



Gross Solids Removal Devices

Design Guidance

December 2020

California Department of Transportation
HQ Division of Design

For individuals with sensory disabilities, this document is available in alternate formats upon request. Please call or write to:

**Caltrans Division of Design
Office of Hydraulics and Stormwater Design
P.O. Box 942874, Sacramento, CA 94274-0001**

(916) 653-8896 Voice or dial 711 to use a relay service.

Table of Contents

List of Figures.....	v
List of Tables	v
List of Abbreviations.....	vii
1. Introduction.....	1-1
1.1 Design Responsibility.....	1-1
1.2 Gross Solid Removal Devices.....	1-2
1.2.1 The Linear Radial GSRD	1-2
1.2.2 The Inclined Screen GSRD	1-4
2. Basis of TBMP Detail Drawings.....	2-1
2.1 Design Criteria.....	2-2
2.2 Special Designs	2-2
2.3 Inline vs. Offline Placement.....	2-3
2.4 Safety Considerations.....	2-3
2.5 Restrictions/Coordination.....	2-4
3. Getting Started	3-1
3.1 Preliminary Design Parameters	3-1
3.2 Preliminary Calculations.....	3-9
4. BMP Selection.....	4-1
4.1 Step 1: Review Site Conditions.....	4-1
4.2 Step 2: Identify Candidate GSRD Types.....	4-1
4.3 Step 3: Check Available Space	4-1
4.4 Step 4: Check Grade	4-2
4.5 Step 5: Select GSRD Configuration	4-4
4.5.1 Linear Radial and Linear Radial (HV).....	4-4
4.5.2 Inclined Screen.....	4-5
4.6 Step 6: Check Wall Openings.....	4-6
5. BMP Layout.....	5-1
5.1 GSRD Layout	5-1
5.2 Inlet and Outlet Pipe Requirements.....	5-1
5.3 Space Considerations	5-2
5.4 Construction Requirements	5-2
6. Design Elements.....	6-1
6.1 Maintenance	6-1
6.2 Design Storm	6-1



TABLE OF CONTENTS

6.3	Flow Splitters.....	6-2
6.4	Energy Dissipation.....	6-2
7.	PS&E Preparation.....	7-1
7.1	Plans.....	7-1
7.2	Specifications.....	7-2
7.2.1	Standard Specifications.....	7-2
7.2.2	Standard Special Provisions.....	7-3
7.2.3	Non-Standard Special Provisions.....	7-3
7.3	Project Cost Estimates.....	7-3
7.3.1	PID and PA/ED Phases.....	7-3
7.3.2	PS&E Phase.....	7-4
7.4	Developing GSRD Cost Estimates.....	7-4
7.5	Plan Sheet Approval.....	7-4
7.6	GSRD Nomenclature.....	7-5
8.	Special Designs.....	8-1
8.1	Flow Rate (Linear Radial and Inclined Screens).....	8-1
8.2	Debris Area (Linear Radial and Inclined Screens).....	8-2
8.3	Pipe Diameter (Linear Radial and Inclined Screens).....	8-3
8.4	Customizing the GSRD Detail Drawings.....	8-4
9.	Design Example.....	9-1
9.1	GSRD Selection Example.....	9-1
9.2	PS&E Preparation.....	9-5
10.	References.....	10-1



List of Figures

Figure 1-1. Linear Radial (HV) GSRD	1-3
Figure 1-2. Inclined Screen GSRD	1-5
Figure 3-1. GSRD Debris Area vs. Drainage Area	3-2
Figure 3-2. Linear Radial (HV) Screen Height vs. Inlet Wall Opening	3-9
Figure 4-1. Typical GSRD Selection Flowchart	4-3
Figure 4-2. Linear Radial GSRD Structure Cross Section	4-4
Figure 4-3. Linear Radial (HV) GSRD Structure Cross Section	4-5
Figure 4-4. Inclined Screen Structure Cross Section	4-6
Figure 9-1. Aerial Photograph Outfall 405-3190.....	9-1
Figure 9-2. As-Built Drainage Profile – Outfall 405-3190	9-2
Figure 9-3. Example Layout Plan.....	9-6
Figure 9-4. Example Drainage Plan	9-7
Figure 9-5. Example Drainage Profile	9-8

