



Design Guidance Gross Solids Removal Devices

August 2025

California Department of Transportation
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1120 N Street
Sacramento, California 95814
<http://www.dot.ca.gov/hq/env/stormwater/index.htm>

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List of Abbreviations, Terms

'	foot, feet	min	minimum
"	inch, inches	nSSP	Non-Standard Special Provision
ac	acre	OG	original grade
AWP-P	AASHTOWare Project Preconstruction	OHSD	Office of Hydraulics and Stormwater Design
BMP	Best Management Practice	PA/ED	Project Approval/Environmental Document
CB	catch basin	PCBs	Polychlorinated biphenyls
CF	cubic foot, cubic feet	PE	Project Engineer
cfs	cubic feet per second	PECE	Preliminary Engineer's Cost Estimate
CMP	corrugated metal pipe	PID	Project Initiation Document
CRZ	Clear Recovery Zone, (AASHTO)	PM	post mile
CSP	Corrugated Steel Pipe	PPCE	Project Planning Cost Estimates
DEA	Department of Environmental Analysis	PS&E	Plans, Specifications and Estimate
DES	Department of Environmental Services	RCP	Reinforced Concrete Pipe
FRP	fiberglass reinforced plastic	RW	right-of-way
ft	foot, feet	RWQCB	Regional Water Quality Control Board
ft/s	foot/second, feet/second	S	slope
gal	gallons	SSHM	Small Storm Hydrology Method
gpm	gallons per minute	SSP	Standard Special Provision
GSRD	Gross Solids Removal Device	STGA	Significant Trash Generation Area
H	Wall Height	SWDR	Stormwater Data Report
HDM	Highway Design Manual	SWRCB	State Water Resources Control Board
HQ	Headquarters	TBMP	Treatment Best Management Practice
HSU	Hydrodynamic Separator Unit	TMDL	Total Maximum Daily Load
Ht	height	yr	year
HV	High Velocity		
in	inch, inches		
L	Screen Length		
LR	Linear Radial		
LRFD	Load and Resistance Factor Design		
m	meters		
max	maximum		

Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating the Caltrans Gross Solids Removal Devices (GSRDs) into projects during the planning and design phases of highways and facilities. GSRDs are Treatment Best Management Practices (TBMPs) which use screening technology to capture the gross solids, or trash, such as paper, plastics, glass, and naturally occurring debris that may be conveyed by stormwater runoff. The primary functions of this document are to:

1. Describe a GSRD
2. Provide design guidance
3. Review the required elements for implementing GSRD details into the Drainage Profile(s) and Estimates at (PS&E).
4. Provide a design example

It is assumed that the need for post construction TBMPs has already been determined in accordance with the guidelines and procedures presented in the Project Planning and Design Guide (PPDG; Caltrans 2023b).

The following guidance is provided based on Caltrans pilot studies and professional design experience. Designers may utilize alternatives to the calculation methodologies presented in this guidance. Sections 9 through 13 include an overview and examples of non-standard GSRD designs. Alternative calculations and design decisions are documented in the project Stormwater Data Report (SWDR) and the Project Files. The SWDR template can be found in the PPDG.

1.1 Design Responsibility

The Project Engineer (PE) is responsible for the design of GSRD hydrology, hydraulics, grading, and traffic because they are part of the highway drainage system. The designer must consider the highway grading plans and the impacts the GSRD may have on the roadway, especially in consideration of the clear recovery zone (CRZ). Coordinate with other functional experts to implement successful and functioning GSRDs.

Refer to Chapter 800 of the Highway Design Manual, the Headquarters (HQ) Office of Hydraulics and Stormwater Design (OHSD), and District Hydraulics Engineer for project drainage requirements.

1.2 Gross Solid Removal Devices

There are two approved GSRD types, the Linear Radial (LR) and the Inclined Screen (IS). The configurations and sizing calculations in this guidance are for standard, inline designs specifically designed for 100 percent removal of gross solids 3/16 inch (in) [5 millimeter (mm)] or greater from stormwater runoff with the capacity to retain one year's worth of solids loading to facilitate annual cleaning. However, it is preferred that GSRDs be placed offline with an upstream flow splitter to minimize the size of the TBMP. See Section 2.4 for additional details. Additionally, if the design includes cleaning more frequently than one year, or if the GSRDs

standard configurations are modified, the design and sizing calculations must be modified as a Special Design. See Sections 9 through 13 for an overview and examples of projects that used alternative configurations and sizing.

1.2.1 The Linear Radial GSRD

The Linear Radial GSRD described in this guide is designed for flows up to 21.9 cubic feet per second (cfs), gross solids accumulation volume of up to 358 gallons, and grades with slopes (inlet to outlet) up to 4:1 (H:V). It utilizes 3/16 in x 2.5 in nominal louver slots to remove gross solids, litter, and debris from stormwater runoff. The slots are machined into a 2 foot (ft) or other diameter, stainless steel pipe usually housed in a concrete vault. The Linear Radial GSRD is designed such that the influent flows through the linearly aligned screens. Both the inlet and outlet pipes are aligned with the axis of the radial screen to provide debris capture while allowing the stormwater to exit via the slots. Other highlights of the Linear Radial GSRD include:

- Long and narrow shape, well suited for narrow rights-of-way
- Applicable to sites with as little as 4.4 in of elevation drop to sites with as much as 50 in of elevation drop
- Overflow mechanism at the upstream end
- Unslotted initial pipe section (usually a product of length)
- Smooth, solid bottom intermediate sections (following the initial section) to move settled litter toward the downstream end of the screen
- Multiple wall heights to accommodate varying pipe depths and pipe slopes
- Six lengths to accommodate varying flow rates and gross solids accumulation volume
- Sloped floor for self-draining without permanent pool of water
- Solids storage area to accommodate a once per year maintenance cycle
- Grated cover for safety

The Standard Plans include two Linear Radial GSRD configurations: one model for influent runoff velocities less than or equal to 8.2 feet per second (ft/s) (referred to as “Linear Radial” in the drawings), and one for high velocity (HV) influent runoff with velocities greater than 8.2 ft/s (referred to as “Linear Radial (HV)” in the drawings). Rendered images of the Linear Radial (HV) are presented in Figure 1-1.

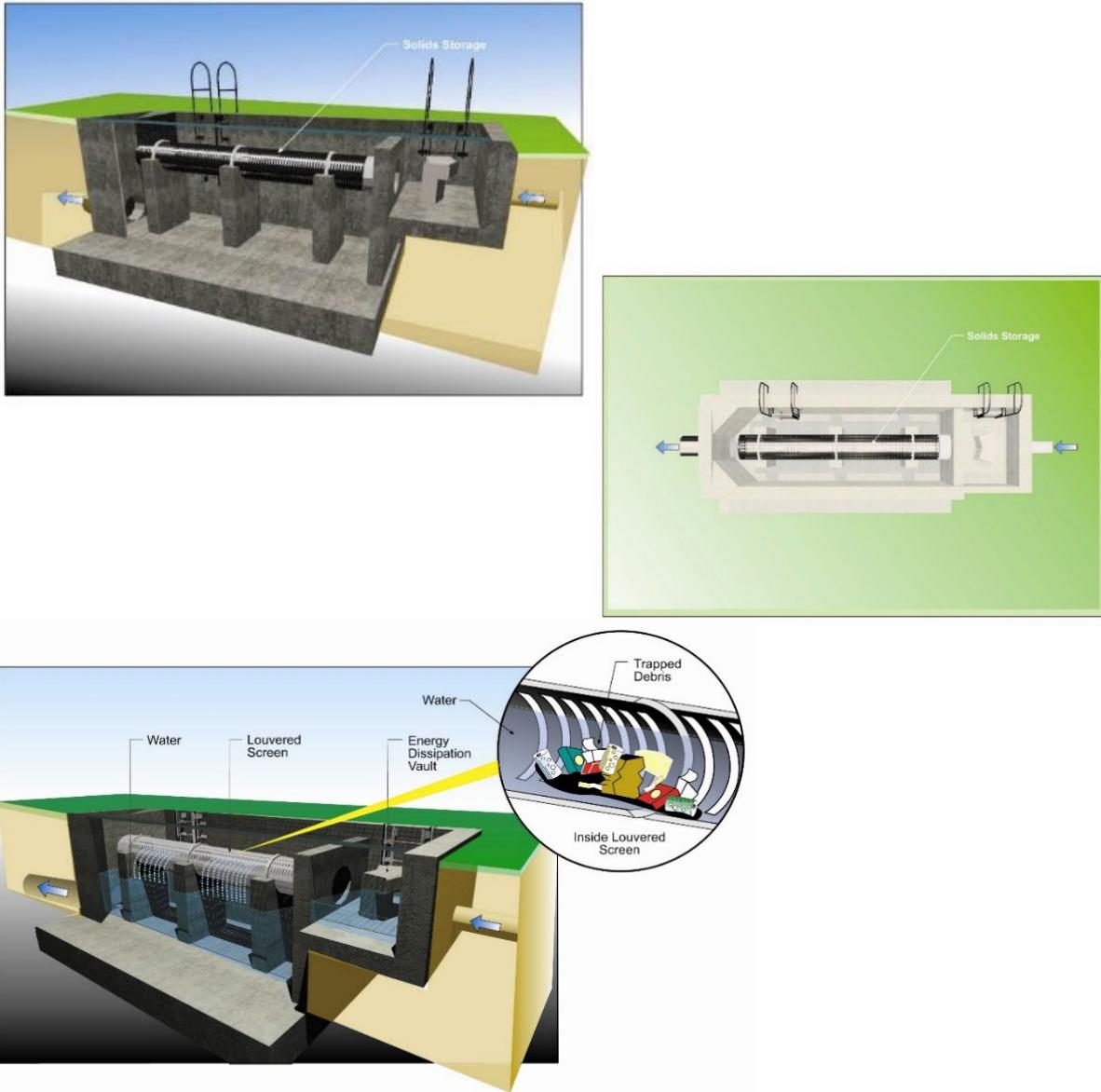


Figure 1-1. Linear Radial (HV) GSRD

1.2.2 The Inclined Screen GSRD

The second type of approved GSRD is the Inclined Screen GSRD, which is designed for flows up to 20.4 cfs, gross solids accumulation volume of up to 428 gallons, and grades with slopes up to 1.5:1. It uses a wedge-wire screen to remove litter, debris, and gross solids. With this GSRD, the stormwater runoff enters at the top of the device and flows down the screen. The runoff passes through the screen, while the litter, debris, and gross solids are pushed down the screen and retained in a confined storage area at the bottom of the device. This device uses flow deflectors and a jet creating device at the dissipation slab to decrease maintenance. The jet-creating device, shown in Figure 1-2, relies on the Coanda-effect, which harnesses hydraulic power to induce self-cleansing thereby increasing the efficiency of the screen throughout the desired range of flow and solids loading. A curved section aids in flow separation between the dissipation slab and top of screen.

Other highlights of the Inclined Screen GSRD include:

- Nearly square shaped structure that mimics or can function similar to a drainage junction box
- Multiple screen lengths to accommodate varying flow rates and gross solids accumulation volumes
- Multiple wall heights to accommodate varying pipe depths and embankment slopes
- Sloped floor for self-draining without permanent pool of water
- Solids storage area to accommodate a once per year maintenance cycle
- Grated cover or cable railing for safety

The Inclined Screen comes in a sloped sidewall version and is primarily applicable to sloped embankment conditions. Rendered images of the Inclined Screen GSRD are presented in Figure 1-2.

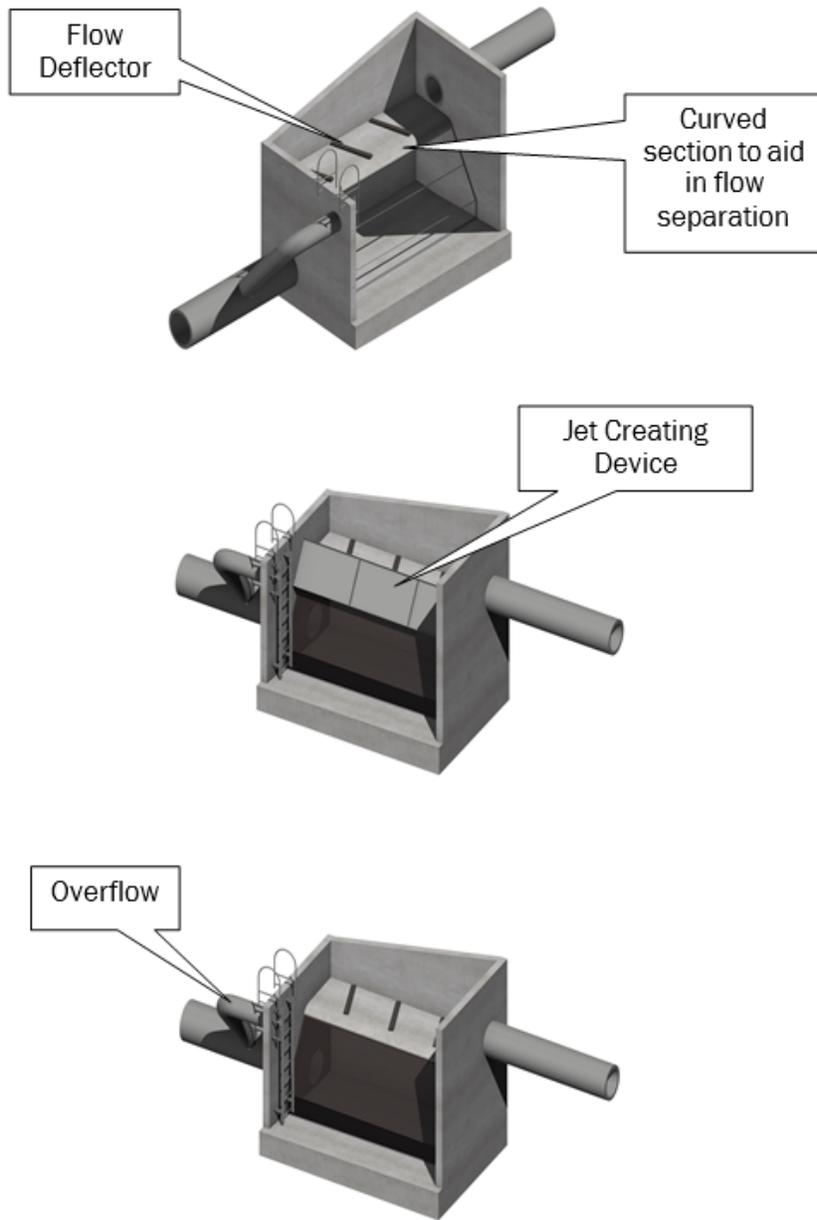


Figure 1-2. Inclined Screen GSRD

Section 2

Basis of GSRD Standard Plans

The Caltrans Permit includes requirements for treating stormwater for trash on highways. Caltrans has identified statewide Significant Trash Generating Areas (STGAs) in the Trash Monitoring Plan that require consideration of full trash capture TBMPs (Caltrans 2024). GSRDs are a full trash capture TBMP and should be considered in the design for projects that have 10,000 sf of NIS (5,000 sf for non-highway) and are within a watershed where any of the following exists:

1. A Total Maximum Daily Load (TMDL) restriction for trash
2. Discharges to a 303(d) listed waterway for trash
3. Has been identified as an STGA
4. Required by a Regional Basin Plan

The GSRD screens are designed to remove all litter and solids that are 3/16 in (5 mm) nominal¹ and larger. The site must have sufficient hydraulic head for the TBMP to operate by gravity.

The primary factors incorporated into the basis of design are as follows:

1. The GSRD must be able to capture gross solids nominally 3/16 in (5 mm) and larger in size from stormwater runoff.
2. The GSRD must be able to:
 - a. Treat the 1-year, 1-hour (1-yr, 1-hr) flow², and
 - b. Treat or bypass the design flow³, typically using the Q_{25} design storm, as specified in the Highway Design Manual (HDM) under Chapter 830 when installed inline.

Note that the flow rate herein refers to the design flow used to size the GSRD. The flow rate will be either the 1-yr, 1-hr flow (bypass used) or the 25-yr flow (no bypass used).

Litter and trash loading data need to be determined to properly size the devices for the given drainage area. Designers should consult with District Maintenance regarding litter and debris loads. Caltrans has prepared a statewide STGA inventory to document STGAs in a GIS-based web map. STGA mapping is available at:

<https://experience.arcgis.com/experience/543e95ec5eed4339a4733a890de4697c/>

¹ The 3/16-in (5 mm) dimension is based on statewide trash requirements set forth in the Caltrans Statewide NPDES Permit (Caltrans Permit).

² The Caltrans Permit specifies that trash devices must be designed to treat the peak flow rate resulting from a 1-yr, 1-hr storm.

³ An explanation of Design Storm peak flow determination and an example calculation can be found in Section 3 of the DPPIA Design Guidance (Caltrans 2021).

2.1 Trash Loading Rates

In addition to full trash capture devices, Caltrans plans to achieve compliance with the requirements in the Caltrans Permit to control trash from the Caltrans right-of-way (RW) through implementation of institutional trash control actions. Vegetation and enhanced maintenance measures have been shown in recent Caltrans studies to reduce the volume of trash reaching full trash capture devices. Institutional controls can include:

- Sweeping freeways
- Collecting trash from freeways and moderate-rated vegetation areas
- Connecting people experiencing homelessness with locally administered social services and discouraging encampments

Scientific-based trash discharge studies to substantiate full or partial trash reduction compliance are on-going. Initial findings from studies indicate that trash loading rates are lower than anticipated in prior design guidance. The trash generation studies are described in more detail below.

The California Stormwater Quality Association (CASQA) has provided guidance on trash loading rates in the Trash Control Measure Implementation Guidance (CASQA 2021) based on studies published in 2014. Caltrans then adopted a trash loading rate of 75 gallons per acre (10 CF per acre). Caltrans subsequently conducted pilot studies on trash nets and vegetated area trash capture, and found that trash loading rates in full trash capture devices on highways were much lower than expected. Differences in trash loading may be due to differences in land use (residential and commercial land uses versus highway), and are likely influenced by the presence of vegetated areas around inlets on highways. In addition, Caltrans studies were mostly conducted after plastic bag ban ordinances were implemented whereas previous studies preceded the policy change. Caltrans pilot studies indicate the rate of trash loading with institutional controls (vegetation and maintenance activities) can range from 0.0-4.78 gal/ac/yr. It is therefore important to get input from maintenance staff and do a field review of each location to determine what loading rate will be appropriate at each GSRD location. The prior Caltrans prescribed trash loading rate of 75 gallons per acre is no longer supported. Refer to Trash Net Design Guidance Section 3 (Caltrans 2020a), the Trash Assessment Implementation Plan (Caltrans 2023), and the Caltrans Statewide Trash Control Compliance Plan (Caltrans 2024) to estimate actual loading rate based on debris area characteristics. Table 2-1 below presents the range of recommended Trash Loading Rates to use only when no site-specific information is available or a field review is not possible.

Table 2-1. Trash Loading Rates

STGA Rating¹	CASQA Trash Loading Rate² (gal/ac/yr)	Caltrans Trash Loading Rate with Institutional Controls (gal/ac/yr)³	Min. Design Trash Loading Rate (gal/ac/yr)
Moderate	7.5	-	-
High	30	7.5	5
Very High	90	7.5 - 30	5

1. Significant Trash Generating Areas (STGAs) with a rating of low are considered to be in compliance with the Caltrans Permit without further treatment.
2. Source: Trash Control Measure Implementation Guidance (CASQA 2021)
3. Institutional Controls include vegetation and maintenance actions. Source: Caltrans Statewide Trash Control Compliance Action Plan Draft Final (Caltrans 2024)

Checklist T-1, Part 7 in the PPDG, assists in evaluating the initial feasibility of a GSRD for a project. The checklist identifies design elements that should be considered. Once the feasibility of the device has been confirmed using Checklist T-1, Part 7, use the following subsections to further understand the feasibility of a GSRD for a given site.

2.2 Design Criteria

GSRDs must meet certain design criteria to perform as an effective TBMP. The GSRD Standard Plans have been developed for specifying their use in projects. Table 2-2 and Table 2-3 present the design criteria to be used in sizing GSRDs.

Table 2-2. Linear Radial GSRD Design Criteria

Parameter	Units	Min. Value LR / LR (HV) ¹	Max. Value LR / LR (HV) ¹
Trash Loading Rate	gal/acre/yr	5	-
Flow Rate	cfs	-	21.9
Gross Solids Storage Volume	gal	65 / 65	358 / 358
Inlet & Outlet Wall Opening ²	in	16/16 (inlet) 16/16(outlet)	51\51 (inlet) 51\51 (outlet)
Elevation Drop across device	in	4.4 / 7.0	47.4 / 47.7
Inlet Runoff Velocity	ft/s	-	8.2 / 20

1. Minimum corresponds to LR with one pipe screen section, and maximum corresponds to six pipe screen sections
2. See Section 3.1, parameter 8. In order for the GSRD Standard Plans to not restrict the type of inlet/outlet pipe, maximum wall openings are specified instead of inside pipe diameters. The PE would then be responsible for making sure the pipe would fit within that opening. For minimum pipe diameter for storm drains, see HDM Table 838.4 (Caltrans 2023c).

Table 2-3. Inclined Screen GSRD Design Criteria

Parameter	Units	Min. Value ¹	Max. Value ¹
Trash Loading Rate	gal/ac/yr	5	-
Flow Rate	cfs	-	20.4
Annual Trash Volume	gal	121	428
Inlet/Outlet Wall Opening ²	in	16	30
Elevation drop across device	in	66	66
Inlet Runoff Velocity	ft/s	-	20

1. Minimum corresponds to Inclined Screen with one screen length, and maximum corresponds to six screen lengths.
2. For minimum pipe diameter for storm drains, see HDM Table 838.4 (Caltrans 2023c)

The Standard Plans don't include specific flow line elevations and other dimensions unique to the project; these must be included in the Drainage Profile sheet for each location. The Standard Plans are intended for standard configuration designs under normal conditions and typical external loading requirements, which are outlined in the "General Notes", "Design Notes", and "Detail of Design Loading Cases" sections on the Legend of the drawings.

