILED

Velocity (V,fps): 0.97 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.22	0.32	0.27	18.44	18.71	0.01	18.72	Upstream
			17.57	17.84		17.85	Downstream

Exhibit E.1.6

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Pipe 24 - Drainage Area 17
East Outfall

DMA

C =	0.25	
i =	3.13	in/hr
A =	0.160	AC

Weighted C Factor			
	C factor	DMA Area [SF]	DMA Area [AC]
Imperv. Area	0.95	0	0.000
Perv. Area	0.25	6986	0.160

Design Flow (Q,cfs):	0.13	Pipe
Q=CiA	0.13	DMA
pipe slope =	0.030	
n =	0.012	
Percent Full	0.8	

Time of Concentration	
P_2	2.53
n	0.24
L	79
S	0.5
T_c	3.67
T_c Total	**3.89**

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	63
S	0.006
Across-Sect	0.25
Pw	0.74
Rh	0.34
V	4.67
T_c	0.23

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.030	1.00	12.57	0.012	270.26	216.20	21.5	ACCEPTABLE
36	0.030	0.75	7.07	0.012	125.49	100.39	17.8	ACCEPTABLE
30	0.030	0.63	4.91	0.012	77.17	61.74	15.7	ACCEPTABLE
24	0.030	0.50	3.14	0.012	42.56	34.05	13.5	ACCEPTABLE
20	0.030	0.42	2.18	0.012	26.17	20.94	12.0	ACCEPTABLE
18	0.030	0.38	1.77	0.012	19.76	15.81	11.2	ACCEPTABLE
15	0.030	0.31	1.23	0.012	12.15	9.72	9.9	ACCEPTABLE
12	0.030	0.25	0.79	0.012	6.70	5.36	8.5	ACCEPTABLE
10	0.030	0.21	0.55	0.012	4.12	3.30	7.6	ACCEPTABLE
8	0.030	0.17	0.35	0.012	2.27	1.82	6.5	ACCEPTABLE
6	0.030	0.13	0.20	0.012	1.06	0.84	5.4	ACCEPTABLE
4	0.030	0.08	0.09	0.012	0.36	0.29	4.1	ACCEPTABLE
3	0.030	0.06	0.05	0.012	0.166	0.13	3.4	ACCEPTABLE
2	0.030	0.04	0.02	0.012	0.056	0.05	2.6	FAILED

Velocity (V,fps): 0.36 V=Q/A

Inlet 12 (DMA 14)		
Depth	7.93	ft
Spread, T	1.63	ft

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.06	0.16	0.11	18.5	18.61	0.00	18.61	Upstream
			17.94	18.05		18.05	Downstream

Exhibit E.1.6

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Pipe 23
East Outfall

PIPE CAPACITY: $Q_{pipe} = (1.49/n*R2/3*S1/2)*A$

Cummulative

C =	0.60	
i =	-	in/hr
A =	0.350	AC

Weighted C Factor		
	C factor	Cumm. Area [AC]
Imperv. Area	0.95	0.174
Perv. Area	0.25	0.176