List of Tables

Table 2-1. Linear Radial GSRD Design Criteria.....	2-2
Table 2-2. Inclined Screen GSRD Design Criteria	2-2
Table 3-1. GSRD Design Flows	3-2
Table 3-2. GSRD Debris Areas	3-3
Table 3-3. GSRD Out-to-Out Dimensions ¹	3-4
Table 3-4. Linear Radial GSRD Elevation Drop.....	3-6
Table 3-5. Linear Radial (HV) GSRD Elevation Drop	3-7
Table 3-6. Linear Radial (HV) GSRD Maximum Wall Openings.....	3-8
Table 7-1. Example of Locations of Construction.....	7-2
Table 8-1. GSRD Screen Capacities	8-1



TABLE OF CONTENTS

This page intentionally left blank.



List of Abbreviations

'	foot/feet	SSHM	Small Storm Hydrology Method
"	inch/inches	SWRCB	State Water Resources Control Board
BEES	Basic Engineering Estimating System	SSP	Standard Special Provision
BMP	Best Management Practice	TBMP	Treatment Best Management Practice
CB	catch basin	TMDL	Total Maximum Daily Load
CF	cubic foot		
cfs	cubic feet per second		
CMP	corrugated metal pipe		
CRZ	Clear Recovery Zone, (AASHTO)		
CSP	Corrugated Steel Pipe		
ft	foot/feet		
FRP	fiberglass reinforced plastic		
gpm	gallons per minute		
GSRD	Gross Solids Removal Device		
H	Wall Height		
HDM	Highway Design Manual		
HQ	Headquarters		
HSU	Hydrodynamic Separator Unit		
Ht	height		
HV	High Velocity		
in	inches		
L	Screen Length		
LR	Linear Radial		
m	meters		
max	maximum		
min	minimum		
nSSP	Non-Standard Special Provision		
OG	original grade		
OHSD	Office of Hydraulics and Stormwater Design		
PE	Project Engineer		
PM	post mile		
PS&E	Plans, Specifications and Estimate		
R/W	right-of-way		
RWQCB	Regional Water Quality Control Board		
S	slope		



TABLE OF CONTENTS

This page intentionally left blank.



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 Caltrans highways and facilities. GSRDs are Treatment Best Management Practices (TBMPs) which use screening technology to capture the trash or gross solids 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 an Infiltration Trench into Plans, Specifications, and Estimates (PS&E) packages
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 2019a).

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. 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 stormwater infiltration 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 for project drainage requirements. To achieve sustainability requirements, the Project Development Team (PDT) is encouraged to use native and climate appropriate vegetation that does not require irrigation and requires the least amount of maintenance.



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 intended for standard inline designs specifically designed for 100 percent removal of gross solids 3/16-inch (5 mm) or greater from stormwater runoff with the capacity to retain one year's worth of solids loading to facilitate annual cleaning.

It is preferred that GSRDs be placed offline with an upstream flow splitter to minimize the size of the BMP. See Section 2.3 for additional details. The calculations in this guidance assume instantaneous runoff to the BMP (i.e., 'slug-flow') which is likely conservative. Alternative sizing calculations, like unsteady-flow storage routing, may be used to refine the BMP size, see Section 8.1. Additionally, if the design includes cleaning more frequently than one year or if GSRDs are installed in parallel, the sizing calculations can be modified as a Special Design.

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), debris areas up to 4.74 acres (see Section 3.2 for an explanation of debris area), and grades with slopes (inlet to outlet) up to 4:1 (H:V). It utilizes 3/16-inch x 2.5-inch nominal louver slots to remove gross solids, litter and debris from stormwater runoff. The slots are machined into a 2 foot (ft) diameter stainless steel pipe usually housed in a concrete vault. The Linear Radial GSRD is designed such that the influent runoff 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 right-of-ways
- Applicable to sites with as little as 4.5 inches of elevation drop to sites with as much as 5 ft of elevation drop
- Overflow mechanism at the upstream end
- Unslotted initial pipe section, usually a product of length
- Smooth, solid bottom intermediate sections (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 debris areas
- 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 GSRD Detail Drawings (Caltrans 2020b) include two Linear Radial configurations – a model for influent runoff velocities less than or equal to 8.2 ft per second (referred to as “Linear Radial” in the drawings), and a model for high velocity (HV) influent runoff with velocities greater than 8.2 ft per second (referred to as “Linear Radial (HV)” in the drawings).