2.3 Special Designs

A Special Design will be required for sites or conditions that do not meet the standard design criteria listed in Table 2-2 and Table 2-3, such as:

- High ground water table (above the bottom of the concrete footing of the GSRD)
- Surcharge loads that exceed the Division of Engineering Services (DES) Underground Structures design criteria, which uses the Load and Resistance Factor Design (LRFD)
- Inadequate bearing capacity
- Inlet velocities which exceed 20 ft/s at the inlet
- Excessive settlement due to liquefaction
- Linear Radial configurations with more than 6 screen lengths
- More frequent cleanings, calculations assume one annual cleaning. Additional cleanings allow standard sized GSRDs to treat a larger debris area.
- GSRDs used in parallel or in series

If a special design is used, the design criteria and drawings must be developed for the specific site. See Section 9 for more information on Special Designs and Sections 10 through 13 for examples of Special Design projects.

2.4 Inline vs. Offline Placement

A GSRD can be placed in an inline or offline configuration. While offline placement is preferred, inline is more common therefore all calculations in this guidance assume an inline configuration.

A. Inline Placement

A GSRD is placed in an inline configuration when runoff greater than the peak flows generated by the 1-yr, 1-hr storm must flow through the device. Designing a TBMP in an inline configuration is not the preferred method but may be acceptable due to space restrictions.

For inline placement, the TBMP must be sized to pass the runoff greater than the peak flows generated by the 1-yr, 1-hr event through the TBMP to downstream conveyance without objectionable backwater effects to upstream facilities and without causing erosion.

B. Offline Placement

A GSRD is placed in an offline configuration when runoff greater than the peak flows generated by the 1-yr, 1-hr event is diverted around the TBMP by means of an upstream flow diversion. Flow diversion structures typically consist of flow splitters, weirs, orifices, or pipes to bypass excess runoff. Even in an offline placement, overflow bypass must be considered.

2.5 Safety Considerations

GSRDs should be located using the general roadway drainage considerations for safety and CRZ concept in the AASHTO manual (AASHTO 2011). Traffic safety is an important part of highway drainage facility design. The GSRD should provide a traversable section for errant traffic leaving the traveled way within the CRZ (HDM Topics 304, 309, and 861.4), as applicable. Coordinate with other functional experts such as District Traffic Operations, District Maintenance, District Hydraulics, Geotechnical Design, Structure Design, and Traffic Safety, as applicable.

Consult with District Traffic Operations for all proposed placements to determine if guard railing is required. GSRDs should have detailing that preclude ready access by the public.

2.6 Restrictions/Coordination

Successful implementation and utilization of the Standard Plans require coordination with District Hydraulics, District Maintenance, District Traffic Operations, District Landscape Architecture, Geotechnical Design, and Traffic Safety, as applicable per site design and proper siting of the devices. Therefore, it is important to take note of siting requirements and restrictions when designing the GSRD, particularly for retrofit applications. The drawings should not be used or modified for any conditions outside the range of values presented in Table 2-2 and Table 2-3 (for exceptions see Section 9). Design decisions and coordination must be documented in the SWDR and project file.

Additional restrictions applicable to the use of the Standard Plans are documented on the “Gross Solids Removal Device, General Notes” Sheet, and are as follows:

- The Standard Plans are not applicable for use in corrosive environments, abrasive flow conditions, or areas where there are substantial freeze-thaw conditions
- The Standard Plans are not applicable if the inlet pipe is not oriented between 70 and 90 degrees (horizontal) from the inlet wall
- The Standard Plans are not applicable if the velocity of the runoff entering the GSRD exceeds 20 ft/s
- The Standard Plans are not applicable for use within the traveled way or where the GSRD will be subject to traffic loads (LRFD; AASHTO 2023)
- The Standard Plans are not applicable in conditions where the seasonally high groundwater level is above the bottom of the GSRD footing
- The Standard Plans are not applicable if the backfill or finished grade differential exceeds 4 ft between sidewalls or the lesser of the wall height “H” or 4 ft between inlet and outlet walls

If the site conditions do not meet all the above requirements, a special design will be required. See Section 9 for more information on Special Designs.

Section 3

Getting Started

In preparation for selecting, sizing, and laying out the appropriate GSRD, existing site conditions are evaluated to obtain and assess the necessary design parameters that will be used to determine which of the GSRDs included in the standard drawings is suitable. This section presents the design parameters incorporated into the GSRD drawings and a list of calculations that need to be performed to support the GSRD selection process.

It is assumed that the need for a GSRD has already been determined in accordance with the guidelines and procedures presented in Section 2 and in the PPDG. It is further assumed that the specific site for the TBMP has been selected. As a result, no TBMP selection or site selection guidelines are provided herein.

This guidance and the Standard Plans assume that the GSRD is configured inline. Additionally, alternative sizing calculations may be used to refine the TBMP size. When an offline configuration or alternative sizing calculations are used a Special Design may be necessary, see Section 9.

3.1 Preliminary Design Parameters

The following design parameters are needed to utilize the GSRD Standard Plans.

1. **Design Storm Flow Rate:** As specified in HDM Chapter 830, the quantity of runoff resulting from the selected design storm (which is typically a 25-year design storm), must be determined for inline systems. Table 3-1 presents the maximum flow rates that each GSRD type is designed to convey (larger flows may be bypassed upstream of the device).

Table 3-1. GSRD Design Flows

GSRD	Type	Max. Flow Rate(cfs)
Linear Radial	LR-1	3.5
Linear Radial	LR-2	7.1
Linear Radial	LR-3	11.0
Linear Radial	LR-4	14.5
Linear Radial	LR-5	18.4
Linear Radial	LR-6	21.9
Linear Radial (HV)	LR(HV)-1	3.5
Linear Radial (HV)	LR(HV)-2	7.1
Linear Radial (HV)	LR(HV)-3	11.0
Linear Radial (HV)	LR(HV)-4	14.5
Linear Radial (HV)	LR(HV)-5	18.4
Linear Radial (HV)	LR(HV)-6	21.9
Inclined Screen	A	5.8
Inclined Screen	B	8.7
Inclined Screen	C	11.7
Inclined Screen	D	14.6
Inclined Screen	E	17.5
Inclined Screen	F	20.4

- Annual Trash Volume:** The GSRD annual trash volume is sized based on the device's debris area, or untreated tributary drainage area, and the trash loading rate. The required annual trash volume is equal to the debris area times the trash loading rate. In many cases, the debris area is equivalent to the tributary drainage area, but it differs when multiple drainage areas drain to a single discharge point, and one or more of the individual drainage areas are treated with a GSRD. An example demonstrating the difference between drainage area and debris area is presented in Figure 3-1.

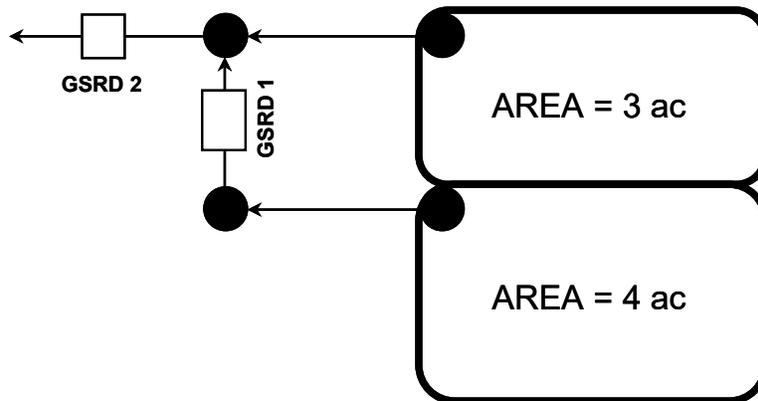


Figure 3-1. GSRD Debris Area vs. Drainage Area

In the above figure, GSRD 2 has a total tributary drainage area of 7 ac. However, four of those acres are being treated by GSRD 1. As a result, the debris area (i.e., the untreated area generating gross solids) for GSRD 2 is the untreated portion of the drainage area, or 3 ac. If GSRD 1 did not exist, then the debris area for GSRD 2 would be equivalent to its tributary drainage area of 7 ac. Therefore, the design hydraulic drainage area may be larger or smaller than the debris area depending on site specific drainage area runoff characteristics.

Table 3-2 presents the annual trash volume (in gallons) that each GSRD type is designed to accommodate. It is important to note that design flow rates may control the selection of the GSRD along with annual trash volume. Refer to Section 2.1 to estimate actual trash loading rate based on debris area characteristics. Table 2.1 provides trash loading rates for sites where no site-specific information is available.

To calculate the required annual trash volume, use the following equation:

$$V = D \times R$$

Where:

V = Required annual trash volume needed (gal)

D = Debris area (ac)

R = trash loading rate (gal/ac/yr)

Table 3-2. GSRD Annual Trash Volume

GSRD	Type	Max. Annual Trash Volume (gal)¹	Max. Annual Trash Volume (CF)¹
Linear Radial	LR-1	65	8.7
Linear Radial	LR-2	123	16.4
Linear Radial	LR-3	182	24.3
Linear Radial	LR-4	241	32.2
Linear Radial	LR-5	300	40.1
Linear Radial	LR-6	358	47.9
Linear Radial (HV)	LR(HV)-1	65	8.7
Linear Radial (HV)	LR(HV)-2	123	16.4
Linear Radial (HV)	LR(HV)-3	182	24.3
Linear Radial (HV)	LR(HV)-4	241	32.2
Linear Radial (HV)	LR(HV)-5	300	40.1
Linear Radial (HV)	LR(HV)-6	358	47.9
Inclined Screen	A	121	16.1
Inclined Screen	B	182	24.3
Inclined Screen	C	246	32.9
Inclined Screen	D	303	40.5
Inclined Screen	E	364	48.7
Inclined Screen	F	428	57.2

1. Maximum annual trash volume assumes 50% capacity for LR and LR(HV) and 25% capacity for Inclined Screens.

3. **GSRD Dimensions:** The footprint requirements of each GSRD were developed based on the design flow rates and annual trash volume. The total length and width of the GSRD, including footings (referred to as the “out-to-out concrete dimensions” in the drawings), are presented in Table 3-3.

Table 3-3. GSRD Out-to-Out Dimensions¹

GSRD	Type	Width (ft)	Length (ft)²
Linear Radial	LR-1	11.5	14.4
Linear Radial	LR-2	11.5	19.4
Linear Radial	LR-3	11.5	24.4
Linear Radial	LR-4	11.5	29.4
Linear Radial	LR-5	11.5	34.4
Linear Radial	LR-6	11.5	39.4
Linear Radial (HV)	LR(HV)-1	11.5	16.8
Linear Radial (HV)	LR(HV)-2	11.5	21.8
Linear Radial (HV)	LR(HV)-3	11.5	26.8
Linear Radial (HV)	LR(HV)-4	11.5	31.8
Linear Radial (HV)	LR(HV)-5	11.5	36.8
Linear Radial (HV)	LR(HV)-6	11.5	41.8
Inclined Screen	A	10.3	4.3
Inclined Screen	B	10.3	6.0
Inclined Screen	C	10.3	7.6
Inclined Screen	D	10.3	9.3
Inclined Screen	E	10.3	11.0
Inclined Screen	F	10.3	12.7

1. *Linear Radial out-to-out dimension includes footing.*
2. *Length dimension is in the direction between inlet and outlet walls of devices.*

4. **Linear Radial GSRD – Number of Grates and Overlap at Outlet Wall:** The number of grates can be determined by taking the inside length between inlet wall and outlet wall shown on the plans, divided by the sum of the width of each grate (2.4 ft), and rounded to the nearest whole number. See “Linear Radial Grate Panel Details” sheet for table with number of grates required for each type of Linear Radial GSRD.

The grate overlap at the outlet wall is measured from the inside of the wall outward to the end of the grate and is 0.7 ft for all Linear Radial and Linear Radial (HV) GSRDs. This overlap was predetermined by adding the width of each grate (2.4 ft) plus the average gap between each grate (0.1 ft) multiplied by the number of grates required. The overlap length is shown on “Linear Radial Grate Panel Details” sheet. Refer to Grate Layout detail and Note 1.

5. **Inlet Velocity:** The velocity of the runoff entering the GSRD must be known to determine if velocity dissipation is required upstream of any of the GSRDs. For the Linear Radial GSRD, when the maximum inlet velocity exceeds 8.2 ft/s, the Linear Radial (HV) GSRD is required. The Linear Radial (HV) has the same design flow rates and debris areas as the Linear Radial (as presented in Table 3-1 and Table 3-2). When the inlet velocity exceeds 20 ft/s for any of the GSRDs, velocity dissipation is required.
6. **Depth to Inlet Pipe:** The depth from finished grade to the flow line of the GSRD inlet pipe is utilized to select the appropriate wall height of the GSRD structure. The GSRD Standard Plans include configurations for varying wall heights to facilitate utilization in a wide variety of conditions.

Each of the six Linear Radial configurations (LR-1 through LR-6), and each of the six Linear Radial (HV) configurations [LR(HV)-1 through LR(HV)-6], come in three wall height configurations:

- 4 ft
- 6 ft
- 8 ft

The Inclined Screen GSRDs are primarily intended to be used for sloped embankment installations where the top of wall elevation is lower at the outlet end.

7. **Elevation Drop:** The Standard Plans have elevation drop requirements (i.e., the difference between the flow lines of the inlet pipe and outlet pipe at the inside face of the GSRD wall) across the device, and the project site must have the available elevation drop to meet these requirements. The required flow line elevations and other details should be shown on the Drainage Profile sheet for each system.

For the Linear Radial GSRD and Linear Radial (HV) GSRD, the elevation drop across the device is a function of the structure wall height and the number of intermediate louvered pipe screen sections (each intermediate section is 5 ft long). Each wall height/screen sections combination has a range of allowable elevation drops because the drawings provide some flexibility in where the inlet pipe connects to the GSRD. For example, the higher wall height configurations allow more flexibility in placement of the inlet pipe. It is important to note that the elevation drop must occur over a specific horizontal distance (i.e., the length between the inlet and outlet pipe, or the inside length of the structure). This provides the minimum and maximum slope that an existing pipe must exhibit in order to be retrofitted with a Linear Radial GSRD. A summary of this information is presented in Table 3-4 and Table 3-5 and applies to the Linear Radial GSRD and Linear Radial (HV), respectively.

Dynamic head losses (such as entrance and exit losses from the GSRD vaults) should also be considered. These losses should be checked to verify that the upstream hydraulic grade line is not adversely affected by the placement of a GSRD within the drainage profile. Drainage profiles having a fairly flat slope close to the elevation of the upstream drop inlet are more problematic than a GSRD placed at toe of a slope below a roadway and drainage system on an embankment. Refer to the UC Davis report "Laboratory Testing of Gross Solids Removal Devices" for additional guidance on dynamic head losses (Caltrans 2005).

Table 3-4. Linear Radial GSRD Elevation Drop

LR ¹	Wall Ht.(ft)	Inside Vault Length (ft) ²	Inlet Pipe Cover Elevation Drop (ft) Min / Max ³	Drop between Inlet and Outlet Inverts (ft) Min / Max	Max. Elevation Drop (ft) ⁴
1	4	11.9	1.00 / 1.00	0.25 / 0.37	0.25
1	6	11.9	1.00 / 3.00	0.25 / 2.37	2.00
1	8	11.9	2.00 / 5.00	0.25 / 3.70	3.33
2	4	16.9	1.00 / 1.00	0.25 / 0.42	0.25
2	6	16.9	1.00 / 3.00	0.25 / 2.42	2.00
2	8	16.9	2.00 / 5.00	0.25 / 3.75	3.33
3	4	21.9	1.00 / 1.00	0.25 / 0.47	0.25
3	6	21.9	1.00 / 3.00	0.25 / 2.47	2.00
3	8	21.9	2.00 / 5.00	0.25 / 3.80	3.33
4	4	26.9	1.00 / 1.00	0.25 / 0.52	0.25
4	6	26.9	1.00 / 3.00	0.25 / 2.52	2.00
4	8	26.9	2.00 / 5.00	0.25 / 3.85	3.33
5	4	31.9	1.00 / 1.00	0.25 / 0.57	0.25
5	6	31.9	1.00 / 3.00	0.25 / 2.57	2.00
5	8	31.9	2.00 / 5.00	0.25 / 3.90	3.33
6	4	36.9	1.00 / 1.00	0.25 / 0.62	0.25
6	6	36.9	1.00 / 3.00	0.25 / 2.62	2.00
6	8	36.9	2.00 / 5.00	0.25 / 3.95	3.33

1. Number of screen sections
2. The inside vault length is the distance between the inside of the inlet and outlet walls of the structure. The concrete floor of the vault is sloped at 1 percent.
3. Pipe cover is the depth between finished grade and top of pipe. Use 1) 24 in diameter pipe for inlet pipe except when pipe cover is shown as 1 ft. then use 18" and 2) 6" between top of wall and finished grade. Assumed 3" pipe thickness. Refer to plans for Longitudinal Section - Minimum and Maximum Screen Height details. See "Linear Radial - Layout" sheet.
4. Flow line of screen to concrete floor

Table 3-5. Linear Radial (HV) GSRD Elevation Drop

LR (HV) ¹	Wall Ht.(ft)	Inside Vault Length (ft) ²	Inlet Pipe Cover Elevation Drop (ft) Min / Max ³	Drop between Inlet and Outlet Inverts (ft) Min / Max	Max. Elevation Drop (ft) ⁴
1	4	14.3125	1.00 / 1.00	0.48 / 0.58	0.25
1	6	14.3125	1.00 / 3.00	0.48 / 2.58	2.00
1	8	14.3125	2.00 / 5.00	0.48 / 3.91	3.33
2	4	19.3125	1.00 / 1.00	0.48 / 0.63	0.25
2	6	19.3125	1.00 / 3.00	0.48 / 2.63	2.00
2	8	19.3125	2.00 / 5.00	0.48 / 3.96	3.33
3	4	24.3125	1.00 / 1.00	0.48 / 0.68	0.25
3	6	24.3125	1.00 / 3.00	0.48 / 2.68	2.00
3	8	24.3125	2.00 / 5.00	0.48 / 4.01	3.33
4	4	29.3125	1.00 / 1.00	0.48 / 0.73	0.25
4	6	29.3125	1.00 / 3.00	0.48 / 2.73	2.00
4	8	29.3125	2.00 / 5.00	0.48 / 4.06	3.33
5	4	34.3125	1.00 / 1.00	0.48 / 0.78	0.25
5	6	34.3125	1.00 / 3.00	0.48 / 2.78	2.00
5	8	34.3125	2.00 / 5.00	0.48 / 4.11	3.33
6	4	39.3125	1.00 / 1.00	0.48 / 0.83	0.25
6	6	39.3125	1.00 / 3.00	0.48 / 2.83	2.00
6	8	39.3125	2.00 / 5.00	0.48 / 4.16	3.33

1. Number of screen sections
2. The inside vault length is the sum of L1 and L2; L1 is length of the concrete floor sloped at 1 percent and L2 is length of the concrete floor sloped at 5 percent. The total length is the distance between the inside of the inlet and outlet walls of the structure.
3. Pipe cover is the depth between finished grade and top of pipe. Use 1) 24 in diameter pipe for inlet pipe except when pipe cover is shown as 1 ft. then use 18" and 2) 6" between top of wall and finished grade. Assumed 1" for pipe thickness. Refer to plans for Longitudinal Section - Minimum and Maximum Screen Height details. See "Linear Radial - (HV) - Layout" sheet.
4. Flow line of screen to concrete floor

8. **Size and Material of Inlet/Outlet Pipes:** The largest (inside) diameter pipe that could be connected to a standard GSRD is a function of the wall opening size and the pipe wall thickness. The maximum wall opening size is limited to avoid interfering with the reinforcement of the GSRD walls as designed in the Standard Plans. For example, a 24 in Corrugated Steel Pipe (CSP) might require a 27 in wall opening, while a 24 in Reinforced Concrete Pipe (RCP) might require a 30 in wall opening. The Standard Plans provide maximum wall openings instead of inside pipe diameters in order to allow for more options in material and size of the inlet/outlet pipes. The PE is responsible for making sure the pipe fits within that opening.

Since the Linear Radial GSRD inlet pipe connects directly to a 24 inch louvered screen pipe, only 24 inch inside diameter inlet pipes and smaller should be considered at the inlet side of the device for the Linear Radial GSRD. Designers should also consider the maximum flow rate of the device of 21.9 cfs when considering the inlet pipe size. Designers should confirm that the pipe size and the resulting wall openings, wall heights, and slope of the slab is within the allowable footprint confinements of the Standard Plans.

The Linear Radial (HV) GSRD comes in three wall height configurations: 4, 6, and 8 ft. The Linear radial (HV) supports variable screen heights. Whereas the Linear Radial inlet pipe connects directly to the 24 in louvered pipe screen, the Linear Radial (HV) inlet pipe connects to an open energy dissipation chamber, so it may exceed the size of the louvered pipe screen. Minimum and maximum inlet and outlet wall openings relative to wall height are shown in Table 3-6.

Table 3-6. Linear Radial & Linear Radial (HV) GSRD Maximum Wall Openings

GSRD Configuration	Wall Height (ft)	Max. Inlet Wall Opening (in)	Max. Outlet Wall Opening (in)
LR-1 through -6 & LR(HV)-1 through -6	4	27	27
LR-1 through -6 & LR(HV)-1 through -6	6	51	51
LR-1 through -6 & LR(HV)-1 through -6	8	51	51

The Inclined Screen GSRD comes in six types (A, B, C, D, E and F). The maximum inlet and outlet wall opening for all types is 30 in. The size of the wall opening is limited due to the flow limitation of the device, which is 20.4 cfs.

Section 4

TBMP Selection

The process for selecting the most appropriate GSRD for a given site will often be an iterative process where several, if not all, of the design factors presented in Section 3 are evaluated together. The most important aspect of the GSRD selection process is review of the site conditions and the existing drainage plan (if a retrofit). Figure 4-1 presents the typical process flowchart for selecting and sizing the most appropriate GSRD type for a specific project. Selecting which GSRD to use (Linear Radial, Linear Radial (HV), or Inclined Screen) for a particular project is a six step process. Each step is discussed in detail in the following sections.

This guidance and the Standard Plans assume that the GSRD is configured inline. Additionally, alternative sizing calculations may be used to refine the TBMP size. When an offline configuration or alternative sizing calculations are used a Special Design may be necessary, see Section 9.

4.1 Step 1: Review Site Conditions

Review site conditions to ensure that none of the site restrictions discussed in Section 2 are present, and to confirm that there is available, unobstructed area for placement of the GSRD.