Design Flow (Q,cfs): 0.65 Pipe
Q=CiA

pipe slope = 0.025
n = 0.012

Percent Full 0.8

Time of Concentration	
P_2	-
n	-
L	-
S	-
T_c	-

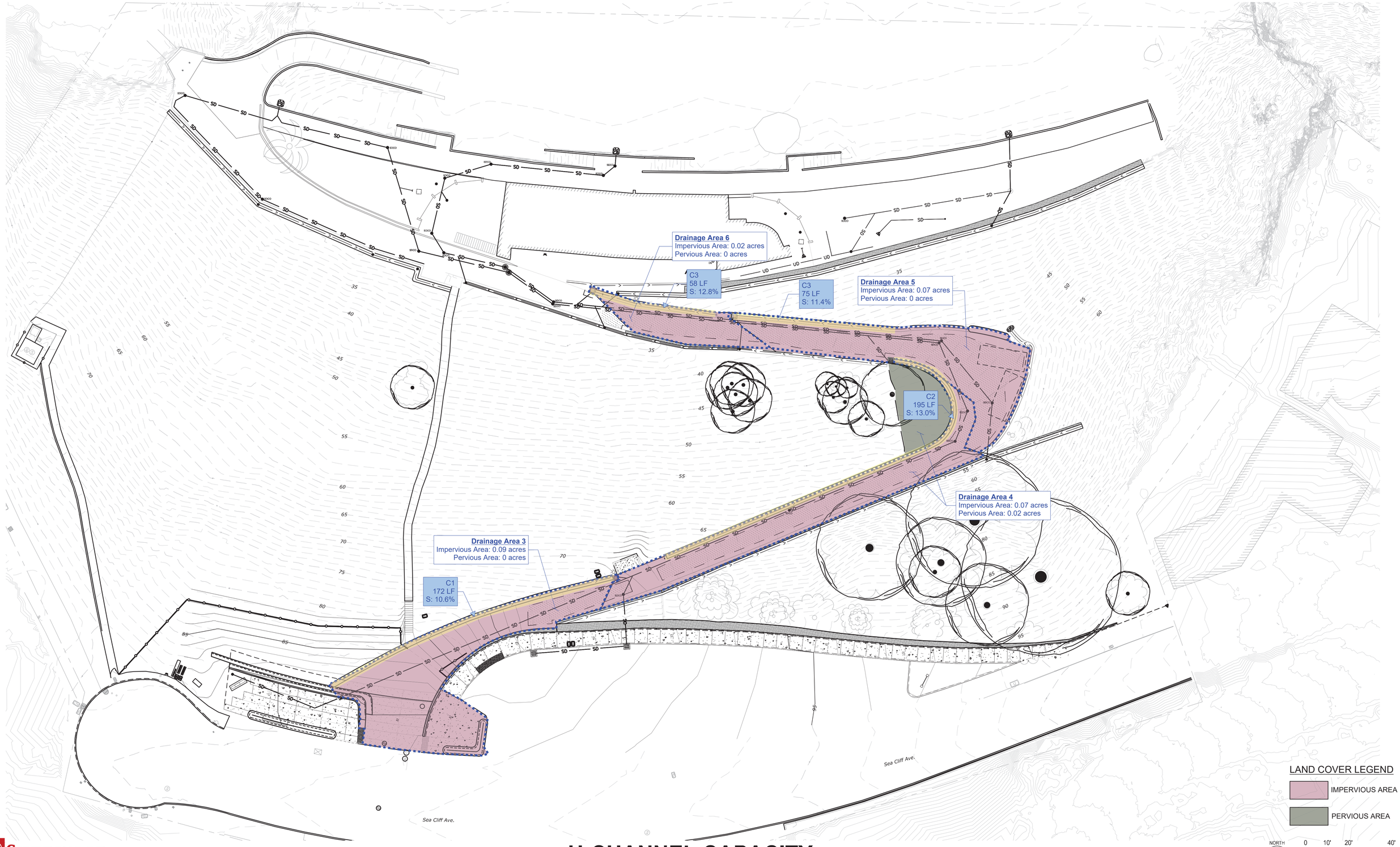
*Continuation and combination of P22 ad P24

PIPE INFORMATION AND SIZE CHECK								
size (in)	slope(s)	R (ft)	A (sq.ft)	n	Q(cfs)	% of Q	V (ft/s)	Size Result
48	0.025	1.00	12.57	0.012	246.71	197.37	19.6	ACCEPTABLE
36	0.025	0.75	7.07	0.012	114.56	91.64	16.2	ACCEPTABLE
30	0.025	0.63	4.91	0.012	70.45	56.36	14.4	ACCEPTABLE
24	0.025	0.50	3.14	0.012	38.85	31.08	12.4	ACCEPTABLE
20	0.025	0.42	2.18	0.012	23.89	19.12	11.0	ACCEPTABLE
18	0.025	0.38	1.77	0.012	18.04	14.43	10.2	ACCEPTABLE
15	0.025	0.31	1.23	0.012	11.09	8.88	9.0	ACCEPTABLE
12	0.025	0.25	0.79	0.012	6.12	4.90	7.8	ACCEPTABLE
10	0.025	0.21	0.55	0.012	3.76	3.01	6.9	ACCEPTABLE
8	0.025	0.17	0.35	0.012	2.08	1.66	5.9	ACCEPTABLE
6	0.025	0.13	0.20	0.012	0.96	0.77	4.9	ACCEPTABLE
4	0.025	0.08	0.09	0.012	0.33	0.26	3.7	FAILED
3	0.025	0.06	0.05	0.012	0.152	0.12	3.1	FAILED
2	0.025	0.04	0.02	0.012	0.051	0.04	2.4	FAILED