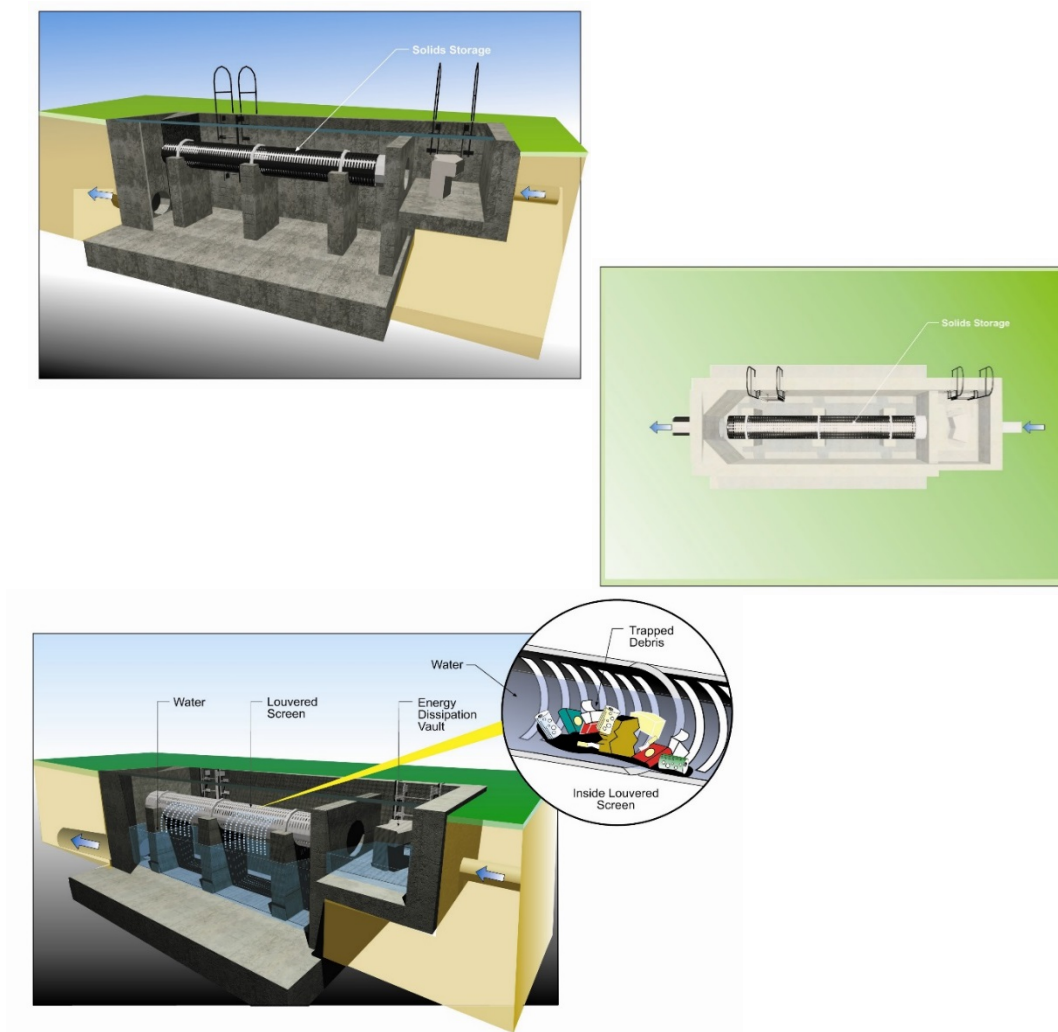


Figure 1-1. Linear Radial (HV) GSRD

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, debris areas up to 7.74 acres 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 by increasing the self-cleansing 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 debris areas
- 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.