4.2 Step 2: Identify Candidate GSRD Types

Calculate the design flow rate and the annual trash volume. Using Table 3-1 and Table 3-2, select the appropriate candidate GSRD Type(s). Should one or both of the calculated values lie between two table entries, select the GSRD type with the entry greater than the calculated value. For example, if the project has a design flow of 8.8 cfs and an annual trash volume of 245 gal, then either the Linear Radial LR-5 or the Inclined Screen Type C could be selected for further consideration. If either of the calculated values is outside the range of all table entries (e.g., if the design flow rate is greater than 21.9 cfs or the annual trash volume is greater than 428 gal), a Special Design may be required.

If a Linear Radial is identified as a potential GSRD, use the runoff inlet velocity to determine if the Linear Radial (HV) is required.

4.3 Step 3: Check Available Space

Using Table 3-3, compare the “out-to-out” concrete dimensions of the candidate GSRD type(s) to the available footprint of the site to make sure it fits, and to verify there is enough room for maintenance. In general, the GSRD should have a clear, unobstructed space within the right-of-way, but outside the Clear Recovery Zone (CRZ). Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the CRZ. The GSRDs should typically be located along the outside shoulder or in the embankment of the fill or cut section. If feasible, a GSRD can be located within an interchange or within some other highway facilities such as maintenance facilities or rest areas. GSRDs require sufficient space or access for maintenance and inspection including the use of vacuum trucks and other equipment to remove accumulated trash, perform inspections and maintain the GSRD.

If the selected GSRD can be placed within the available site area with maintenance access, then move to Step 4. Potential GSRDs identified in Step 2 that have larger footprint requirements than are available at the site are eliminated from further consideration unless a special design is performed.

4.4 Step 4: Check Grade

If one of the candidate GSRDs is a Linear Radial or Linear Radial (HV), make sure the elevation drop requirements presented in Table 2-2, Table 3-4, and Table 3-5 can be satisfied. If one of the candidate GSRDs is an Inclined Screen, make sure the minimum elevation drop requirements presented in Table 2-3 can be satisfied.

Note that for a retrofit, a concrete collar may have to be inserted in existing pipes to achieve the required elevation drop. Candidate GSRDs that require more elevation drops than what the site can provide are eliminated from future analysis.

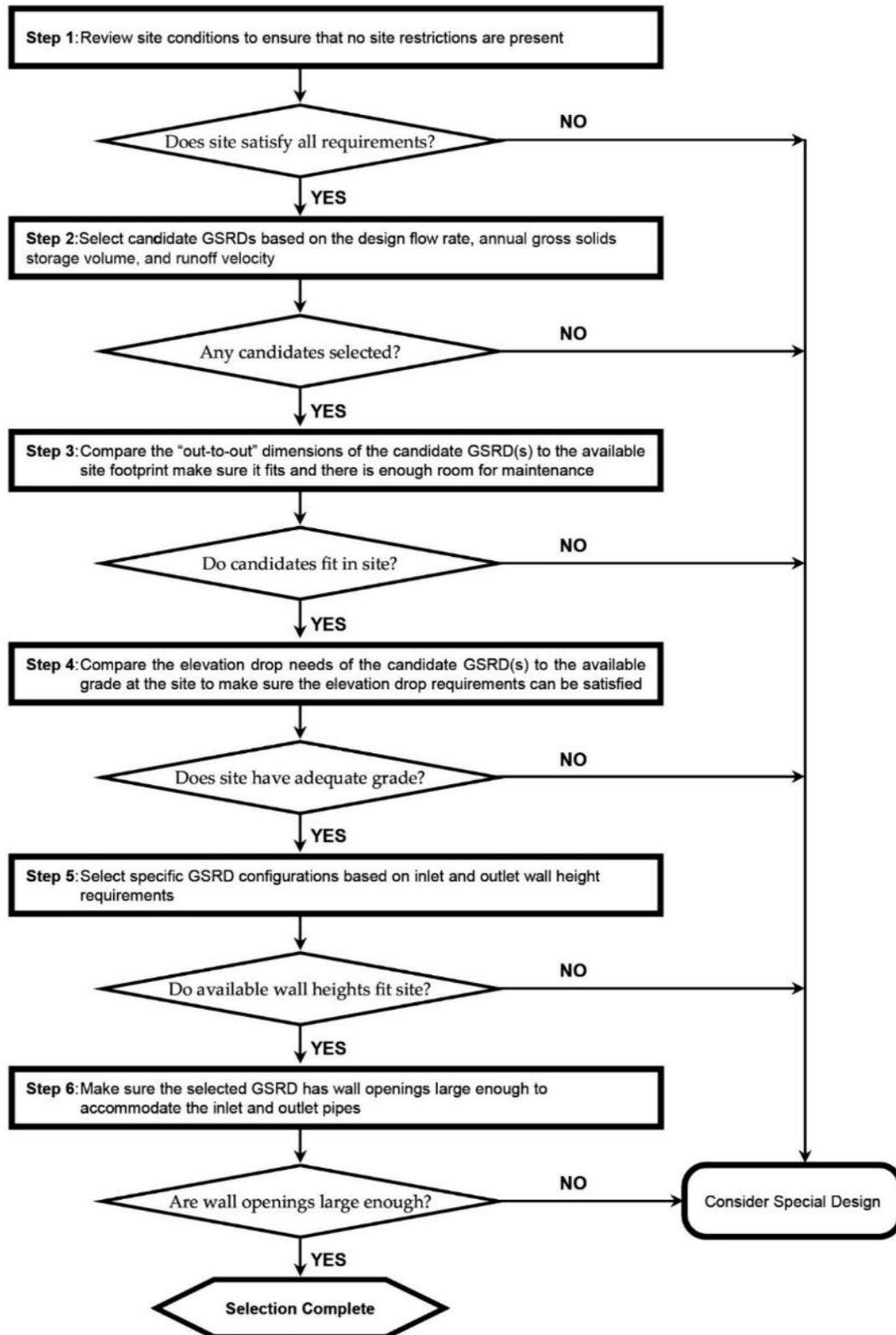


Figure 4-1. Typical GSRD Selection Flowchart

4.5 Step 5: Select GSRD Configuration

Specific GSRD configurations are then selected based on inlet and outlet wall height requirements. The Standard Plans are not applicable if the backfill or finished grade differential exceeds 4 ft between sidewalls or exceeds the lesser of the wall height “H” or 4 ft between inlet and outlet walls. Figure 4-2, Figure 4-3, and Figure 4-4 present structural schematics of each type to support the accompanying text.

4.5.1 Linear Radial and Linear Radial (HV)

The proposed inlet pipe flow line elevation and finished grade elevation are used to determine which available wall height configuration (4, 6, or 8 ft) best fits the inlet end site conditions. For the Linear Radial, the selected wall height must be equal to or greater than the sum of the following two components:

- Depth to the inlet pipe flow line
- 9 in (6 in for the wall segment above finished grade, and 3 in for the gap between the structure floor and the inlet pipe invert).

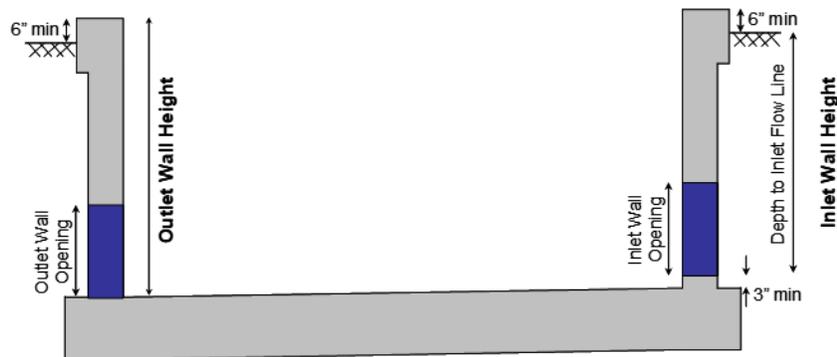


Figure 4-2. Linear Radial GSRD Structure Cross Section

For the Linear Radial (HV), the selected wall height must be equal to or greater than the sum of the following two components:

- Depth to the inlet pipe flow line
- 15 in (6 in for the wall segment above finished grade, 6 in for the floor slope of the energy dissipation chamber, and 3 in for the gap between the inlet pipe invert and the structure floor).

The structure dimensions, site grading, and pipe depths are then used to determine which standard wall height configuration (4, 6, or 8 ft) best fits the outlet end site conditions. The selected outlet wall height must achieve a top-of-wall elevation at least 6 in above finished grade. Since the Linear Radial has a single, constant wall height, the selected outlet wall height is then compared to the inlet wall height, and the larger of the two is used as the Design Wall Height.

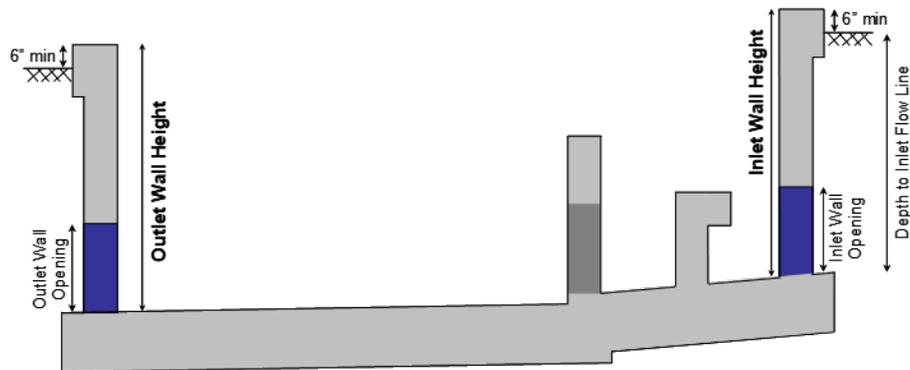


Figure 4-3. Linear Radial (HV) GSRD Structure Cross Section

4.5.2 Inclined Screen

The only unknown depth to be determined is the elevation difference between the top of the inlet pipe and finished grade. This depth is used to determine which available wall height configuration (9 through 13 ft) best fits the inlet end site conditions. The selected inlet wall height must be equal to or greater than the sum of the following components:

- Depth between top of wall and finished grade – 6 in
- Depth between finished grade and top of inlet pipe
- Depth of 24 in pipe plus pipe thickness
- Depth between inlet and outlet flowline elevations (1 in for the gap between inlet pipe invert and the top of the energy dissipation slab plus 65 in between the energy dissipation slab and the outlet pipe invert)
- Subtract the elevation difference between the outlet pipe invert and the point at which the top of base slab intersects with the outlet wall. See Figure 4-4. The elevation difference is the screen length multiplied by bottom slope of the base slab, which is 2 percent

The structure dimensions, site grading, and pipe depths are then used to determine which available outlet wall height configuration best fits the outlet end site conditions. The selected outlet wall height must achieve a top-of-wall elevation at least 6 in above finished grade. The outlet pipe invert to top of the energy dissipation slab is 65 in. The minimum outlet wall height is 2 ft between the top of wall and the top of energy dissipation. These minimum outlet wall requirements are compared to the proposed elevation difference between outlet pipe flowline and finished grade plus 6 in to proposed top of wall. The greater of these dimensions is used for the outlet wall height.

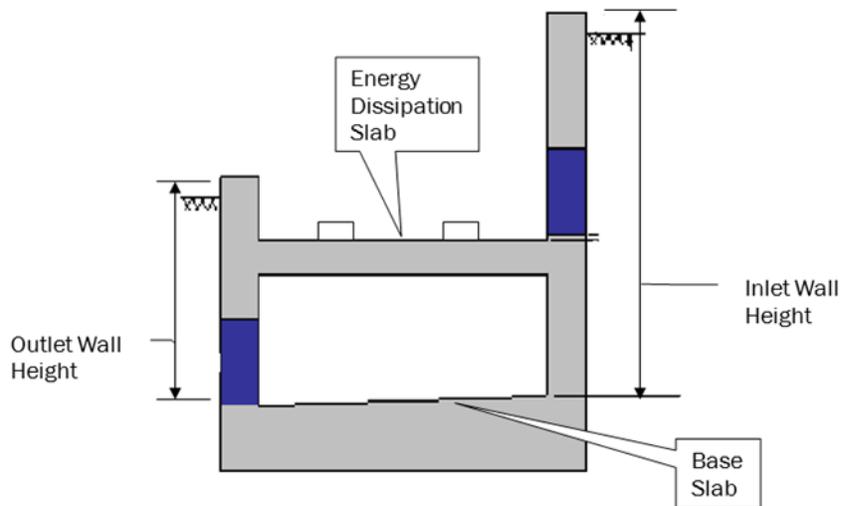


Figure 4-4. Inclined Screen Structure Cross Section

4.6 Step 6: Check Wall Openings

The final step is to make sure the selected GSRD has wall openings to accommodate the inlet and outlet pipes. Refer to Section 3.1, parameter 8 “Size and Material of Inlet/Outlet Pipes”.

Section 5

TBMP Layout

This section discusses various detailing needed to place a GSRD within a project, including detailing of the conveyances carrying runoff into and away from the devices and space and constructability requirements.

5.1 GSRD Layout

Prior to reviewing site restrictions and comparing the possible GSRD footprint to the site location, the Project Engineer (PE) should have a rough idea of how the GSRD will be laid out on the site. Each type of GSRD has specific factors that must be considered when laying out the GSRD.

Linear Radial GSRD: The layout of the Linear Radial GSRD is set by positioning the GSRD inlet wall perpendicular (or at an offset of no more than 10 degrees) to the inlet pipe (i.e., the direction of the in-coming flow), and by adhering to the limitations of the GSRD design. The layout of the Linear Radial GSRD must consider the following:

- The Linear Radial GSRD footprint “out-to-out” concrete dimensions compared to the available site footprint
- Existing inlet/outlet drain pipe configuration and layout compared to the Linear Radial GSRD requirements
- Necessary screen height to match existing conditions

Inclined Screen GSRD: The layout of the Inclined Screen GSRD is set by positioning the GSRD in line (or at least within 80 degrees) with the direction of the in-coming flow, and by adhering to the limitations of the GSRD design. The layout must consider the following:

- The Inclined Screen GSRD footprint “out-to-out” concrete dimensions compared to the available site footprint
- Existing inlet/outlet drain pipe configuration and layout compared to the Inclined Screen GSRD requirements, plus potential upstream and downstream pipe replacement (retrofit case)

5.2 Inlet and Outlet Pipe Requirements

As presented in Section 3.1, the Standard Plans are applicable for inlet and outlet wall openings up to a specific diameter. Should the existing drain pipes exceed the maximum opening, a special design may be required as discussed in Section 9.

5.3 Space Considerations

GSRDs require sufficient space and/or access ramps for maintenance and inspection, including the use of vacuum trucks and other equipment to remove accumulated gross solids and debris.

The site area must be able to accommodate the GSRD structure, which is verified by checking the structure dimensions using the out-to-out concrete dimensions as shown in the Standard Plans. Verify the proposed GSRD locations with District Maintenance to confirm sufficient space and access for maintenance and inspection of the structure.

5.4 Construction Requirements

Construction requirements for the GSRDs are specified in the drawings and accompanying special provisions (see Sections 7.1 and 7.2). Critical elements of construction are the screen opening dimensions for all GSRDs and the concrete structure dimensions for the Inclined Screen. It is critical that the screen openings are fabricated to be 3/16 in (5 mm) in size. Larger openings may result in 3/16 in (5 mm) size gross solids passing through the screen, which would be considered non-compliant with the TMDL regulation(s). The specified structure wall dimensions are such that the gap between the screen and the wall (on both sides) is no more than 3/16 in (5 mm), thereby preventing gross solids larger than 3/16 in (5 mm) in size from passing through the device. If the distance between the screen support walls is more than the specified dimension, the gap between the screen and the walls will be more than 3/16 in (5 mm). If the distance between the screen support walls is less than the specified dimension, the fabricated screen may not fit.

Section 6

Design Elements

The Standard Plans are a complete set of structure plans and do not require additional items of work or features for their operation. In addition to the gross solids treatment mechanisms, the drawings include grating, ladder, cable railing, and associated quantities. It is the PE's responsibility to determine which of these elements are required for a specific site.

Additional appurtenances may be added to the GSRDs for safety, appearance, or protection of the solids containment area. For example, adding grating to the GSRD to enclose the gross solids containment area. There may be a need for additional or different fencing around the GSRD, or additional ladders may be used. Although changes such as these will not likely affect the design and operation of the GSRDs, any changes to the drawings are considered a special design.

In a retrofit where a section of existing piping is replaced with a GSRD, a concrete collar is required to connect the existing upstream and/or downstream pipe to the GSRD.

6.1 Maintenance

Discuss proposed GSRD location and access with the District Maintenance Stormwater Coordinator, as maintenance is critical to these devices. Provide vehicle access to the vault area to facilitate cleaning. Maintenance access roads or vehicle pullouts, if required, must be located within Caltrans right-of-way or within a maintenance easement and must be able to accommodate all sizes of vehicles to cover routine visits; they must allow for trash and debris removal, likely using a vacuum truck. Coordinate with District Maintenance Stormwater Coordinator on maintenance access to the device.

6.2 Design Storm

Both storm volume and peak flow conditions must be considered in the evaluation of runoff conditions. The Design Storm is the event that generates runoff rates or volumes that the drainage facilities are designed to handle (see HDM, Topic 831). For this guidance manual, the term Design Storm is used in reference to designing drainage facilities and refers to the peak drainage facility design event as determined in accordance with the HDM⁴.

6.3 Flow Splitters

Flow splitters are upstream drainage bifurcation structures designed to direct inflows corresponding to the treatment volume to TBMPs and to divert peak flows. Possible conditions requiring the implementation of a flow splitter in conjunction with an TBMP are listed below:

- Backwater effect in the TBMP
- Large peak storm effects
- Inlet/Outlet pipe elevation constraints

⁴ For convenience in this document, the Design Storm flow is referred to as Q_{25} . However, other recurrence intervals may have been used for the roadway drainage design, as described in HDM Chapter 830, Transportation Facility Drainage; confer with District Hydraulics.

- Available capacity of overflow device discharge connection
- Downstream effects of an overflow device

A detailed hydraulic analysis will be required to properly size and design the flow splitter structure, which is covered in the Flow Splitters Design Guidance (Caltrans 2020b).

6.4 Energy Dissipation

An energy (i.e., velocity) dissipater may be needed if the runoff velocity exceeds 20 ft/s. The dissipater would be located upstream of the GSRD and would not require any changes to the Standard Plans. The design of the energy dissipater must be coordinated with District Hydraulics.

Section 7

PS&E Preparation

This section provides guidance for incorporating GSRDs Drainage Profiles into the PS&E package, discusses typical specifications that may be required, and presents information about estimating construction costs.

While every effort has been made to provide accurate information here, the PE is responsible for incorporating all design aspects of GSRDs into the PS&E in accordance with the requirements of Section 2 of the Construction Contract Development Guide (Caltrans 2022).

7.1 Plans

This section provides guidance for incorporating the Standard Plans into a PS&E package. The PE is responsible for incorporating the GSRD design into the PS&E in accordance with the procedures typically followed when developing a PS&E package. For example, the applicable layout, grading, drainage, and detail sheets should be updated to reflect the required design features of the GSRD with the appropriate references to incorporate the Standard Plans into the PS&E package.

The PS&E drawings for most projects having a GSRD may include:

- **Layout(s):** Show location(s) of the GSRD(s) and callout standard GSRD configuration types. This will aid in recognizing, both within and outside Caltrans, that GSRDs were placed within the project limits.
- **Grading Plan(s):** Show the GSRD on this sheet for clarity and associated grading surrounding the GSRD should be shown on these sheet(s).
- **Drainage Plan(s), Profiles, Details, and Quantities:**
 - Drainage Plan sheets should show each GSRD in plan view, along with other existing and proposed drainage conveyance devices that direct the runoff into the device.
 - Drainage Profile sheets should show the GSRD in profile within the drainage conveyance system. These sheets should also call out the specific GSRD inlet and outlet flow line (surface) elevations and invert elevation.
 - Drainage Detail sheets should show the details as needed to construct or clarify GSRD interface points. Most of the required information is included on the Standard Plans. Other details may be necessary to adequately reflect the required improvements.
 - Drainage Quantity sheets should include a summary of quantities table with station, offset, and dimensions of the GSRDs and should include all pay and non-pay items associated with the construction of the GSRD, except for those items that will be placed on the Summary of Quantities sheets.
- **Temporary Water Pollution Control Plans:** These sheets are used to show the temporary TBMPs used to establish the GSRDs and compliance with the Construction General Permit.

When multiple GSRD units will be used for a project or contract, a Location of Construction table should be considered. This table could present each GSRD, the corresponding outfall, location, GSRD type and configuration, and other pertinent information. This table may be

incorporated into an existing drawing if there is room (e.g., Layout, Construction Detail), or may be developed as a separate drawing if necessary. An example is presented in Table 7-1.

Table 7-1. Example of Locations of Construction

LOC	Outfall	Post Mile	Station	GSRD Type	GSRD Configuration
1	405-3031	30.31	34.1 LT 488+05.7	LR-6	LR-6-1830
2	405-3120	31.20	34.1 LT 501+64.2	LR-4	LR-4-2440
3	405-3138	31.38	42.8 RT 505+12.4	LR-4	LR-4-2440
4	405-3148	31.48	67.7 RT 10+56.5	LR-2	LR-2-1220
5	405-3163	31.63	40.0 RT 509+18.9	LR-4	LR-4-2440

7.2 Specifications

Contract specifications for GSRD projects are in the Standard Specifications, Standard Special Provisions (SSPs), and may include non-Standard Special Provisions (nSSPs). In some cases, specific nSSPs have been developed by OHSD.

The various items of work needed to construct the GSRD are typically organized under an umbrella 'GSRD' and paid for as each (EA). Optionally, separate listings could be made for each contract item of work, with separate measurements and payments. The PE and the District Office Engineer should consider which method would better serve the project.

7.2.1 Standard Specifications

Standard Specifications are to be used for a project that constructs a GSRD. Consider the construction of the GSRD in the context of the entire project to determine what Standard Specifications are applicable.

7.2.2 Standard Special Provisions

OHSD developed the following SSPs for use with the Standard Plans and is available in the Office of Construction Contract Standards:

- SSP 61-1 Permeable Material for Freeze-Thaw Conditions
- SSP 62-12 Fiber Reinforced Plastic (FRP) Grating (Linear Radial and Inclined Screen)

7.3 Project Cost Estimates

Project Cost Estimates are required at every phase of the project – Project Initiation Document (PID), Project Approval/Environmental Document (PA/ED), and PS&E. The Caltrans Division of Design, Office of Project Support has developed the following website to assist in the development of cost estimates:

<https://dot.ca.gov/programs/design/cost-estimating-improvements>

This website includes links to Chapter 20 Project Development Cost Estimates of the Project Development Procedures Manual and Caltrans Cost Estimating Guidelines.