Velocity (V,fps): 1.20 V=Q/A

HGL and EGL Calculations							
Q/Qfull	d/D	Depth of flow, y (ft)	Elev. Head z (ft)	HGL	Velocity Head	EGL	
0.17	0.28	0.23	17.44	17.67	0.02	17.70	Upstream
			16.82	17.05		17.08	Downstream

Exhibit E.1.6



U-CHANNEL CAPACITY

REHABILITATION OF CHINA BEACH
SAN FRANCISCO, CA

December 3, 2021

Exhibit E.1.7

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U-Channel Capacity

C1 - DMA 3

Weighted C Factor			
	C Factor	Area [SF]	Area [AC]
Impervious Area	0.95	3797	0.087
Pervious Area	0.25	0	0
		Weighted C Factor	0.95

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	61
S	0.15
T_c	0.41

T_c Total	0.47

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	113
S	0.125
Across-Sect	0.67
Pw	1.16
Rh	0.58
V	30.45
T_c	0.06

Q=CiA

Drainage Area Flow Rate		
C	0.95	
i	3.13	in/hr
A	0.087	acres
Design Flow (Q, cfs)		0.26
Velocity (ft/s)		0.66

Channel Sizing Information Check									
Size (in)	Slope	Hydraulic Radius, R	Area (sf)	Manning's n	Q (cfs)	50% of Q	Velocity (ft/s)	Check	Normal Depth (ft)
12	0.09	0.58	0.393	0.013	9.365	4.682	23.85	ACCEPTABLE	0.248

$\tau_o = \gamma RSo$

Sheer Stress		
γ	62.4	lbf/ft^3
R	0.58	ft
So	0.090	
Sheer Stress (lbr/ft^2)		3.24

Freeboard		
Channel Depth	0.5	ft
Channel Depth	0.248	ft
Freeboard (ft)		0.25

C2 - DMA 4

Weighted C Factor			
	C Factor	Area SF	Area Acres
Impervious Area	0.95	3022	0.069
Pervious Area	0.25	820	0.019
Weighted C Factor			0.801

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	38
S	0.12
T_c	0.31

T_c Total	0.47

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	196
S	0.115
Across-Sect	0.39
Pw	1.16
Rh	0.34
V	20.36
T_c	0.16

Q=CiA

Drainage Area Flow Rate		
C	0.801	
i	3.13	in/hr
A	0.088	acres
Design Flow (Q, cfs)		0.22
Velocity (ft/s)		0.56

Channel Sizing Information Check									
Size (in)	Slope	Hydraulic Radius, R	Area (sf)	Manning's n	Q (cfs)	50% of Q	Velocity (ft/s)	Check	Normal Depth
12	0.11	0.34	0.393	0.013	7.218	3.609	18.38	ACCEPTABLE	0.225

$\tau_o = \gamma RSo$

Sheer Stress		
γ	62.4	lbf/ft^3
R	0.34	ft
So	0.110	
Sheer Stress (lbr/ft^2)		2.31

Freeboard		
Channel Depth	0.5	ft
Channel Depth	0.225	ft
Freeboard (ft)		0.28

Exhibit E.1.8

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C3 - DMA 5

Weighted C Factor			
	C Factor	Area SF	Area Acres
Impervious Area	0.95	2964	0.068
Pervious Area	0.25	0	0.000
		Weighted C Factor	0.950

Time of Concentration		
Sheet Flow		
P_2	2.53	2.53
n	0.011	0.011
L	58	32
S	0.128	0.11
T_c	0.42	0.28

T_c Total	0.75

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	75
S	0.128
Across-Sect	0.39
Pw	1.14
Rh	0.34
V	21.73
T_c	0.06

Q=CiA

Drainage Area Flow Rate		
C	0.950	
i	3.13	in/hr
A	0.068	acres
Design Flow (Q, cfs)		0.20
Velocity (ft/s)		0.52