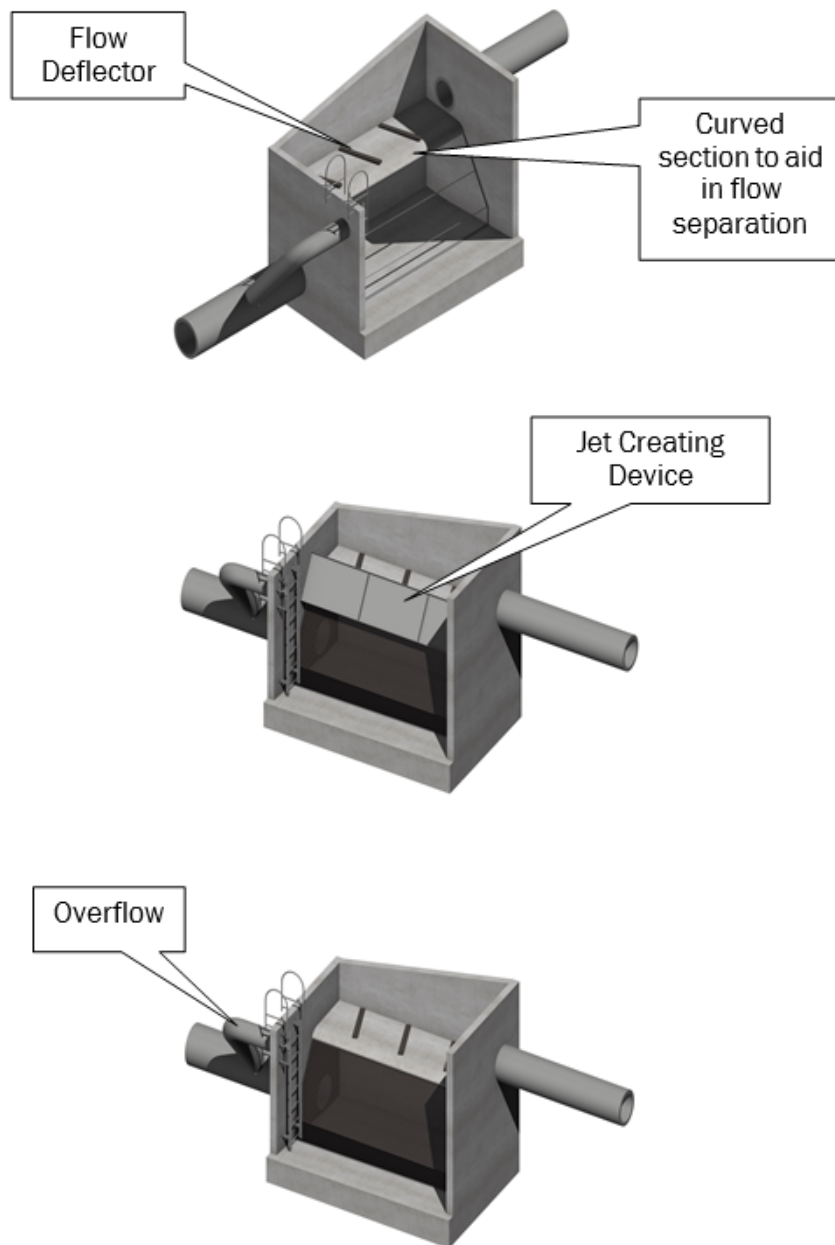


Figure 1-2. Inclined Screen GSRD

This page intentionally left blank.



Section 2

Basis of TBMP Detail Drawings

Caltrans has developed a Statewide Trash Implementation Plan (Plan; Caltrans 2019b) to prevent the discharge of trash to surface waters through stormwater discharges. The Plan identifies statewide Significant Trash Generating Areas (STGAs) requiring consideration of full trash capture BMPs. GSRDs are a full trash capture BMP and be included in the design for projects 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-inch (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-inch (5 mm) and larger in size from stormwater runoff.
2. The GSRD must be able to treat or bypass the design flow, typically using the Q₂₅ design storm, as specified in the Highway Design Manual (HDM) under Chapter 830² when installed inline.

Litter and debris accumulation data need to be available to properly size the devices for the given drainage area. Designers should consult with District Maintenance regarding litter and debris loads. If data is not available, use 75 gal/acre/year for Gross Solids Accumulation Rates shown in Tables 2-1 and 2-2.