7.3.1 PID and PA/ED Phases

A preliminary cost estimate, Project Planning Cost Estimate (PPCE), is required as an attachment of the SWDR during the PID phase of the project. A refined version of the PPCE is developed in PA/ED phase. For details on what needs to be included in PPCE, refer to Section 6.4.9 and Appendix F of the PPDG. This estimate will need to be modified as the project

progresses. If some design is conducted during the PA/ED phase of the project, it is possible that a refined estimate could be made using the methods in Section 7.3.2. A cost escalation should be added for projects that are anticipated to advertise more than a year after the date of the estimate.

7.3.2 PS&E Phase

Preliminary Engineer's Cost Estimates (PECE) are initiated at the beginning of PS&E and are updated until the completion of PS&E phase of the project. PECEs focus on the construction costs of the project and the permanent TBMPs and are inputs to the AASHTOWare Project Preconstruction (AWP-P). Identify Final Pay items and to determine appropriate unit prices for each device. The PE is not responsible for developing earthwork quantities for each GSRD location. This work is included in the unit item cost of the device. Limits of excavation and backfill shall be in accordance with the GSRD "General Notes" Sheet.

7.4 Developing GSRD Cost Estimates

Develop a quantity-based cost estimate. As the design process proceeds, the project cost estimate should be updated as new data becomes available.

GSRD costs are to be reported as EACH in the SWDR. It may not be necessary to include costs for items that support the TBMP in the unit cost. For example, utility relocation, traffic safety items, drainage systems, or site design elements that are required for the project regardless of TBMP construction could be excluded. However, the items that are required due solely to the TBMP construction should be included in TBMP unit cost.

When developing costs based on unit quantities, the unit costs should be based upon the most recent Caltrans Contract Cost Data Book and the District 8 Cost Database Search Page, linked here, for current similar projects:

<https://sv08data.dot.ca.gov/contractcost/>

Estimate the total cost of each GSRD used on the project for tracking TBMP costs at PS&E. Document all BMP costs in the project SWDR at PS&E.

If the GSRD is a Special Design as defined elsewhere in this document, then quantities for cost estimating and construction pay items will need to be calculated and incorporated into the modified drawings and estimates. Note: The Caltrans standard GSRD screen length is 5 ft. Some manufacturers use a standard GSRD screen length of 10 ft. While using a 10 ft GSRD may allow for cost savings from the manufacturer, a 10 ft GSRD design will require a Special Design. See Section 9.

7.5 Plan Sheet Approval

When using standard sized vaults, the Standard Plans should be used. These standard drawings are signed and sealed by OHSD's Chief Engineer. If changes are made to the plans without consent from OHSD, the PE for the project must sign and stamp the sheets.

7.6 GSRD Nomenclature

The following GSRD nomenclature shall be used consistently on PS&E packages and AWP-P.

- LR-# of intermediate screen pipe sections (1-6)-height (4'-0",6'-0",8'-0")
 - Example: LR-1-(4'-0") GSRD
- LR(HV)-# of intermediate screen pipe sections (1-6)-height (4'-0",6'-0",8'-0")
 - Example: LR(HV)-3-(6'-0") GSRD
- Inclined Screen Type (A-F) GSRD
 - Example: INCLINED SCREEN TYPE D GSRD

Section 8

Standard GSRD Design Example

8.1 GSRD Selection Example

This section presents an example of how to implement the procedure presented in Section 4 for a particular site. The site chosen for this example is an outfall in District 7, located at Route 118 EB at Chamberlain Street and Arleta Avenue. An aerial photograph of the site is provided in Figure 8-1, and the As-Built Drainage Profile is provided in Figure 8-2. For this example, the trash loading rate was given as 60 gal/ac/yr.



Figure 8-1. Aerial Photograph of Outfall on Highway 118 at Chamberlain Street and Arleta Avenue

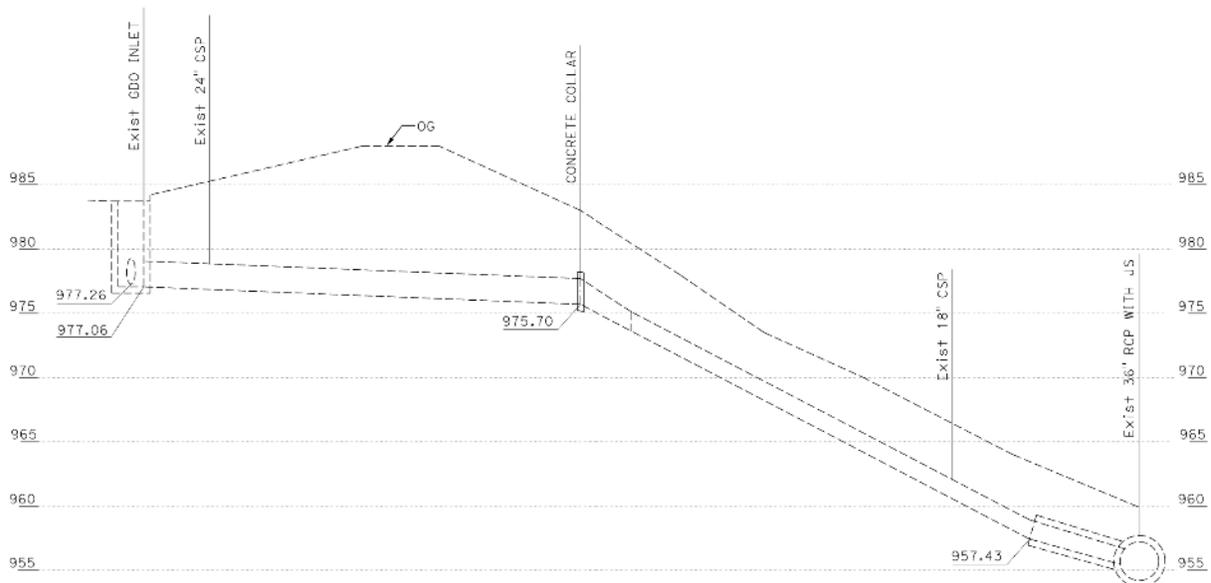


Figure 8-2. As-Built Drainage Profile Highway 118 Outfall at Chamberlain Street and Arleta Avenue

Step 1: Review Site Conditions

Review the site conditions to ensure that none of the site restrictions (e.g., corrosive environments, abrasive flow, freeze-thaw conditions, seasonally high groundwater, soil conditions) are present.

Based on the geotechnical analysis, none of the site restrictions are present at the site.

Step 2: Identify Candidate GSRD Types

Calculate the design flow rate and debris area using Table 3-1 and Table 3-2. Select the appropriate candidate GSRD Type(s). Should one or both of the calculated values fall between two table entries, select the GSRD type with the entry greater than the calculated value.

Hydraulic and hydrologic design calculations for the project site resulted in the following:

- Determine annual trash volume

$$V = D \times R$$

Where:

V = Required annual trash volume needed (gal)

D = Debris area (ac) – 3.2 ac

R = trash loading rate (gal/ac/yr) – 60 gal/ac/yr

- Annual Trash Volume: 192 gallons
- Flow Rate (Q₂₅): 11.14 cfs
- Velocity: 5.68 ft/s

Comparing these values to those in Table 3-1 and Table 3-2 result in two candidate GSRDs: a Linear Radial Type LR-4 or an Inclined Screen Type C. Note that Table 3-2 incorporates a safety factor of 50% of the volume for Linear Radial devices and 25% blinding of Inclined Screens. Both options will support the design flow rate, and the design debris area.

Step 3: Check Available Space

Using Table 3-3, compare the “out-to-out” concrete dimensions of the candidate GSRD type(s) to the available footprint of the site to make sure it fits and there is enough room for maintenance.

The project site is at the end of Chamberlain Street at Arleta Avenue. The roadway (Route 118) is elevated at this point, and the outfall is located at the bottom of the 2:1 sloped embankment. This location provides adequate room for access and maintenance away from Route 118 and Arleta Avenue and does not require access from the roadway. The perpendicular distance between the roadway and the existing RCP that leads to the outfall is approximately 70 ft. The “out-to-out” concrete dimensions of the LR -4 are 29.4 ft by 11.5 ft. Although this is less than the available distance, it may not fit given the 2:1 slope. The “out-to-out” concrete dimensions of the Inclined Screen Type C are 7.6 ft by 10.3 ft. This would probably be a better fit within the available space than the Linear Radial. However, both appear to meet the criteria at this point.

Step 4: Check Grade

If one of the candidate GSRDs is a Linear Radial or Linear Radial (HV), make sure the minimum and maximum elevation drop requirements presented in Table 2-2, Table 3-4, and Table 3-5 can be satisfied. If one of the candidate GSRDs is an Inclined Screen, make sure the minimum elevation drop requirements presented in Table 2-3 can be satisfied.

The existing system consists of a type GDO drainage inlet at the roadway shoulder connected to a 24 in CSP at a 4.2 percent slope, which is connected to an 18 in CSP at a 54.5 percent slope that discharges into a 36 in RCP. The flow line at the outlet of the first drainage inlet is 977.1 ft and the flow line at the RCP approximately 954 ft), resulting in 23.1 ft of available grade.

The minimum elevation drop for the Linear Radial -4 is 0.25 ft, and the maximum is 3.33 ft. The distance over which this drop loss must occur is 26.9 ft. This is the total inside vault length. Refer to Table 3-4. Given the available distance at the project site between the inlet and the outlet (70 ft), the embankment slope, and the existing pipe slopes, it is not possible to limit the drop to 3.33 ft over a distance of 26.9 ft. Therefore, the Linear Radial is rejected as a candidate.

The required elevation drop for the Inclined Screen Type C is 66 in, which must occur over 6.6 ft, and a wall height of between 9 and 13 ft. As a result, the Type C is retained as a candidate GSRD.

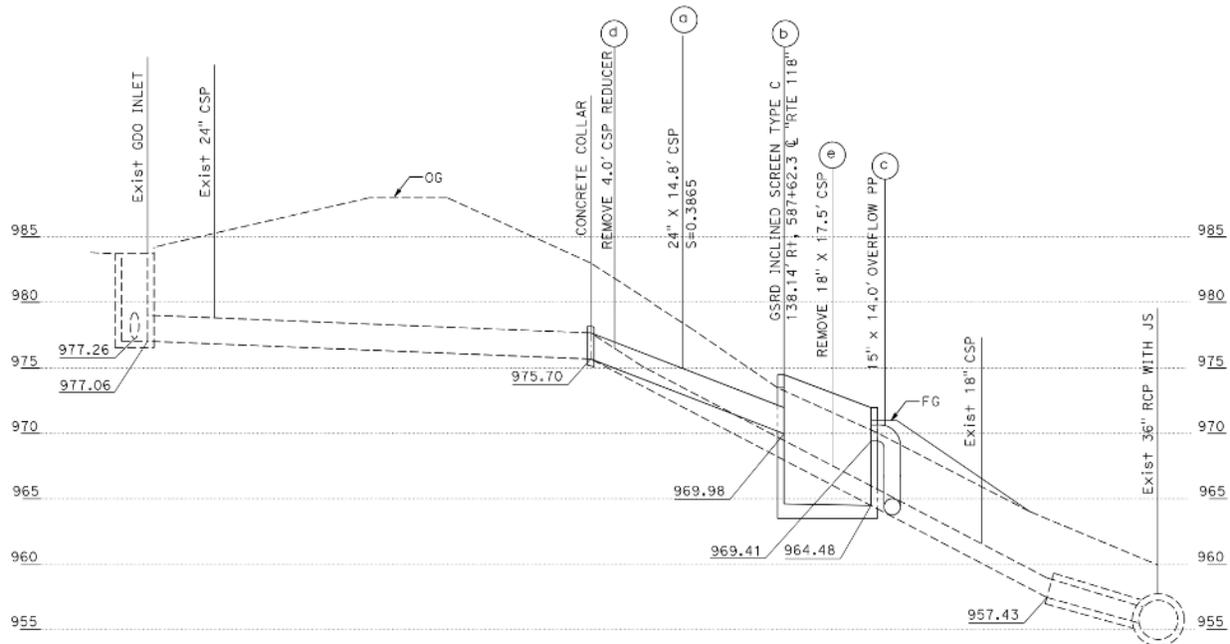


Figure 8-3. Drainage Profile and Proposed GSRD – Highway 118 Outfall at Chamberlain Street and Arleta Avenue

Step 5: Select GSRD Configuration

Specific GSRD configurations are then selected based on inlet and outlet wall height requirements. Figure 4-2, Figure 4-3, and Figure 4-4 present structural schematics of each type to support the accompanying text.

To provide adequate space for access and maintenance, the GSRD is located within a portion of the right-of-way that is accessible from Chamberlain Street. If it is desired to directly connect the existing pipe to the inlet wall, the dimensions provided in the GSRD Standard Plans require the connection to occur at a flow line of 969.98 ft. At the inlet wall, the depth of the existing inlet pipe is 968.02 ft. For this design, the PE is replacing the inlet pipe between the DI and the GSRD. Alternatively, a concrete collar could be used to connect to the existing inlet pipe closer to the GSRD. For this design, the depth to finished grade is 10 ft. The required wall height of between 9 and 13 ft will work. Some minor grading may be necessary around the device to meet the 6 in necessary between finished grade and top of wall. It is extremely important to make sure the survey information is accurate enough to determine the wall heights. It is the PE’s responsibility to obtain accurate survey information.

Step 6: Check Wall Openings

The final step is to make sure the selected GSRD has wall openings large enough to accommodate the inlet and outlet pipes. The openings presented in Table 2-3 are compared to the outside diameters of the inlet and outlet pipes for the Inclined Screen GSRD.

The maximum inlet and outlet wall openings are 30 in. These are both large enough for the existing 24 in and 18 in CSPs.

8.2 PS&E Preparation

For the above example, the incorporation of the GSRD into the PS&E package would be reflected in the project plans and drawings. Standard Plans are also applicable.

The project plans that need to show the GSRD include the following drawings:

- **Layout:** Show the location of the GSRD structure and its stationing. Figure 8-4 presents an example.
- **Drainage Plan:** Show the GSRD with the existing and proposed drainage conveyance system, including pipes and inlets. An example is presented in Figure 8-5.
- **Drainage Profile:** Show the GSRD profile with the existing and proposed drainage conveyance system, including pipes and inlets. An example is presented in Figure 8-6.

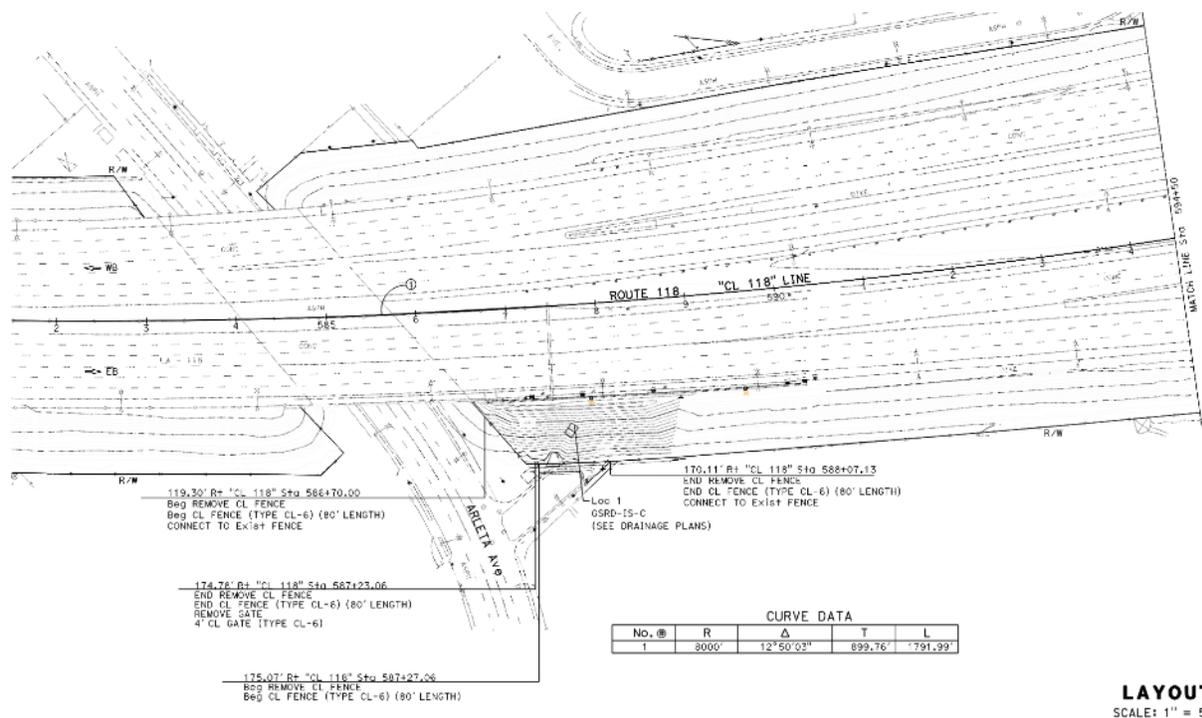


Figure 8-4. Example Layout Plan

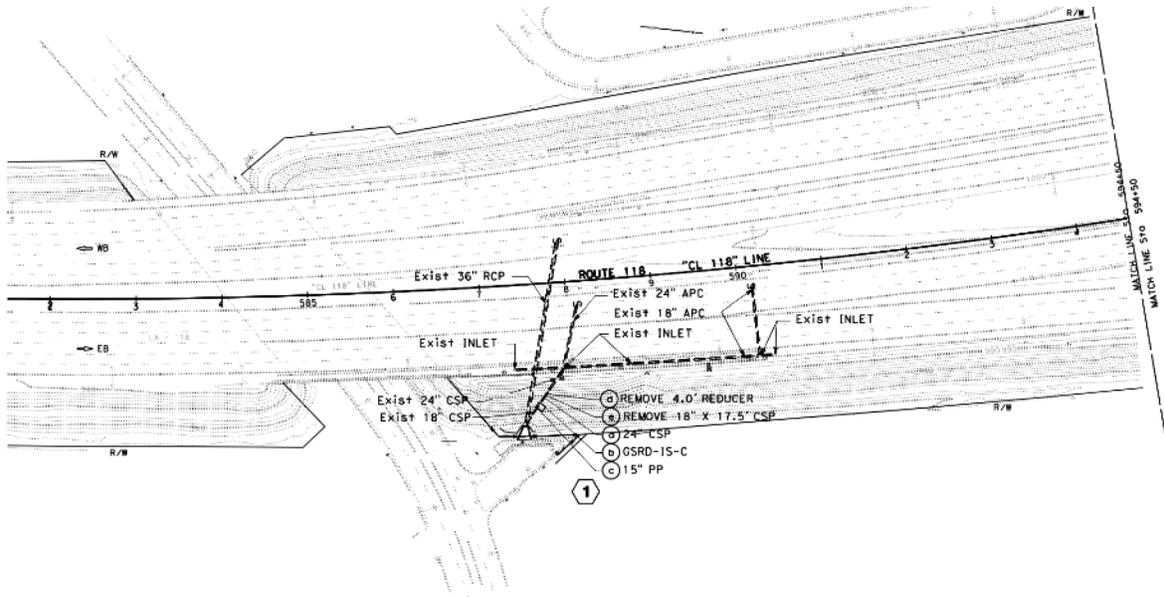


Figure 8-5. Example Drainage Plan

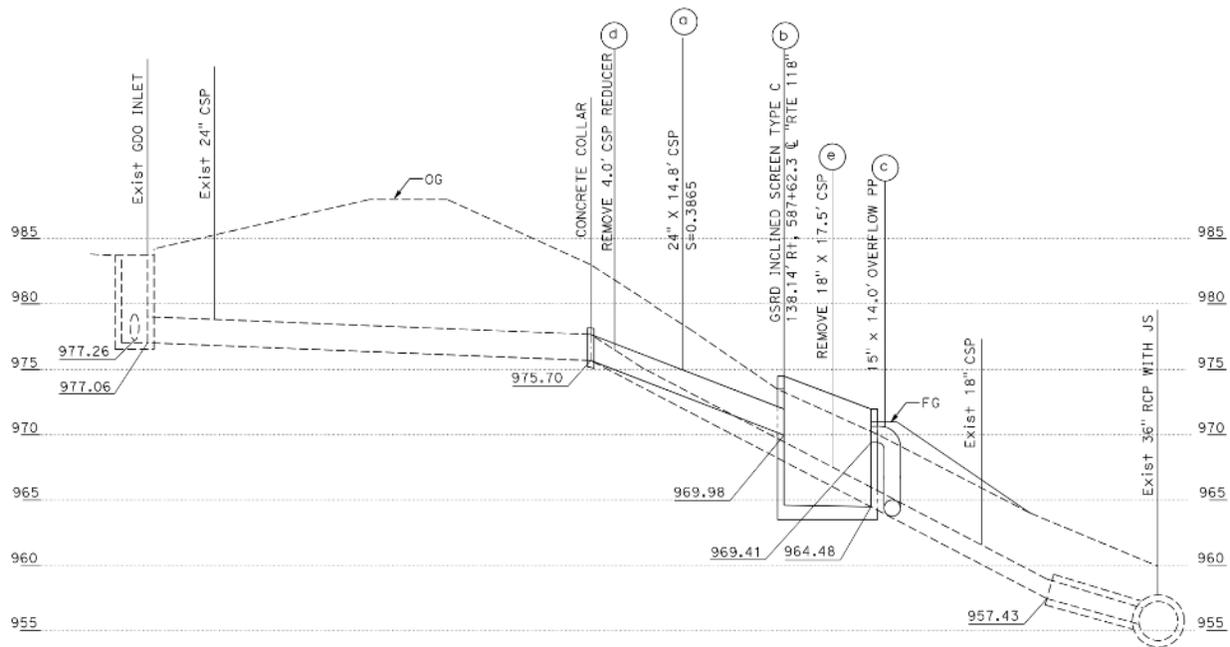


Figure 8-6. Example Drainage Profile

Section 9

Special Designs

This section provides guidance for situations where the specific project requirements do not meet the design parameters as specified in the Standard Plans. The following recommendations are provided as alternatives to expand the applicability of the GSRDs beyond the design elements and constraints shown in the Standard Plans. Note that any of the following design approaches will likely require additional engineering such as a structural and hydraulic analysis.