Channel Sizing Information Check									
Size (in)	Slope	Hydraulic Radius, R	Area (sf)	Manning's n	Q (cfs)	50% of Q	Velocity (ft/s)	Check	Normal Depth
12	0.114	0.34	0.393	0.013	7.434	3.717	18.93	ACCEPTABLE	0.216

$\tau_o = \gamma RSo$

Sheer Stress		
γ	62.4	lbf/ft^3
R	0.34	ft
So	0.114	
Sheer Stress (lbr/ft^2)		2.43

Freeboard		
Channel Depth	0.5	ft
Channel Depth	0.216	ft
Freeboard (ft)		0.28

C4 - DMA 6

Weighted C Factor			
	C Factor	Area SF	Area Acres
Impervious Area	0.95	1011	0.023
Pervious Area	0.25	0	0
		Weighted C Factor	0.95

Time of Concentration	
Sheet Flow	
P_2	2.53
n	0.011
L	28
S	0.136
T_c	0.23

T_c Total	0.27

*Min T_c = 5 min, use i=3.13in/hr

Time of Concentration	
Open Channel Flow	
n	0.012
L	58
S	0.125
Across-Sect	0.39
Pw	1.08
Rh	0.36
V	22.26
T_c	0.04

Q=CiA

Drainage Area Flow Rate		
C	0.95	
i	3.13	in/hr
A	0.023	acres
Design Flow (Q, cfs)		0.07
Velocity (ft/s)		0.18

Channel Sizing Information Check									
Size (in)	Slope	Hydraulic Radius, R	Area (sf)	Manning's n	Q (cfs)	50% of Q	Velocity (ft/s)	Check	Normal Depth
12	0.128	0.36	0.393	0.013	8.166	4.083	20.79	ACCEPTABLE	0.141

$\tau_o = \gamma RSo$

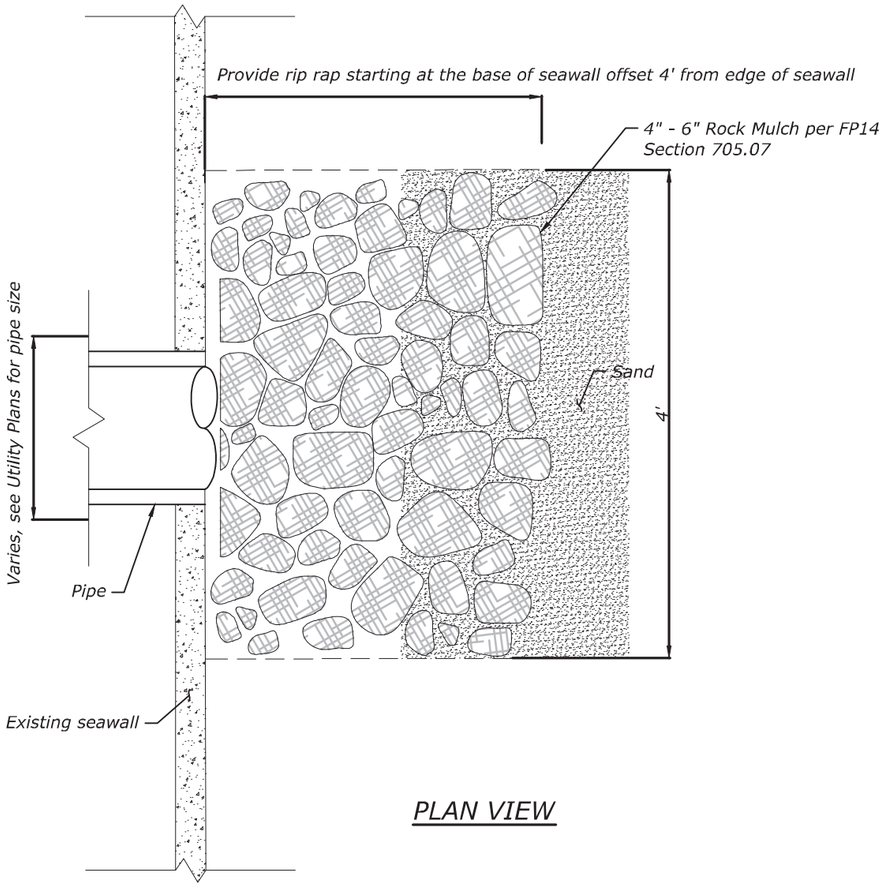
Sheer Stress		
γ	62.4	lbf/ft^3
R	0.36	ft
So	0.128	
Sheer Stress (lbr/ft^2)		2.88