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.

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

² The NPDES Permit specifies that trash devices must be designed to treat the peak flow rate resulting from a one-year, one-hour storm.

2.1 Design Criteria

GSRDs must meet certain design criteria to perform as an effective TBMP. A set of GSRD Detail Drawings have been developed for use in siting GSRDs and can be obtained from OHSD. Tables 2-1 through 2-2 present the design criteria utilized for the development of the GSRD Detail Drawings.

Table 2-1. Linear Radial GSRD Design Criteria

Parameter	Units	Min. Value LR	Min. Value LR (HV)	Max. Value LR	Max. Value LR(HV)
Gross Solids Size	in	3/16	3/16	-	-
Gross Solids Accumulation Rate	gal/acre/yr	-	-	75	75
Flow Rate	cfs	-	-	21.9	21.9
Debris Area	acre	-	-	4.74	4.74
Inlet/Outlet Wall Opening	in	-	-	30/30	27/50
Elevation Drop across device ¹	in	5	7	44	46
Inlet Runoff Velocity	ft/second	-	-	8.2	20

1. minimum corresponds to LR with one pipe screen section, and maximum corresponds to six pipe screen sections

Table 2-2. Inclined Screen GSRD Design Criteria

Parameter	Units	Min. Value	Max. Value
Gross Solids Size	in	3/16	-
Gross Solids Accumulation Rate	gal/acre/yr	-	75
Flow Rate	cfs	-	20.4
Debris Area	acre	-	7.74
Inlet/Outlet Wall Opening	in	-	30/30
Elevation drop across device	in	66	66
Inlet Runoff Velocity	ft/second	-	20

The GSRD Detail Drawings can be renamed and/or revised as necessary by the PE in responsible charge of the project. The drawings 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.

2.2 Special Designs

A Special Design will be required for sites or conditions that do not meet the standard design criteria listed in Tables 2-1 and 2-2, such as:

- High ground water table (above the bottom of the concrete footing of the AVSF)

- 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 per second (fps) 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

See Section 8 for more information on Special Designs.

2.3 Inline vs. Offline Placement

A GSRD can be placed in an inline or offline configuration however, offline placement is preferred.

A. Inline Placement

A GSRD is placed in an inline configuration when overflow events 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 generated during the Design Storm (see Section 6.2) through the TBMP to downstream conveyance without objectionable backwater effects to upstream facilities or causing erosion.

B. Offline Placement

A GSRD is placed in an offline configuration when runoff in excess of the peak flows generated by the 1-year, 1-hour event is diverted around the BMP by means of an upstream flow splitter. Flow diversion structures typically consist of flow splitters, weirs, orifices, or pipes to bypass excess runoff as discussed in Section 6.5. Even in an offline placement, overflow bypass must be considered.

2.4 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). 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.

2.5 Restrictions/Coordination

Successful implementation and utilization of the GSRD Detail Drawings 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 Tables 2-1 and 2-2 (for exceptions see Section 8). Design decisions and coordination must be documented in the SWDR and project file.

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

- The details are not applicable for use in corrosive environments, abrasive flow conditions, or areas where there are substantial freeze-thaw conditions
- The details are not applicable if the inlet pipe is not oriented between 80 and 90 degrees (horizontal) from the inlet wall
- The details are not applicable if the velocity of the runoff entering the GSRD exceeds 20 ft per second
- The details are not applicable for use within the traveled way or where the GSRD will be subject to traffic loads (LRFD; AASHTO 2014)
- The details are not applicable in conditions where the seasonally high groundwater level is above the bottom of the GSRD footing
- The details are not applicable if the backfill or finished grade differential exceeds 4 ft between sidewalls or 8 ft between inlet and outlet walls

If the site conditions do not meet all the above requirements, a special design will be required. Section 8 presents guidelines on how special designs may be achieved.

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 if any of the GSRDs included in the drawings are 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 BMP has been selected. As a result, no BMP selection or site selection guidelines are provided herein.

This guidance and the GSRD Detail Drawings assume that the GSRD is configured inline. Additionally, alternative sizing calculations may be used to refine the BMP size. When an offline configuration or alternative sizing calculations are used a Special Design may be necessary, see Section 8.