This section presents a discussion of the design parameters used in the design of the GSRDs included in the Standard Plans, and how the design may be revised for values outside the range presented in Sections 2 and 3.

9.1 Flow Rate

If the design flow rate exceeds the maximum values presented in Table 2-2 and Table 2-3, the GSRD screen specified in the Standard Plans is not long enough. If this is the case, a modified GSRD with a longer screen may be designed, or a flow splitter may be used. The flow splitter is designed to either distribute the runoff to multiple smaller, standard GSRDs operating in parallel, or to bypass runoff that exceeds the TMDL established design flow.

If a modified GSRD is desired, the required screen length can be determined by using the capacities (given in gallons per minute [gpm] per lineal ft and cfs per lineal ft) presented in Table 9-1.

Table 9-1. GSRD Screen Capacities

GSRD	Screen Capacity (gpm/ft)	Screen Capacity (cfs/ft)
Linear Radial	322	0.72
Linear Radial (HV)	322	0.72
Inclined Screen	785	1.75

Note that the resulting screen length for the Linear Radial and Linear Radial (HV) exclude the unlouvered beginning pipe section.

Once the screen length is determined, the GSRD structure dimensions (i.e., footprint) must be re-calculated. The total length and width of the GSRD (referred to as the “out-to-out concrete dimensions” on the Standard Plans) can be calculated using the following formulas:

- Linear Radial
 - Structure Length (ft) = 5 ft section Screen Lengths + 14.3 ft
 - Structure Width (ft) = 11.5 ft
- Linear Radial (HV)
 - Structure Length (ft) = 5 ft section Screen Lengths + 16.8 ft
 - Structure Width (ft) = 11.5 ft

- Inclined Screen
 - Structure Length (ft) = Screen Length + 1.0 ft
 - Structure Width (ft) = 10.3 ft

If the upstream flow splitter option is desired to utilize multiple GSRDs, the flow splitter must be designed such that each discharge stream does not exceed the flow rate of its respective GSRD. The downstream GSRD structures do not have to be of equal size, and the flow splitter may split the flow from the drainage area disproportionately. In this case, the flow rate, debris area, and trash loading rate contributing to each GSRD will have to be determined for proper sizing of the GSRD structures. If the downstream GSRDs are all Linear Radials or Linear Radials (HV), the radial screens can be combined within a single concrete structure if desired. However, this will require additional engineering analysis, particularly structural analysis.

If the flow splitter is utilized to bypass excess runoff around the GSRD, it must be designed to ensure that the runoff discharging into the GSRD meets or exceeds the design event established by the governing TMDL regulation. Coordinate with District Hydraulics when using a flow splitter for either situation.

9.2 Annual Trash Volume

If the design annual trash volume exceeds the maximum values presented in Table 3-2, the GSRD is not large enough to hold one year's worth of gross solids. If this is the case, either a modified GSRD with a larger storage area may be designed, multiple GSRDs may be used, or one of the standard sizes may be used if District Maintenance commits to a more frequent inspection and cleanout (e.g., two or more times per rainy season provided the flow criteria are met).

For a Linear Radial and Linear Radial (HV) GSRD, the gross solids are contained within the screen pipe, so a larger gross solids storage area requires a longer screen pipe. To calculate the required screen length, use the following equation:

$$\text{Percent Full} = \text{Annual Trash Volume} / \text{Linear Radial GSRD Storage Volume}$$

Where:

Percent Full = percentage of pipe screen occupied by gross solids before cleaning, use 50%⁵

Annual Trash Volume (CF) = debris area * trash loading rate (Section 3.1)

Linear Radial GSRD Storage Volume (CF) = is the total volume of the louvered screen pipe; $\pi * \text{Pipe Radius (ft)}^2 * \text{screen length (ft)}$

The above formula is rearranged to solve for the required Screen Length:

$$\text{Screen Length (ft)} = \frac{\text{Annual Trash Volume}}{\pi * \text{Pipe Radius (ft)}^2 * \text{Percent Full}}$$

The structure length and width are then computed using the formulas presented in Section 8.1.

For the Inclined Screen GSRD, the gross solids are also stored in an area at the bottom of the inclined screen as shown in Figure 9-1. To accommodate a larger debris area, the volume of this area must be increased. This may be accomplished either by lowering the slab, extending one or both of the sidewalls, or by a combination of the two.

⁵50 percent is the allowable capacity used in the development of the Standard Plans.

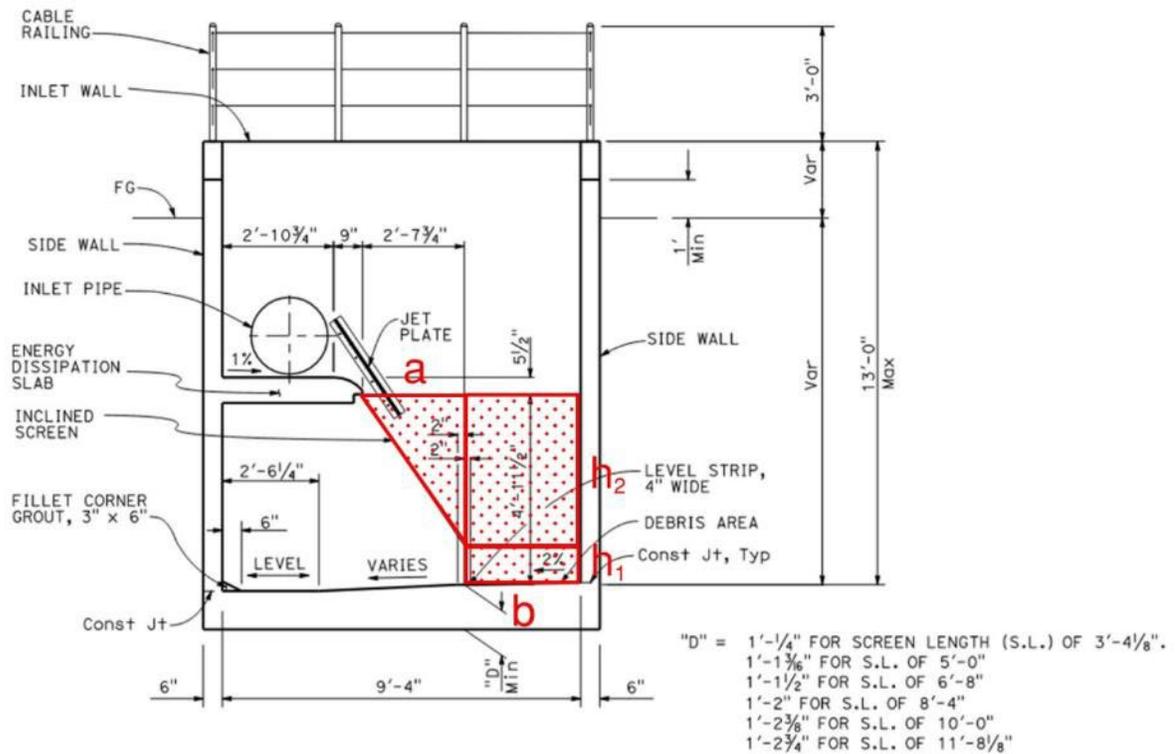


Figure 9-1. Annual Trash Volume for Inclined Screen GSRD

The Inclined Screen GSRD Storage Volume is defined as follows:

$$V = 25\% * ((a * h_2 / 2) + (b * (h_1 + h_2))) * C$$

Where:

- V = Available storage volume (includes using bottom 25 percent of screen, measured along the length of screen, for trash storage), CF
- 25% = Allowable screen blinding⁶
- a = Width of storage area above the inclined screen, ft
- h₂ = Height from bottom to top of inclined screen, ft
- b = Width of storage area above the slab, ft
- h₁ = Height from slab to bottom of inclined screen, ft
- C = Length of Screen, ft

The above equation can be rearranged and solved for desired screen length, storage area width, and storage area depth. Note that a change in any of these three values will require a structural analysis.

⁶The allowable screen blinding of 25% shown in this equation is built into the values in Table 3-2.

9.3 Pipe Diameter

If the designed outside diameter of the GSRD inlet/outlet pipe is larger than the maximum wall opening allowed, a number of options may be considered.

At the upstream end, a flow splitter may be considered. Splitting the flow will allow for smaller diameter pipes; however, there may be a need for multiple GSRDs operating in parallel. This may only be an option if there is enough unobstructed space for more than one GSRD.

A second option would be to try to increase the slope of the inlet pipe. This may allow for a reduction in the diameter of the pipe. If a section of existing pipe is being retrofitted with a GSRD and the existing pipe does not fit within the wall opening, it may be possible to change the pipe material (e.g., from reinforced concrete to corrugated steel) to reduce the pipe thickness and outside diameter. All these options will require additional engineering.

9.4 Customizing the Standard Plans

When using a Special Design, the Standard Plans must be modified to show any changes relative to the design including the following:

- **Design Flow Tables:** If different design flow rates and annual trash volumes are used, these new values are to be reflected in the appropriate design chart on the Legend sheet of the Standard Plans.
- **General Notes:** Any notes should be changed as required to fit the special design including any changes made to the design flows
- **Dimensions:** In general, changing the design of the GSRD structures may result in changes to various dimensions. These should be updated on all sheets, views, sections and details.

Additional changes may be required to facilitate use of the Standard Plans. A structural review is required whenever there are changes in geometry not covered on the drawings. The changed drawings must go through the standard PS&E review process and be signed and sealed by the PE who completes the approved structural calculations. At this stage the plans are no longer Standard Plan sheets and must be coordinated through OHSD.

9.5 Special Design Examples

Sections 10 through 13 include special design examples that have been collected from different municipalities. To comply with the changing trash requirements, municipalities have been using more special design configurations.

It is important to note that each of the examples have been installed recently with limited data on performance and maintenance over multiple rainy seasons. Each municipality has only installed one or two GSRD devices and therefore, the examples cannot be considered standard designs. However, designers can look to these projects as examples for multi-GSRD configurations that handle large debris areas and high flows.

Special Designs must be designed by a qualified professional in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required.

Section 10

Special Design Example 1 – Estudillo Canal Multi-Screen GSRD

10.1 Project Overview

This special design example was designed and installed by Alameda County Clean Water Program in 2019 in partnership with Caltrans. Caltrans currently owns and maintains this portion of Estudillo Canal between the I-880 freeway and Washington Avenue. This project location provides a multi benefit opportunity to reduce high trash loads that are deposited on portions of jurisdictional lands of both Alameda County and Caltrans. Caltrans funded the construction costs of the project while Alameda County will maintain it in perpetuity.

As shown in the Plans for the Installation of Full Trash Capture Devices in Estudillo Canal Downstream of Washington Avenue in San Leandro Alameda County, California (ACPWA 2019), the GSRD device is installed in the existing concrete box channel directly downstream of where the underground culvert daylight. Because it is within the banks of Estudillo Canal, coordination with the Water Board and other environmental agencies was required. The watershed at this location is approximately 3,066 ac. While the device is designed for the entire watershed, existing trash capture devices within the watershed provide treatment of about 1225 ac and therefore the new device provided more trash capture capacity than required.

The GSRD device is attached to a low flow weir or headwall such that high flows bypass the GSRD. The existing Estudillo Canal prior to installation consisted of a rectangular concrete cross-section and was sized for a 15-year flow when it was constructed in the 1950s. Feasibility analyses indicated that the current capacity is approximately 1,700 cfs, whereas the 100-yr peak flow is approximately 2,900 cfs.

Low flows and trash are diverted into six parallel 30" diameter by 8' x 8' = 64' long linear-radial certified full capture GSRD screens. In the 1990s a flow restricting structure (two walls) were constructed to induce additional flow to a high flow bypass which consists of a pair of 96" wide by 48" high rectangular culverts. Construction of the GSRD has minimal hydraulic impact, however, the existing openings in the concrete flow restrictor walls downstream of the devices were enlarged to increase flow discharge at the 5-year storm discharge to compensate for the potential hydraulic effects of the multi-GSRD in the channel. At the 100-yr event, flows were found to be equivalent to existing.



Figure 10-1. Estudillo Canal Multi-screen GSRD

The multi-screen GSRD was installed in 2019. Removable gates allow for blocking low flows.

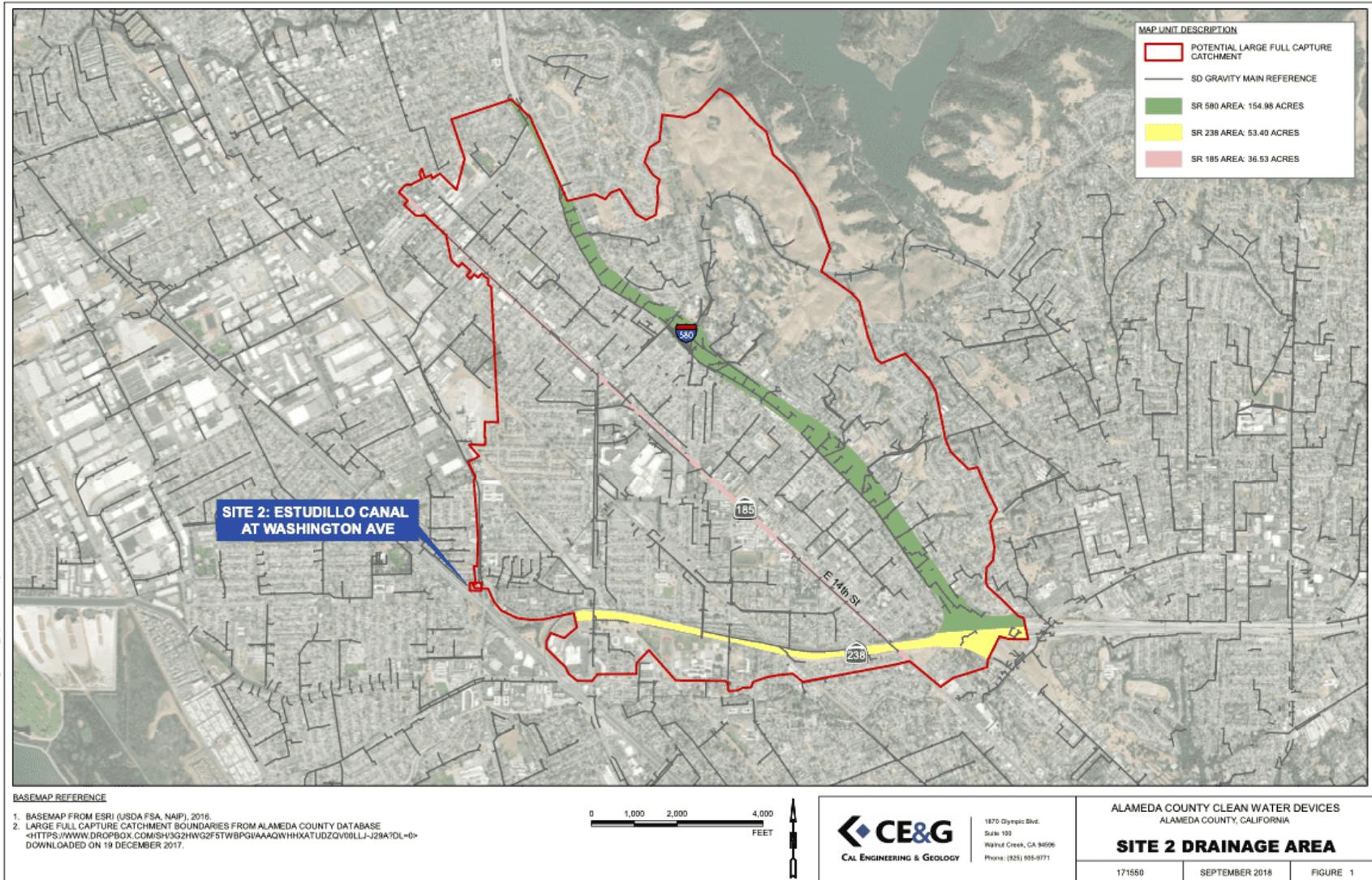


Figure 10-2. Estudillo Canal Multi-screen GSRD, drainage area
Total drainage catchment area is 2,876 ac, including 256 ac from Caltrans ROW.



10.1.1 Plans, Profiles, and Details

The following figures are an excerpt of the plans for the Estudillo Canal multi-screen GSRD. Design drawings for the GSRD screens were prepared by the manufacturer and were not available.

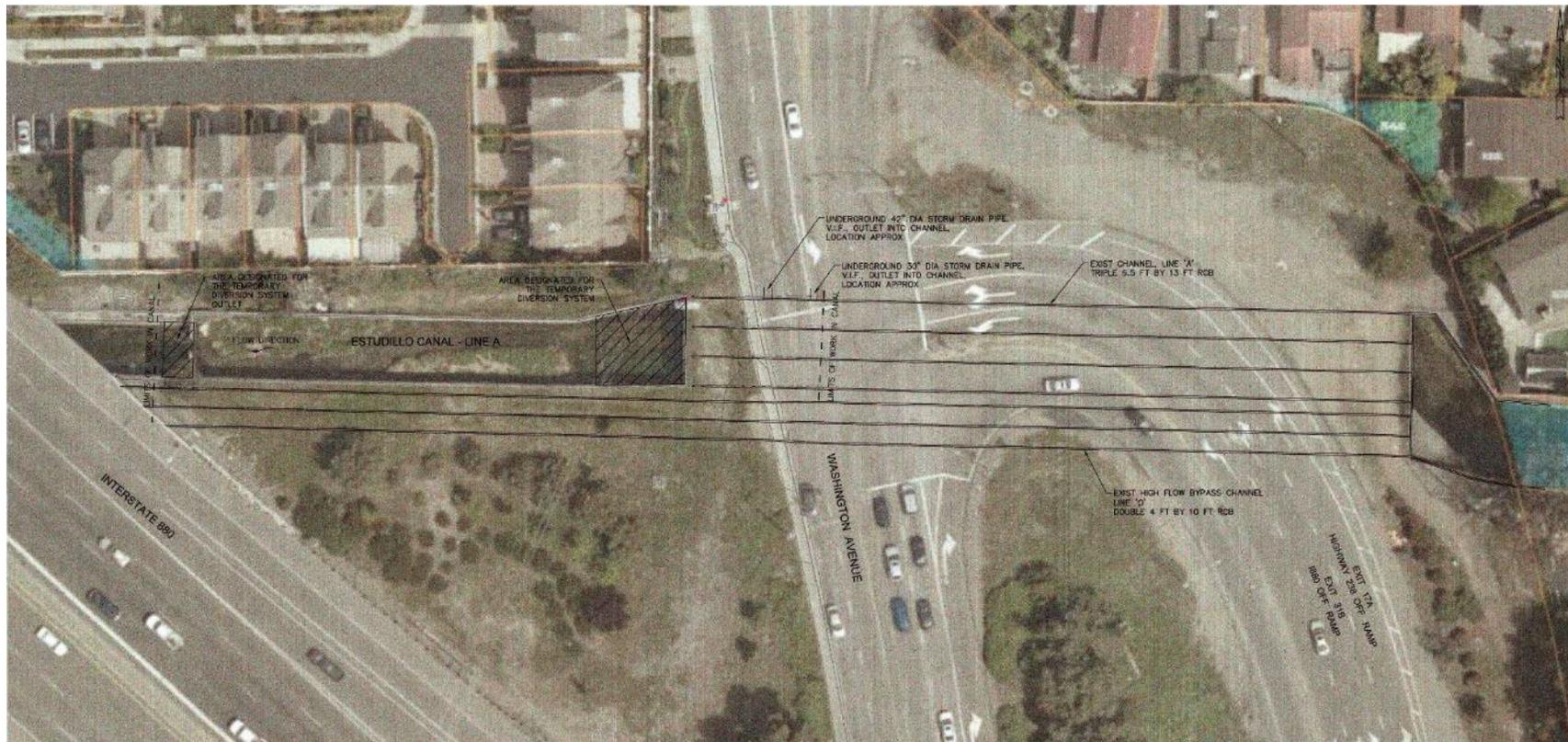


Figure 10-3. Estudillo Canal Multi-screen GSRD, site plan for temporary diversion