Freeboard		
Channel Depth	0.5	ft
Channel Depth	0.141	ft
Freeboard (ft)		0.36

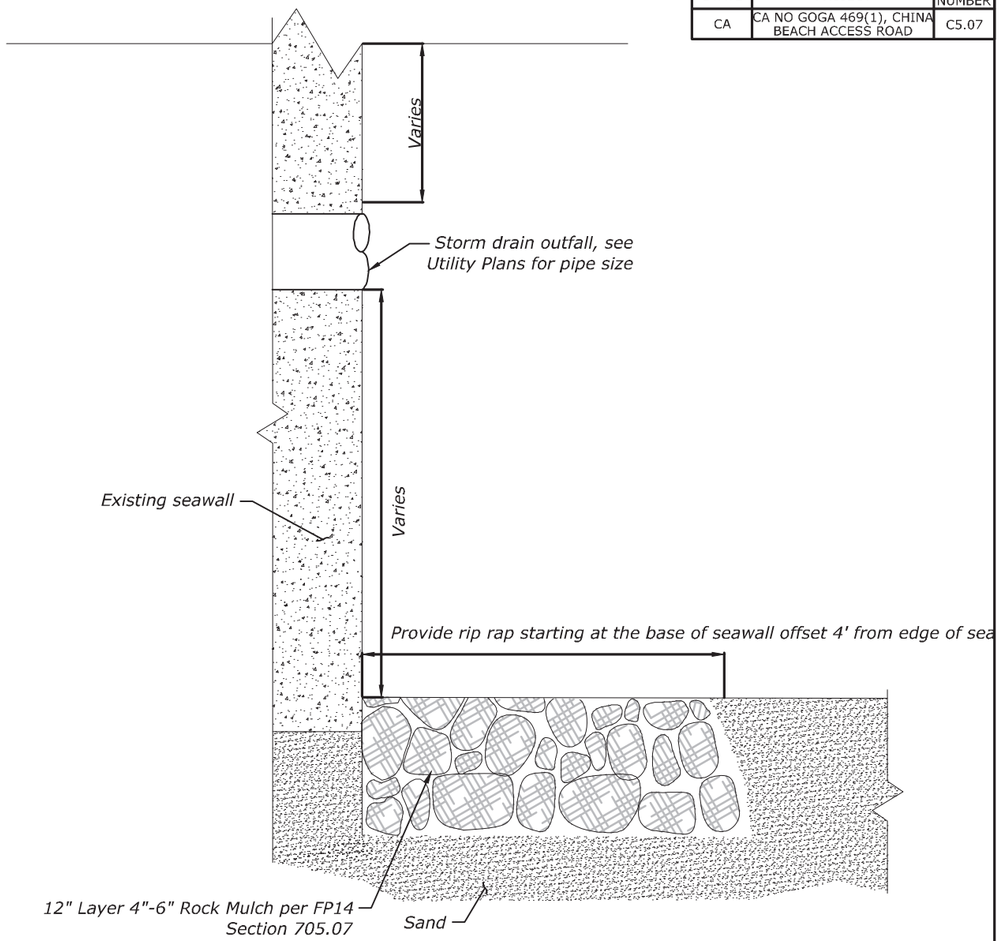
Exhibit E.1.8

Appendix F. Outfall Protection - Riprap Detail

STATE	PROJECT	SHEET NUMBER
CA	CA NO GOGA 469(1), CHINA BEACH ACCESS ROAD	C5.07



PLAN VIEW



PROFILE VIEW

NOTES:

1. 4' x 4' rip rap of 4-6" rock mulch per FP14 Section 705.07 from center of pipe outfall location.

Placed Riprap, Method A

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION

DETAILS
PLACED RIPRAP, METHOD A

Sheet 1 of 1

11/13/2021 4:03:17 PM P:\2018\18-162_China_Rehab\03_Design\01_CAD\04_CD FHWA\C5.0 DETAILS.dwg