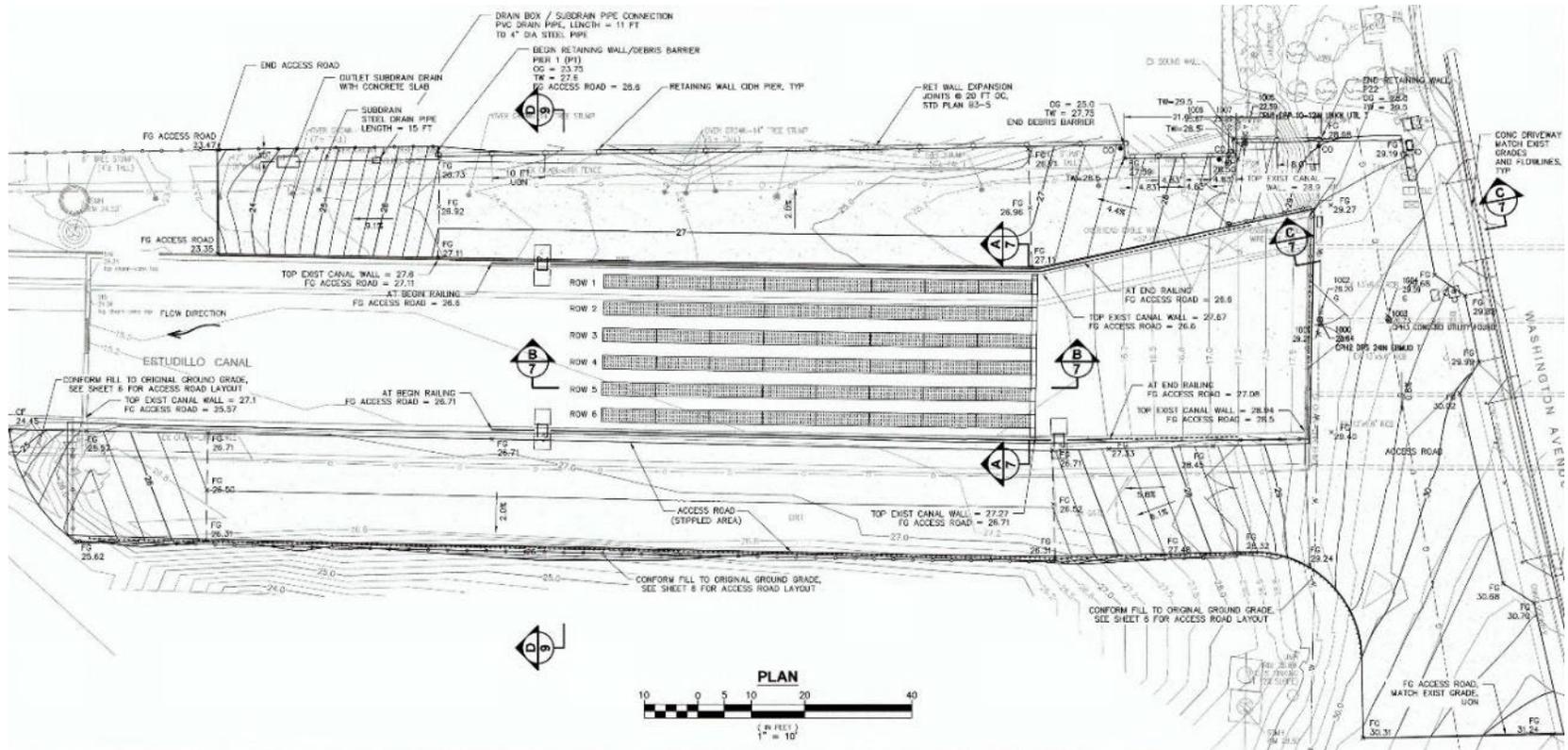


Figure 10-4. Estudillo Canal Multi-screen GSRD, grading and drainage plan

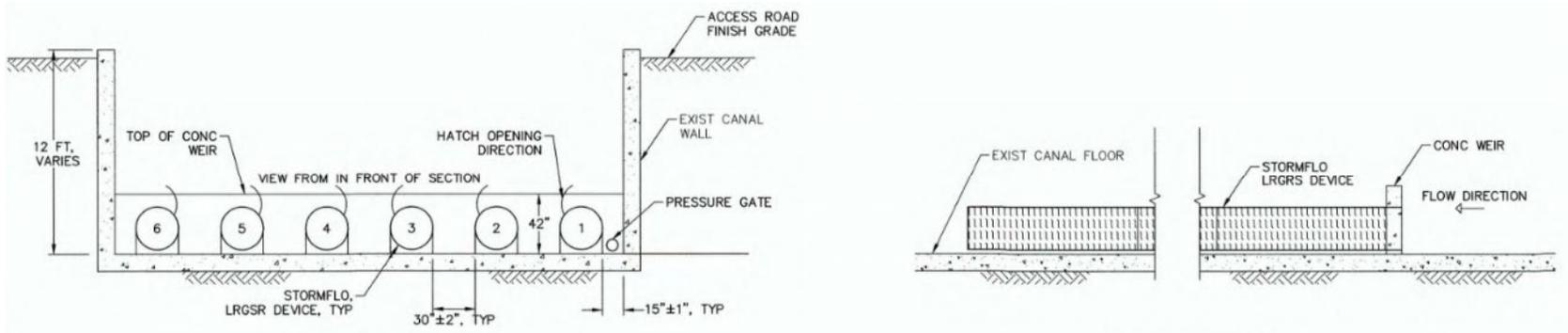


Figure 10-5. Estudillo Canal Multi-screen GSRD, Sections A (left) and B (right)
(ACPWA 2019)

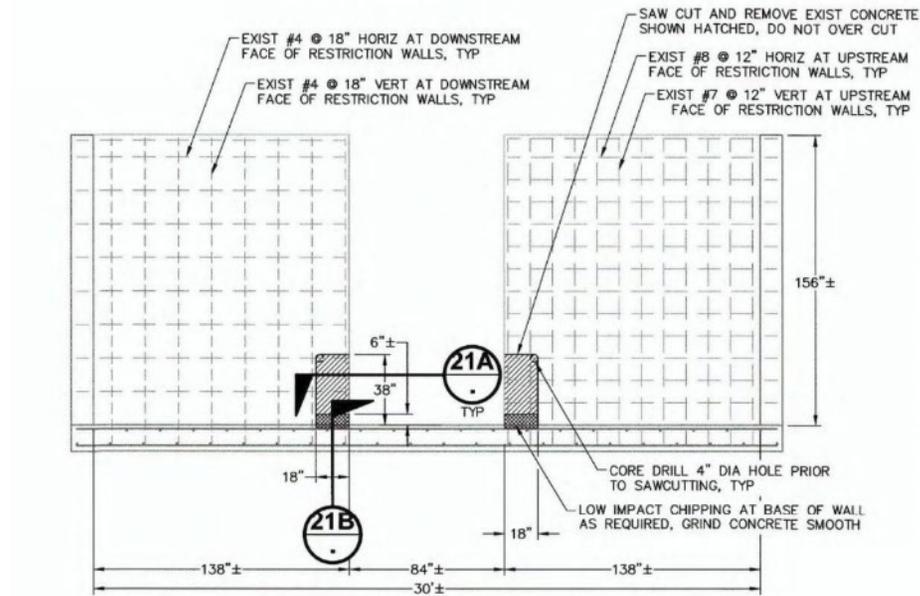


Figure 10-6. Estudillo Canal restrictor wall modification
The existing restrictor wall downstream of GSRD was modified to increase flows slightly (ACPWA 2019).

10.2 Design Criteria

Table 10-1 lists the Design Criteria for the multi-screen GSRD at Estudillo Canal.

Table 10-1. Estudillo Canal Linear Radial GSRD Design Criteria

Parameter	Units	Value
Gross Solids Size	in	3/16 ^a
Design Flow Rate (1-yr, 1-hr)	cfs	337 ^c
Peak Flow Rate (5- to 10-yr)	cfs	1700 ^c
Annual Trash Volume (assume 5 gal/ac/yr)	gal	13,100
Trash Capacity of Device	gal	7,344
Debris Area	acre	2,620 ^c
Catchment Area	acre	3066 ^c
Inlet Wall Opening	in	Three 79 x 156 boxes ^a
Outlet Wall Opening	in	120 x 38 + 84 x 156 restrictor wall ^{a,d}
Elevation Drop across device	in	3 ^a
Inlet Runoff Velocity	ft/s	Unavailable ^a

a. Source: ACPWA 2019

b. Source: Hoffman 2022

c. The pre-project capacity of the channel at the proposed location was approximately a 5-10 year recurrence interval whereas a 100-yr peak flow is approximately 2,900 cfs. Source: (Wood Rodgers 2018).

d. See Figure 10-6

10.2.1 Additional Design Features

Additional design features for this multi-GSRD include:

- Installed in an existing concrete channel with an upstream flow splitter which limited hydraulic capacity of very high flows and reduced costs of the installation.
- Concrete diversion weir to divert flows above design flow
- Sediment collection at the diversion weir produces credits for PCBs and mercury treatment
- GSRD pipe sections are each 10' long which is standard from the manufacturer and reduced cost of fabrication. In addition, diameter of the GSRD was limited to 30" with input from the manufacturer on cost.

10.2.2 Construction Cost

The design and construction cost for this project was approximately \$2,000,000. Costs for this project were lower than other similar projects due to the minimal changes required to the existing concrete channel structure.

10.3 Maintenance

After installation, the County added removable doors to block screen entrances of the GSRD. Half the doors are installed during low flow periods to minimize maintenance needed. Prior to the rainy season, the doors are removed to allow for flows through all the GSRD screens.

A maintenance access road runs parallel to the Estudillo Canal. Improvements were made adjacent to the channel to improve access for maintenance of the trash capture devices.

The frequency of maintenance is still being determined but the devices are currently being checked after each storm with the goal of keeping the frequency of cleaning adequate to keep the debris loading below 50% capacity. Crews clean the site after the first flush rain event of the season when loading is at its highest (Caltrans 2023d). If the unit is touched up with light cleaning after the first flush, fully functional operation will be sustained throughout the wet season without intermittent cleaning. The goal is to clean the unit roughly 3-4 times per year, i.e., before the rain season starts, after the first rain, and during the end of the season. The maintenance crew usually visits the unit every few months to check on the unit, whether it requires cleaning or not.

It takes one day to clean two 8 ft long GSRD screens with a 5 person crew which includes a driver, lead, and three additional staff. It takes approximately 3 days to clean the entire unit and up to a week including sediment clean-out. Debris removal is conducted via a vacuum assisted truck through maintenance hatches on each section of screen. During cleanout, wash water and rakes are used to move debris down to the low end of the GSRD where they are vacuumed out. A temporary berm (large diameter non-floating wattle) is placed downstream of the devices to capture and remove wash water and any debris that fall out of the devices.

The GSRD also captures vegetation and sediment. Sediment tends to collect against the headwall and allows for vegetation to get established. Sediment capture gives the County credit for PCBs and mercury treatment; however, deferred maintenance can lead to development of vegetation and sensitive habitat. In addition to the vacuum assisted truck, equipment such as Grade All, Skid-Steer (flown down to the channel using a crane) are also used. Removing sediment requires an additional day. Lastly, some larger items are caught in the canal and have to be removed manually like box springs, or other dumped large items.



Figure 10-7. Estudillo Canal Multi-screen GSRD, before maintenance

Prior to maintenance in October 2023, four years after installation showing seasonal accumulation of sediment and vegetation.



Figure 10-8. Estudillo Canal Multi-screen GSRD, maintenance activities

Vacuum assisted truck access for cleaning out debris from the device uses adjacent access roads on each side of canal.

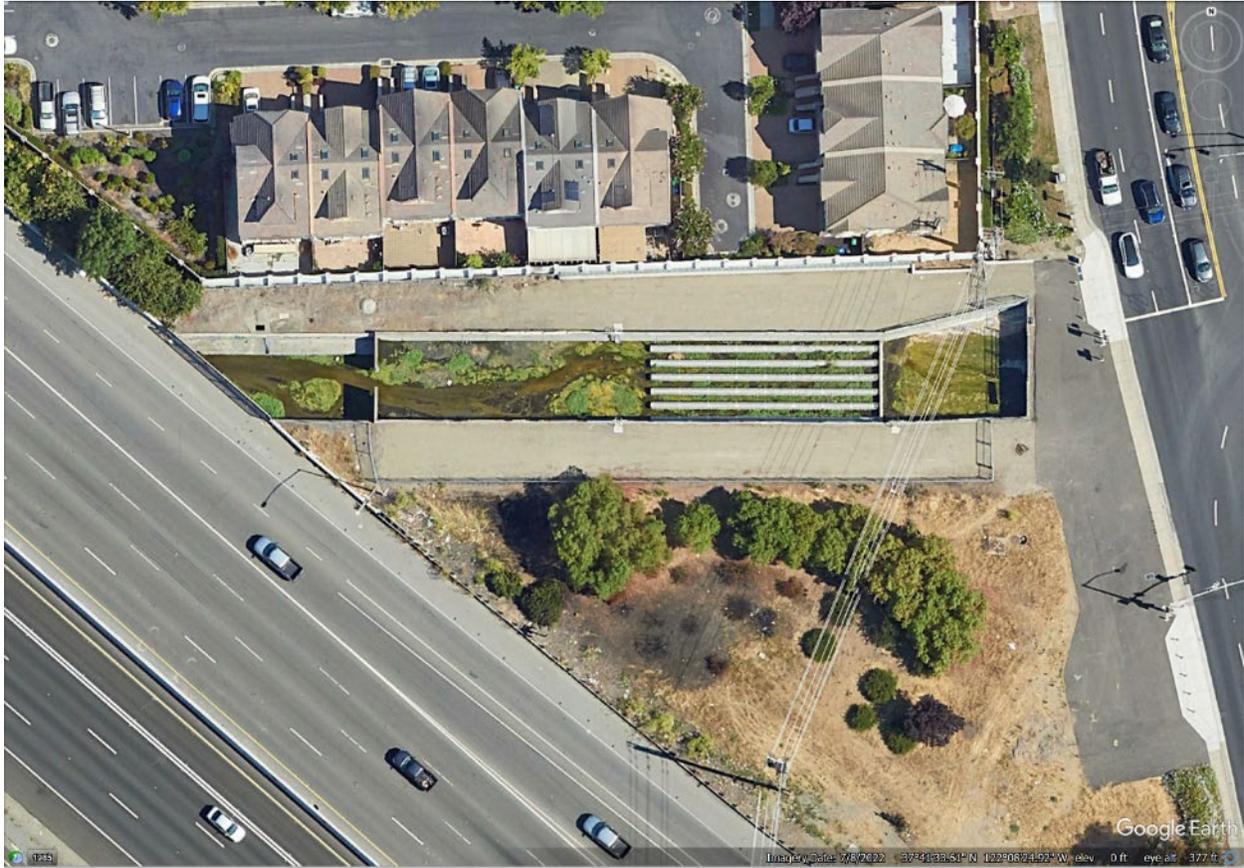


Figure 10-9. Estudillo Canal Multi-screen GSRD, post construction

Aerial imagery source: Google Earth, July 2022.

Section 11

Special Design Example 2 – Meekland Avenue at San Lorenzo Creek Multi-Screen GSRD

11.1 Project Overview

This special design example was designed and installed by Alameda County Clean Water Program in 2019. The multi-screen GSRD installed at corner of Meekland Avenue and Loma Verde Dr. adjacent to San Lorenzo Creek was installed in a large off-stream underground vault structure immediately upstream of existing storm drain outfall locations.



Figure 11-1. San Lorenzo Creek Multi-screen GSRD, after construction

Aerial image source: Google Earth, 2022

The project location presented many design and construction challenges due to the limited project footprint that is bound by an aging roadway bridge structure on one side and existing residential dwellings on the opposite side. Site constraints for this project dictated many aspects of the final design and included:

- Limited project footprint of 40 ft by 50 ft
- Adjacent apartment building within 15 ft of excavation
- No access, equipment or modification within the existing channel wall or creek
- Limited staging area and access
- Overhead utilities
- Equipment size limitations

The vault structure design and construction sequencing were developed to incorporate the excavation shoring system within the final structure. Lightweight Geofoam backfill was utilized above the underground vault to reduce design loads carried by the vault roof system. To mitigate hydraulic impacts caused by the trash capture devices, engineers designed a self-adjusting flow gate within the vault to reduce flooding potential during the design flood event.

Located in the storm drain line next to Meekland Avenue at San Lorenzo Creek this structure drains 925 acres. Low flows and trash are diverted into six parallel 18" diameter linear-radial certified full capture GSRD screens. Due to space constraints, one is 25' long and the remaining five are 30' in length (ACPWA 2018).

With the installation of this multi-screen GSRD and the one installed at Estudillo Canal (Section 10, above), the County expects to attain a 62.6% trash reduction in the majority of the County's high and medium trash generation rate areas (ACPWA, 2019b).

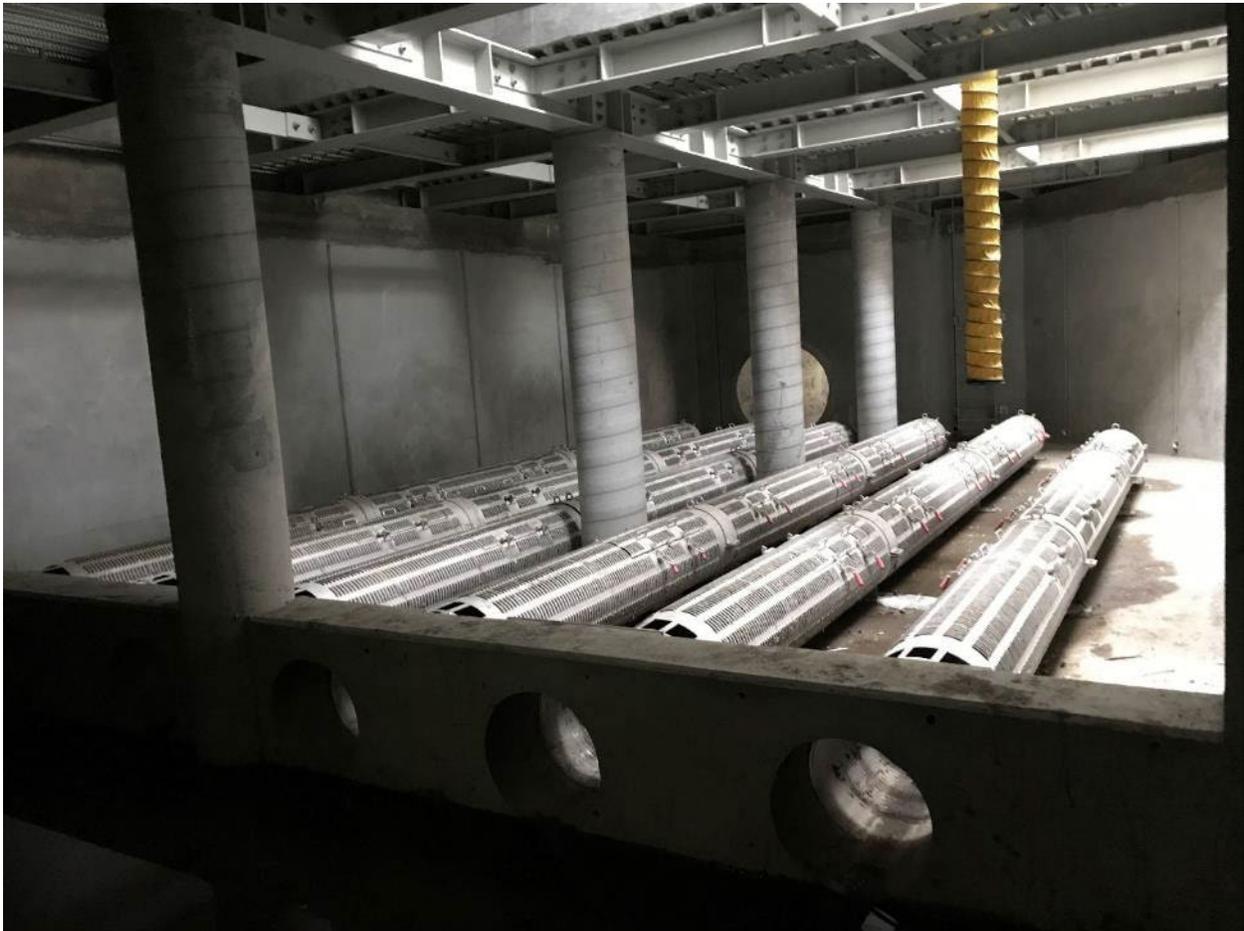


Figure 11-2. San Lorenzo Creek Multi-screen GSRD, structure vault
Inside the vault prior to construction completion.



Figure 11-3. San Lorenzo Creek Multi-screen GSRD, construction
Above the site, prior to construction completion.



Figure 11-4. San Lorenzo Creek Multi-screen GSRD, vault cover after construction

At the surface after construction completion (Image Source: Google Earth, 2023).

11.1.1 Plans, Profiles, and Details

The following figures are an excerpt of the plans for the Meekland Avenue at San Lorenzo Creek multi-screen GSRD. Design drawings for the GSRD screens were prepared by the manufacturer and were not available.

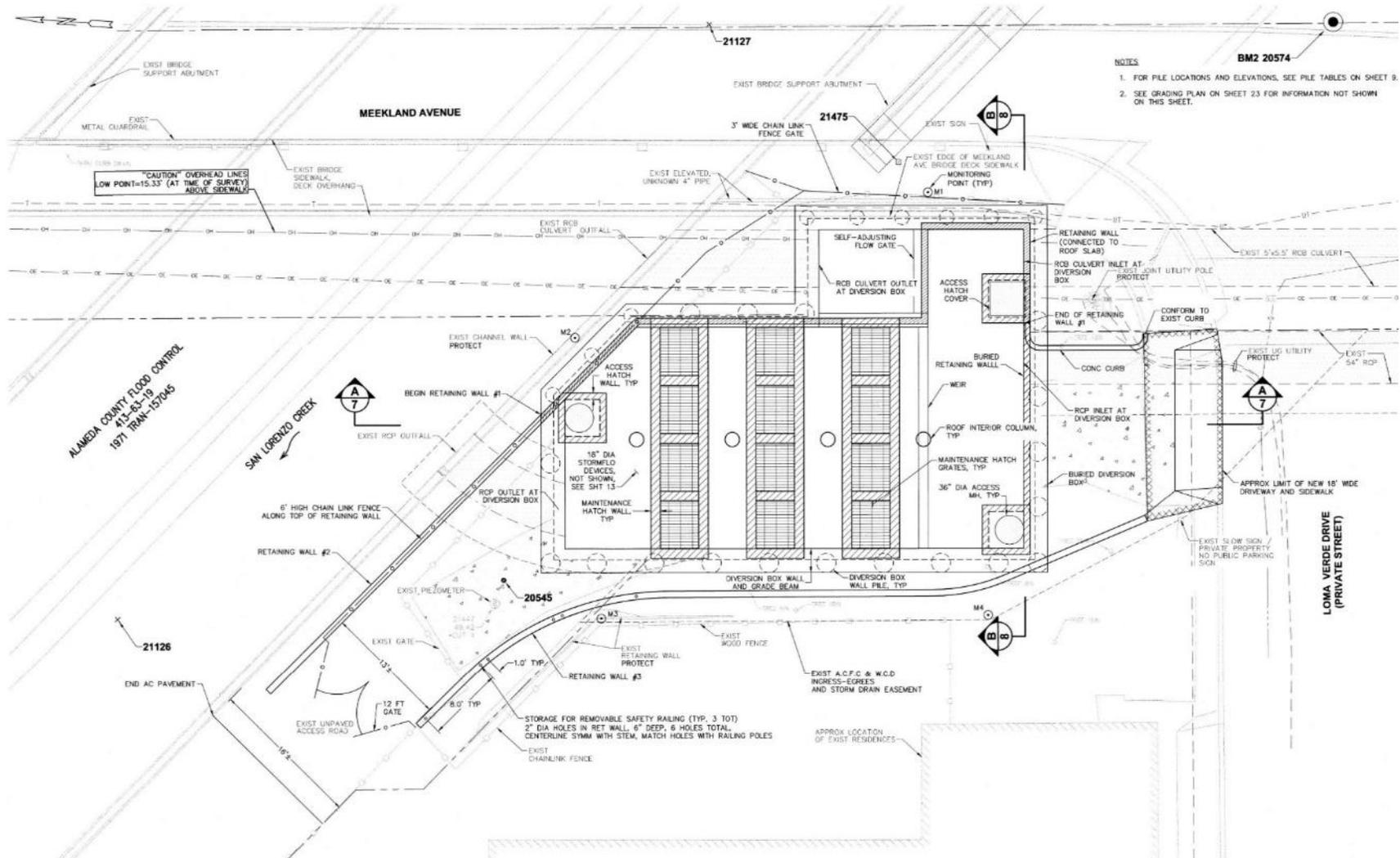


Figure 11-5. San Lorenzo Creek Multi-screen GSRD, site plan

The above plan shows roof hatches. GSRD screens not shown in this view (ACPWA 2018).

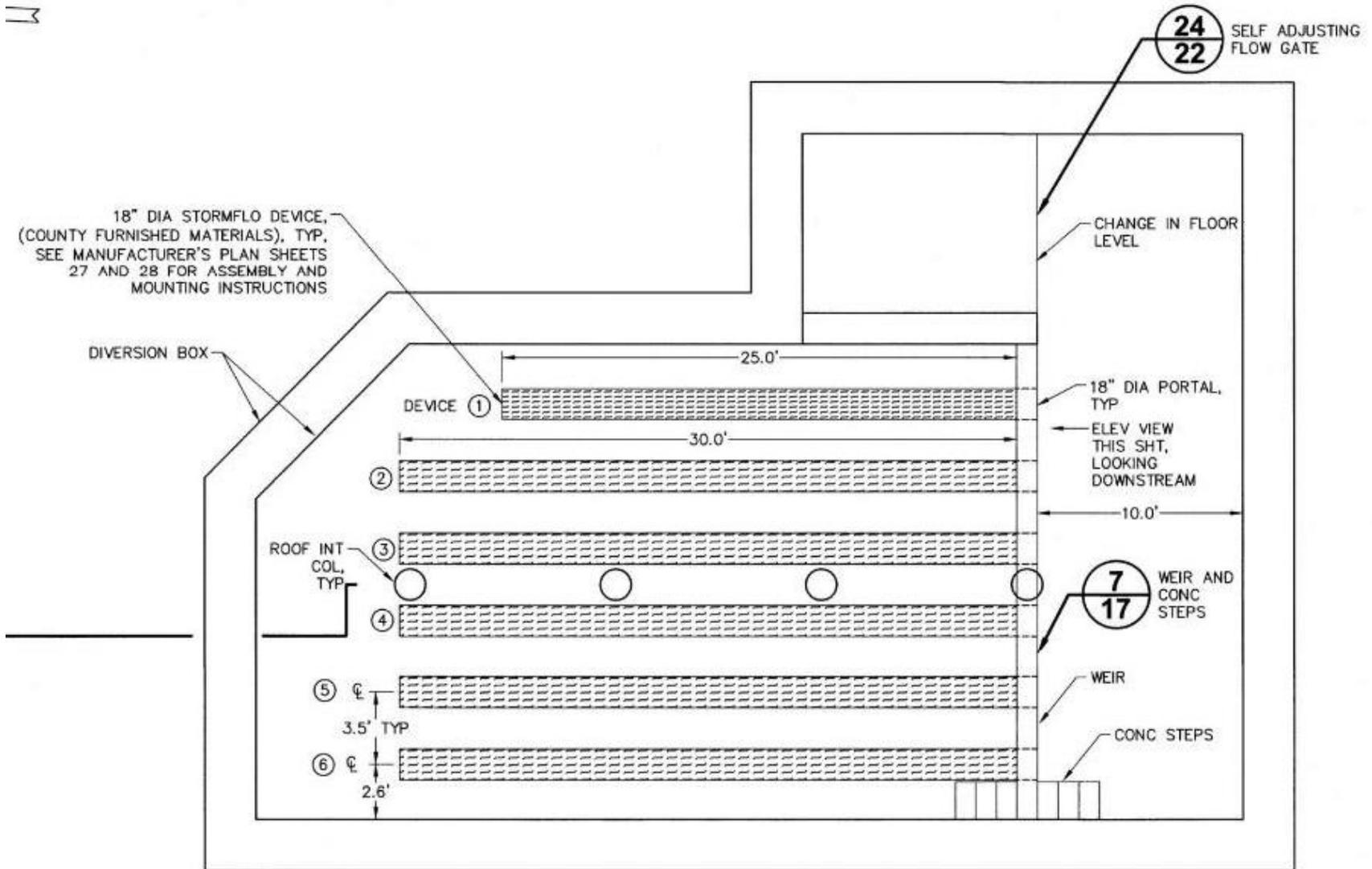


Figure 11-6. San Lorenzo Creek Multi-screen GSRD, device plan

View of multi-screen GSRD plan inside vault (ACPWA 2018).

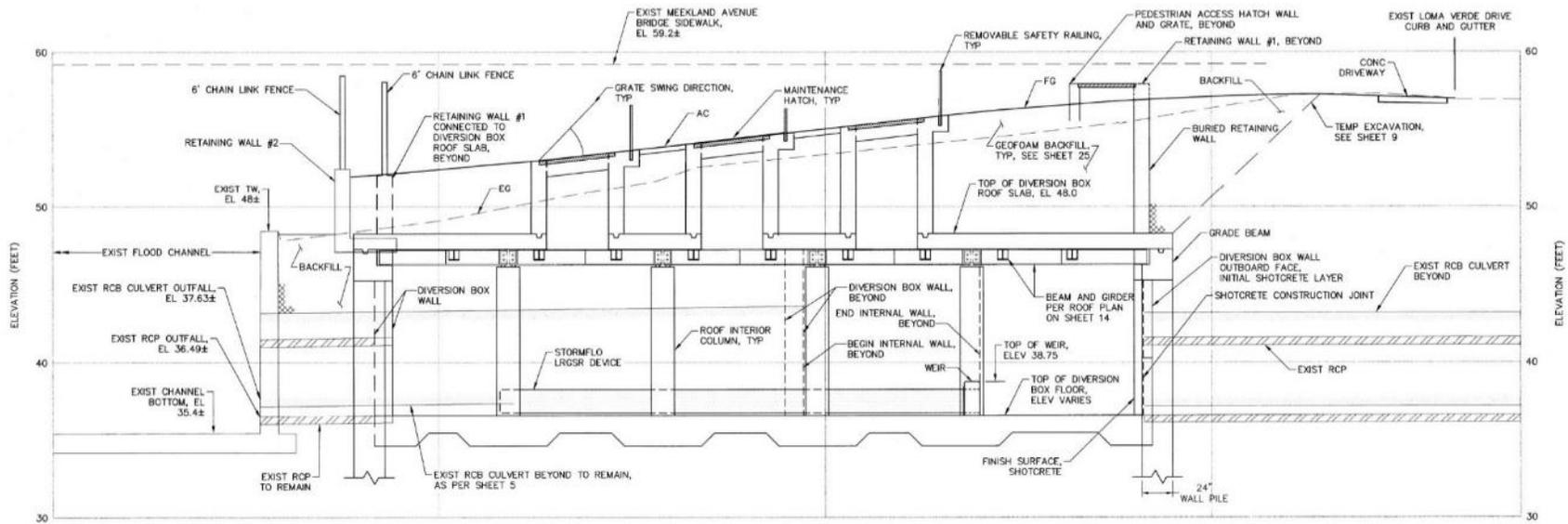


Figure 11-7. San Lorenzo Creek Multi-screen GSRD, Section A-A

See Figure 11-5 for section cut line (ACPWA 2018).

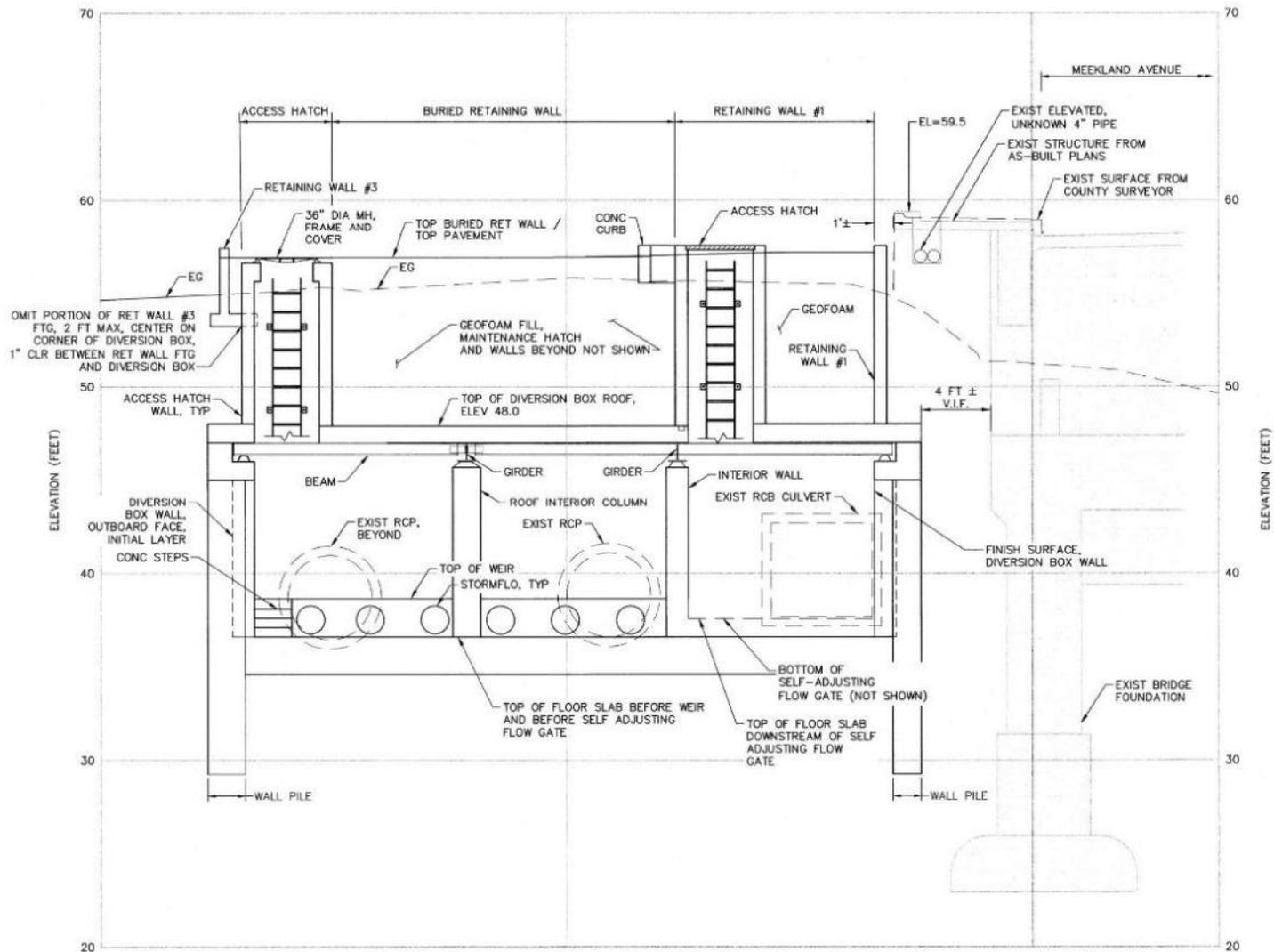


Figure 11-8. San Lorenzo Creek Multi-screen GSRD, Section B-B

See Figure 11-5 for section cut line (ACPWA 2018).

11.2 Design Criteria

Table 11-1 lists the Design Criteria for the multi-screen GSRD at Meekland Avenue at San Lorenzo Creek.

Table 11-1. Meekland Avenue Linear Radial Multi-Screen GSRD Design Criteria

Parameter	Units	Value
Gross Solids Size	in	3/16
Water Quality Flow Rate (1-yr, 6 hr)	cfs	105 ^{a, b}
Peak Design Flow (15-yr, 24 hr)	cfs	235 ^a
Annual Trash Volume (assume 5 gal/ac/yr)	gal	4,625
Trash Capacity of Device	gal	1,157
Catchment Area	acre	925 ^a
Inlet/Outlet Wall Opening	in	box culvert: 60 x 65 RCP: 55 Inlets/Outlets are same ^c
Elevation Drop across device	in	1 ^c
Inlet Runoff Velocity	ft/s	Unavailable

a. Source: Sharon Gosselin, Stormwater Program Manager, Alameda County Public Works Agency

b. The NPDES permit specifies that trash devices must be designed to treat the peak flow rate resulting from a 1-yr, 1-hr storm.

c. Value given is the inside diameter, wall openings unknown. Source: ACPWA 2018

11.2.1 Additional Design Features

Additional Design features for this multi-screen GSRD include:

- Underground vault
- Water quality flow diverted through GSRD using a fixed weir
- Separate outlets for water quality flow and for peak design flow
- Access hatch at surface for maintenance with concrete stairs
- Multi-screens in parallel to minimize weir height and head loss
- Self-adjusting gate for restoring peak flow during peak design storm event
- Lightweight backfill to reduce structure roof loads
- Screen pipe sections are each 10' long which is standard from the manufacturer and reduced cost of fabrication

11.2.2 Design and Construction Cost

The construction costs for this project were approximately \$2,863,000 with an additional \$226,000 to acquire the GSRD device.

11.3 Maintenance

Maintenance staff check the debris level in the GSRD units multiple times during the rainy season and estimate that cleaning is conducted once per year. Three personnel are required to complete the cleanout with one operating a vacuum truck. The other two staff use rakes and or brooms to move debris into the vacuum arm inside the vault. Access into the vault is via multiple hatches at the street level. A ladder to climb down into the vault to rake or broom debris toward the vacuum. The entire cleaning process takes 3 to 4 days. Cleaning upstream of the GSRD is also conducted including silt removal at the overflow diversion structure. The upstream maintenance is not included in the time to clean the units.

Section 12

Special Design Example 3 – Pittsburg Multi-Screen GSRD

12.1 Project Overview

The City of Pittsburg installed a demonstration project consisting of a multi-screen GSRD within an existing basin in 2012. The site originally contained a 64” corrugated pipe that conveyed water under the freeway into a PG&E corridor. Years ago, this section of the pipe was eliminated and left a 35 ft deep pit which holds water and was prone to trash accumulation. The pit now drains into a 42” CMP under a gravel road.

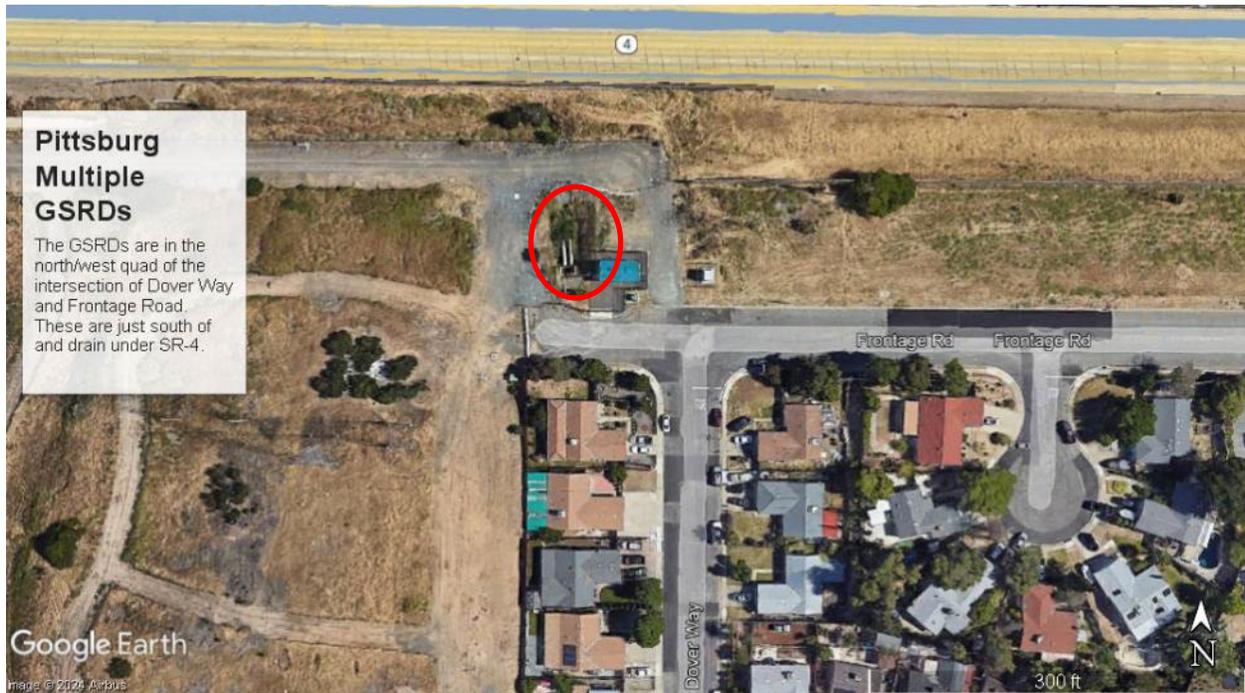


Figure 12-1. Pittsburg Multi-GSRDs after Construction

Aerial image source: Google Earth, 2022

When the Water Board began to prioritize trash capture, the City of Pittsburg designed and installed a multi-screen GSRD which includes two linear radial GSRD screens in parallel. Each screen is 25’ long and 36.5” in diameter.

A low flow box weir was installed at the pipe inlet to the basin which directs low flows into the multi-screen GSRD. Overflows go around the GSRD and water accumulates in the basin. Early on, vandalism was an issue with people trying to steal the metal. The manufacturer has since changed the design of the hinges to make the doors more difficult to steal.⁷

⁷ Source: Personal communication with Jolan Longway, Clean Water Program Coordinator, City of Pittsburg, 2023.



Figure 12-2. Site Conditions prior to Multi-screen GSRD Installation.
Stormwater basin outlet.



Figure 12-3. Pittsburg Multi-screen GSRD installed, south end.
South end with inlet box weir and multi-screen GSRD in riprap basin at the time of installation.



Figure 12-4. Pittsburg Multi-screen GSRD installed, north end.
North end showing multi-screen GSRD in riprap basin and outlet at the time of installation.



Figure 12-5. Pittsburg Multi-screen GSRD, several years after installation.

Several years after installation showing vegetation growth.

12.1.1 Plans, Profiles, and Details

The following figures are an excerpt of the plans for the Pittsburg multi-screen GSRD which were prepared in-house by City staff engineers. Design drawings for the GSRD screens were prepared by the manufacturer and were not available.



Figure 12-6. Pittsburg Multi-Screen GSRD, site plan
(City of Pittsburg, 2011)

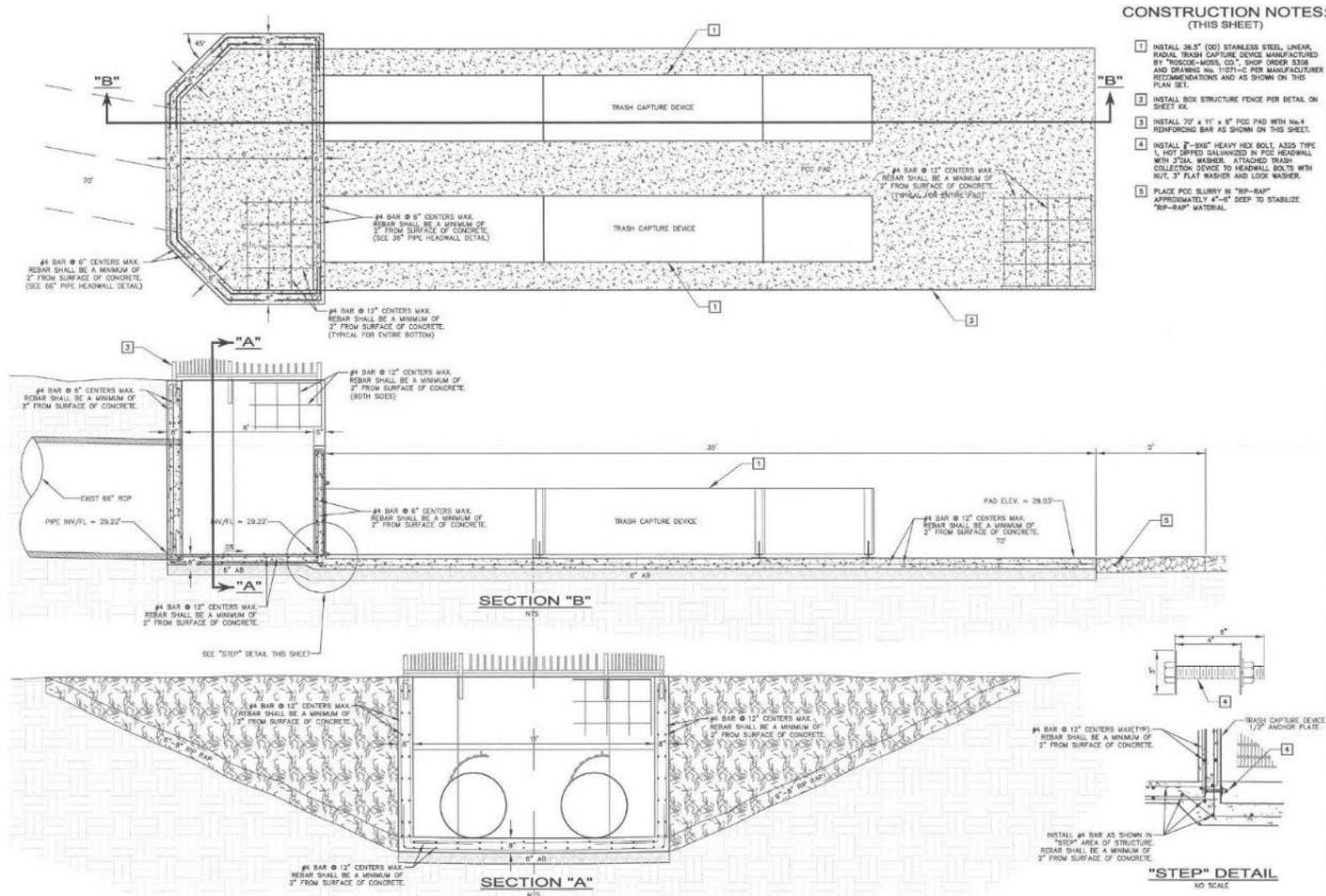


Figure 12-7. Pittsburg Multi-screen GSRD, device plan and sections
(City of Pittsburg, 2011)

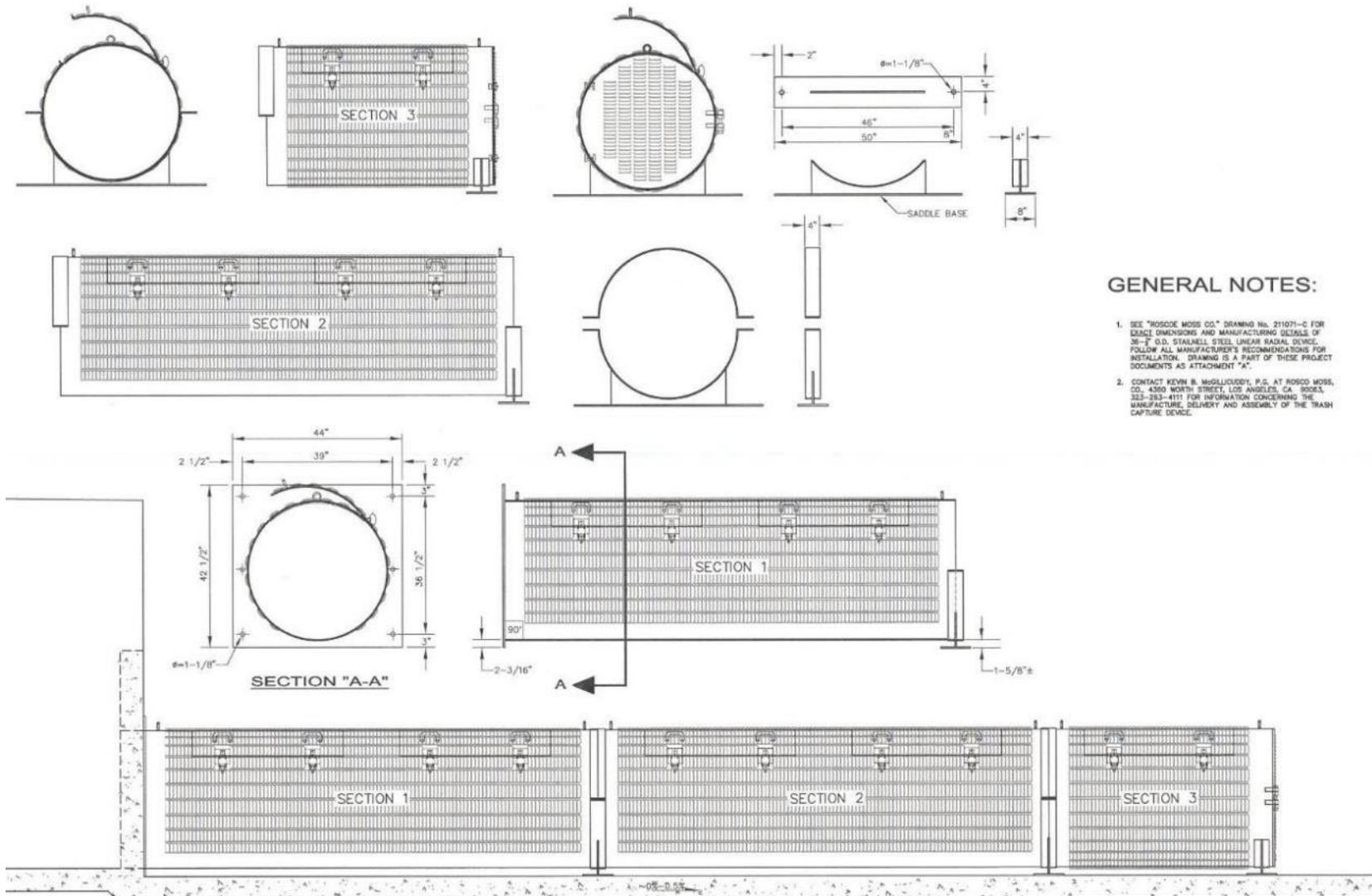


Figure 12-8. Pittsburg Multi-screen GSRD, details

Each GSRD includes two 10 ft screen sections and one 5 ft section (City of Pittsburg, 2011).

12.2 Design Criteria

Table 12-1 lists the Design Criteria for the multi-screen GSRD at Dover Way near SR-4 in Pittsburg, California.

Table 12-1. Pittsburg Linear Radial Multi-Screen GSRD Design Criteria

Parameter	Units	Value
Gross Solids Size	in	3/16
Water Quality Flow Rate (1-yr, 1 hr)	cfs	55 ^b
Peak Design Flow	cfs	unknown
Annual Trash Volume (assumes 8.7 gal/ac/yr)	gal	2,610
Trash Capacity of Device	gal	1,322
Catchment Area	acre	300 ^a
Inlet/Outlet Wall Opening	in	66
Elevation Drop across device	in	1 ^c
Inlet Runoff Velocity	ft/s	unknown

a. Source: Jolan Longway, Clean Water Program Coordinator, City of Pittsburg

b. Source: Roscoe Moss Company

c. Source: City of Pittsburg 2011

12.2.1 Additional Design Features or Challenges

Additional Design features for this multi-screen GSRD include:

- Concrete pad installed below GSRD
- Sides of regraded basin lined with riprap
- Some of the GSRD pipe sections are each 10' long which is standard from the manufacturer and reduced cost of fabrication

12.2.2 Design and Construction Cost

The design for this project was done in-house with the exception of the screens which were designed by the manufacturer. The design cost is unknown. The construction costs for this project were approximately \$87,000 in 2012. The project was funded by a grant from the Association of Bay Area Government's Bay Area Wide Trash Capture Demonstration Project.

12.3 Maintenance

Maintenance is conducted with a vacuum truck and requires 4 people for 1 to 3 hours. Two people vacuum out the GSRD and two people clear vegetation around the screens. Maintenance is typically performed twice a year but occasionally three times per year is required. Access to the GSRD is sometimes constrained because of standing water in the basin which can be hazardous. A stairwell was constructed to access the concrete pad and multi-screen GSRD.

The San Francisco Estuary Partnership tracked the amount of debris recovered from numerous full trash capture devices in 2014. Assuming maintenance was conducted per their standard schedule of twice annually, the trash loading rate derived from the quantities below is equal to

8.7 gal/acre/yr. Their data included trash volumes recovered from a maintenance event in December 2012 for this device (San Francisco Estuary Partnership 2014) and included:

- 14 CF of plastic
- 8.75 CF of paper
- 1.75 CF of metal
- 10.5 CF of sediment
- 140 CF of leaves

The Vista Grande Drainage Basin is a 2.5 square-mile, highly urbanized watershed located in northern San Mateo County, California. Most of the drainage area falls within the limits of the City of Daly City (City); however, a small portion of the northern part of the drainage area is located within the City and County of San Francisco, and a central portion of the drainage area is located within unincorporated San Mateo County. The City plans to construct the Vista Grande Drainage Basin Improvements Project to address storm related flooding in the Vista Grande watershed drainage basin while delivering stormwater to maintain Lake Merced's water level. The existing canal and tunnel do not have adequate hydraulic capacity to convey peak storm flows. The proposed project would alleviate flooding by replacing a section of the undersized canal and diverting stormwater to Lake Merced, reconnecting a significant portion of the Lake Merced Drainage Basin to Lake Merced. Currently, Lake Merced has no outlet, and the Project will reestablish an existing overflow to reconnect Lake Merced to the Pacific Ocean.

The Diversion Structure includes three linear radial GSRD screens in parallel to remove debris and allow direct stormwater discharge to Lake Merced via Impound Lake. Each GSRD screen is 110 ft long, in 10 ft sections, and has a 5 ft diameter. The new facilities upstream of and within the Diversion Structure will be able to divert the 25-year, 4-hour design storm, with a peak flow rate of 1,070 cfs. The existing canal downstream of the Diversion Structure will remain in place, with a capacity of approximately 500 cfs. The Project will rebuild the Vista Grande Tunnel with an enlarged section and hydraulic capacity to match the existing canal flow.

To direct flow into the GSRD, the Diversion Structure will have an approximately 40 ft long reinforced cast-in-place concrete channel between the Arch Culvert and the entrance to the GSRD. Each GSRD screen will be preceded by a 6 ft diameter eccentric reducer to transition flow into the GSRD. The reducers will be cast into the reinforced concrete headwall for the GSRD. The top of the 9 ft high headwall serves as the overflow weir if the GSRD become blocked and water builds up in the inlet channel and Arch Culvert. Under these conditions, approximately 900 cfs can pass over the weir before the inlet channel overflows.

The GSRD screens will be spaced 3 ft apart within a 27 ft wide channel. The spacing between the GSRD screens was reduced from the 30 percent design to reduce costs and the overall size of the Diversion Structure and to allow City staff to clean the GSRD more easily from one side with a truck mounted vacuum system.

The design of the multi-screen GSRD shows a 12 in vertical gap between the screen bottom and the channel floor beneath the screens. The gap will ensure that the flow paths through the screen bottom slots are not restricted by the channel floor. Sediment and small debris that passes through and accumulates under the screens will be removed by City staff hosing the material into the downstream end of the Diversion Structure. The floor underneath the screens is sloped to assist with hosing out of sediment and debris smaller than 5 mm (0.2 in) that passes through the screens.

This project is not yet built and is currently undergoing permitting negotiation with the California Coastal Commission.

13.1.1 Plans, Profiles, and Details

The following figures are an excerpt of the plans prepared in 2020 for the Vista Grande multi-screen GSRD.



Figure 13-2. Vista Grande Multi-screen GSRD, site plan
 The overall project incorporates multiple complex elements (City of Daly City, 2020).

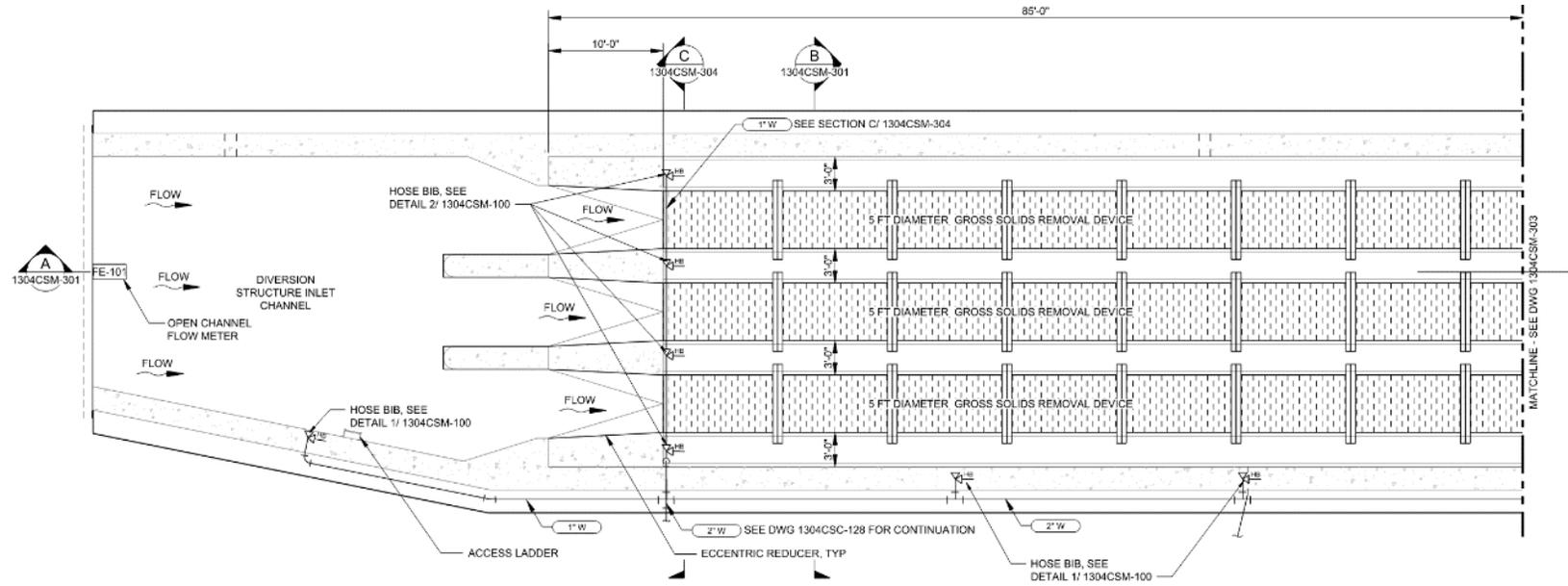


Figure 13-3. Vista Grande Multi-screen GSRD, device plan
The overall length of each GSRD is 110' (City of Daly City, 2020).

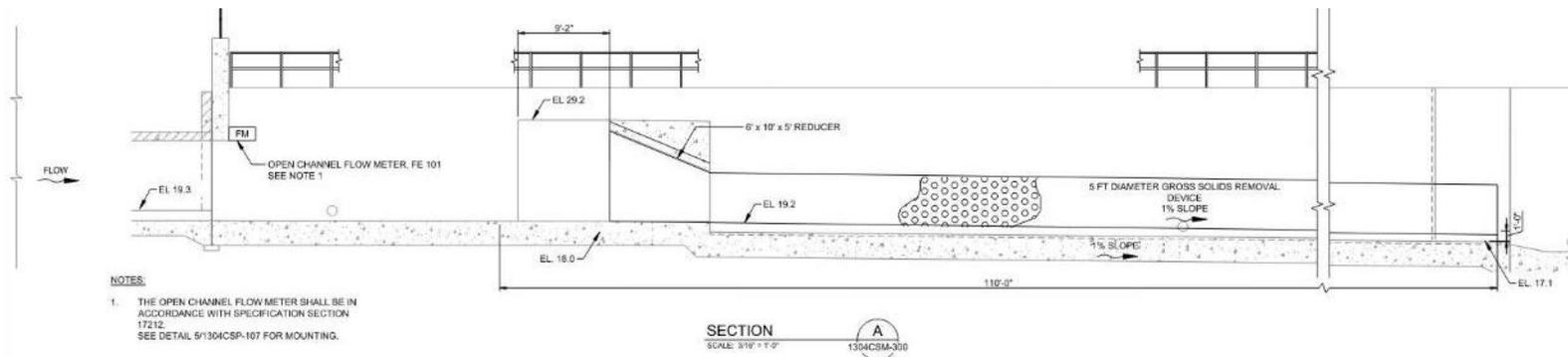


Figure 13-4. Vista Grande Multi-screen GSRD, longitudinal section
The slope of the device is 1% (City of Daly City, 2020).

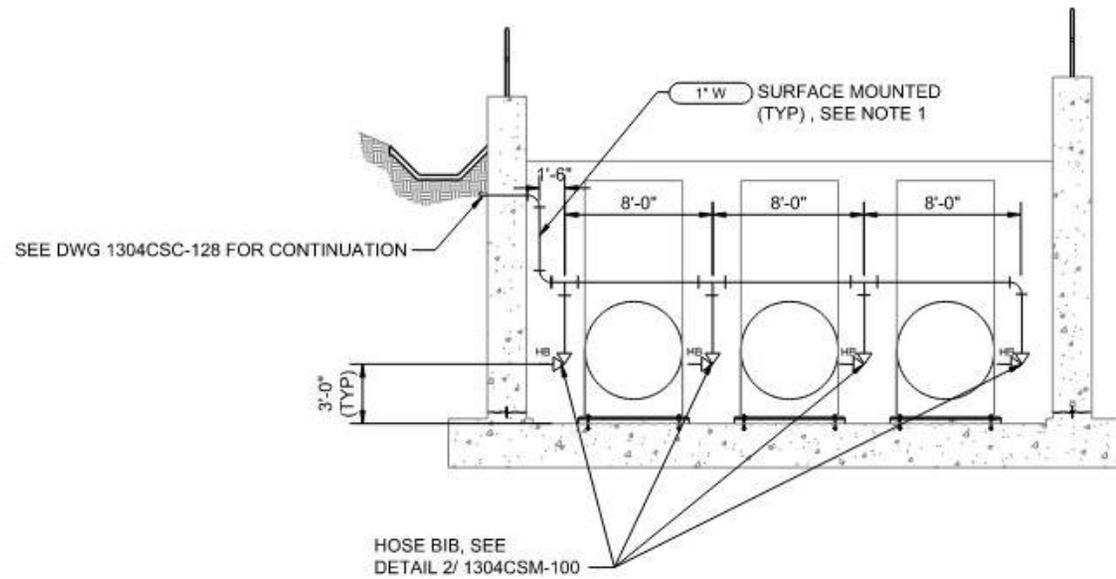


Figure 13-5. Vista Grande Multi-screen GSRD, cross-section
(City of Daly City, 2020)

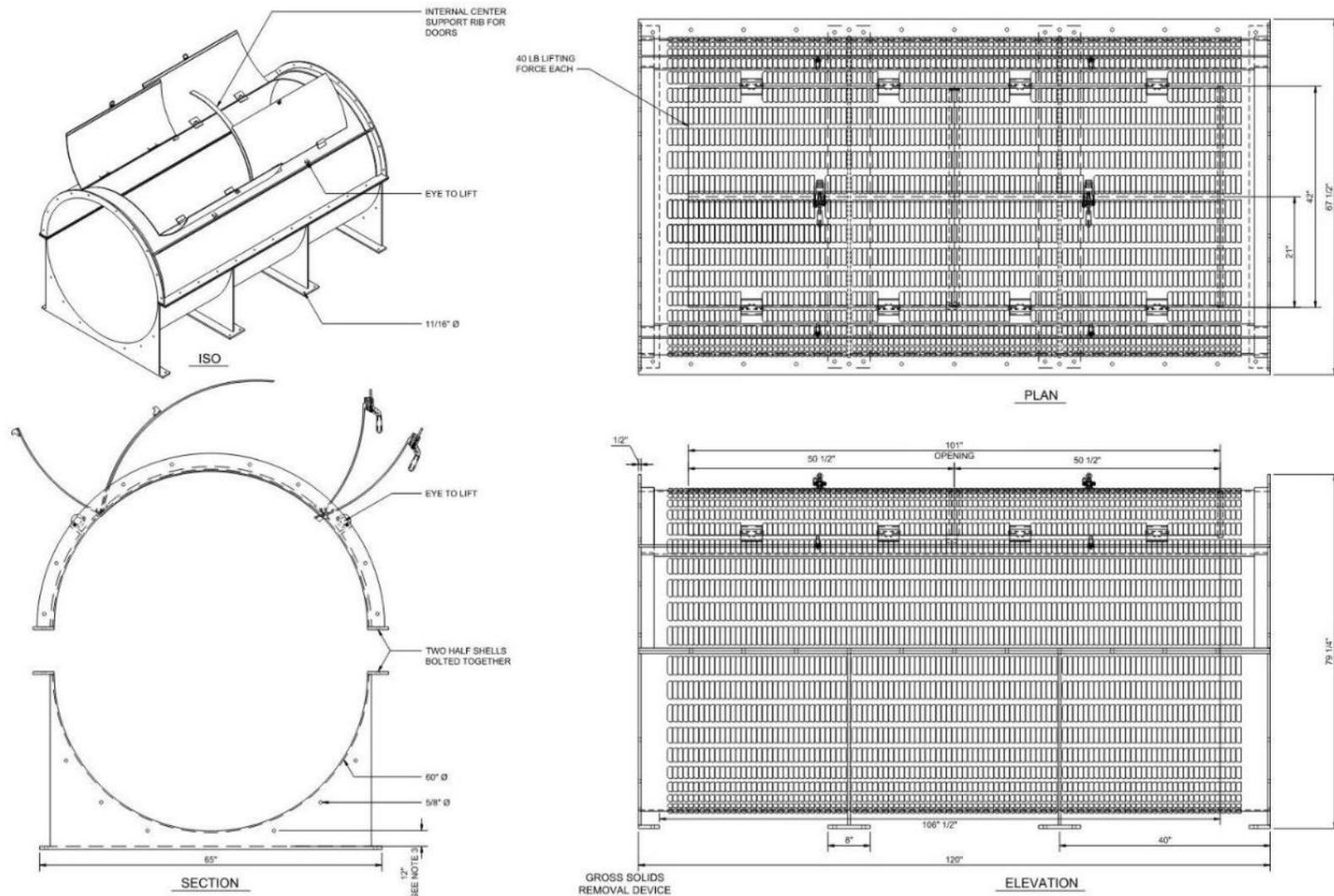


Figure 13-6. Vista Grande Multi-screen GSRD, screen details

Each GSRD section is 10' long (City of Daly City, 2020).

13.2 Design Criteria

Table 13-1 lists the Design Criteria for the Vista Grande multi-screen GSRD in Daly City, California.

Table 13-1. Vista Grande Linear Radial Multi-Screen GSRD Design Criteria

Parameter	Units	Value
Gross Solids Size	in	3/16
Water Quality Flow Rate (1-yr, 1 hr)	cfs	500
Peak Design Flow	cfs	1070
Catchment Area	square mile	2.5
Annual Trash Volume (assuming 5 gal/ac/yr)	gal	8,000
Trash Capacity of Device	gal	19,829
Inlet/Outlet Wall Opening	in	36
Elevation Drop across device	in	1
Inlet Runoff Velocity	ft/s	Unknown

Source: Chris Peters, Senior Manager, Civil Engineering, Brown and Caldwell

13.2.1 Additional Design Features or Challenges

The project involves jurisdictional wetlands and waters, constructed wetlands, a lake, and the Pacific Ocean. Thus, complex permitting across multiple environmental agencies and municipalities has resulted in delays in the initiation of construction for this project.

13.2.2 Design and Construction Cost

The 2022 opinion of cost for construction for the overall project is estimated at \$128M. For the elements of the project related to the GSRD, including the diversion and debris removal structures, screens, slide gates, and new vacuum truck, the estimated construction cost is \$9.7M. The latest opinion of costs for construction was developed in 2022 using the 2020 plan set. A revised set of drawings and opinion of costs is currently under development to address comments and conditions of approval from permitting agencies.

13.3 Maintenance

Because this project is not yet built, there is no information about maintenance demand or frequency however, designers anticipate the following practices and incorporated several design features to facilitate the maintenance. The screens will have 3 ft between and 1 ft channels below them to facilitate maintenance access. The GSRD screens will have hinged hatches that City staff will open to remove debris during maintenance. The hatches will be accessible through the use of a 4 ft tall rolling aluminum scaffolding system with 3 ft tall platform and 2 ft tall step system or miniature ladder. The scaffolding system will be rolled into the channels with the assistance of a 1:4 concrete ramp at the outlet of the GSRD and stored in the storage section of the electrical building. City staff will use a vacuum truck to remove debris from the GSRD. One person will open the hatches and will direct the vacuum head to remove debris from the devices.

Level sensors sending signal through the City supervisory control and data acquisition (SCADA) system installed upstream and downstream of the GSRD will provide the City monitoring data and can be used to alert the City if significant head loss is occurring through the GSRD. An increase in head loss would likely be due to trash accumulation within the GSRD. Based on operation of similar GSRDs in northern California and City staff experience removing debris from the beach below Fort Funston, designers expect that the City will clean the GSRD several times a year, for example, after the first major wet season storm and at the wet season end.

Section 14

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