3.1 Preliminary Design Parameters

The following design parameters are needed to utilize the GSRD Detail Drawings.

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

- Debris Area:** The GSRD gross solids storage area is sized based on the device's debris area, or untreated tributary drainage area. 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.

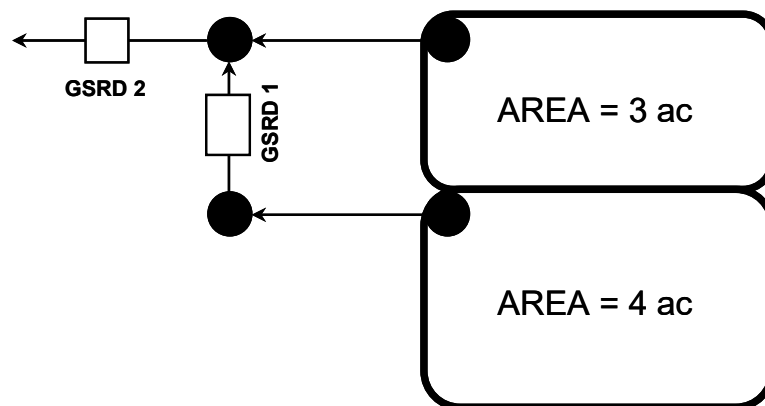


Figure 3-1. GSRD Debris Area vs. Drainage Area

In the above figure, GSRD 2 has a total tributary drainage area of seven acres. 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 three acres. If GSRD 1 did not exist, then the debris area for GSRD 2 would be equivalent to its tributary drainage area of seven acres. 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 maximum Debris Area (in acres) that each GSRD type is designed to accommodate assuming the maximum loading rate of 10 CF (75 gals/ac/yr); however, it should be understood that flow may control the selection of the GSRD along with actual loading rate. Refer to Trash Net Design Guidance Section 3 (Caltrans 2020c) to estimate actual loading rate based on debris area characteristics. Maximum Debris Areas in Table 3-2 can be increase as a ratio of the maximum value of 10 CF (75 gals/ac/yr). As an example, a loading rate of 5 CF for a Type LR-1 would double the maximum debris area to 1.58 acres.

GSRD	Type	Max. Debris Area (acre)
Linear Radial	LR-1	0.79
Linear Radial	LR-2	1.58
Linear Radial	LR-3	2.25
Linear Radial	LR-4	3.16
Linear Radial	LR-5	3.95
Linear Radial	LR-6	4.74
Linear Radial (HV)	LR(HV)-1	0.79
Linear Radial (HV)	LR(HV)-2	1.58
Linear Radial (HV)	LR(HV)-3	2.25
Linear Radial (HV)	LR(HV)-4	3.16
Linear Radial (HV)	LR(HV)-5	3.95
Linear Radial (HV)	LR(HV)-6	4.74
Inclined Screen	A	2.21
Inclined Screen	B	3.31
Inclined Screen	C	4.41
Inclined Screen	D	5.52
Inclined Screen	E	6.63
Inclined Screen	F	7.74

3. **GSRD Dimensions:** The footprint requirements of each GSRD were developed based on the design flow rates and debris areas. 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.

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	9.5
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 – Detail No. 4 inch 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 – Detail No. 4” 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 the Linear Radial (HV) configuration is needed, and 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 per second, 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 Tables 3-1 and 3-2). When the inlet velocity exceeds 20 ft per second 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 Detail Drawings 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 Linear Radial (HV) configurations [LR(HV)-1 through LR(HV)-6], come in three wall height configurations:

- 4 ft
- 6 ft
- 8 ft

The Type 2 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 GSRD Detail Drawings 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.

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 in essence provides the minimum and maximum slope that an existing pipe may exhibit in order to be retrofitted with a Linear Radial GSRD. A summary of this information is presented in Table 3-4. The information presented in the Table 3-5 applies to the Linear Radial (HV).



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, with drainage profiles having a fairly flat slope and close to the elevation of the upstream drop inlet being more problematic than a GSRD placed at toe of a slope below a roadway and drainage system on embankment. Refer to the UC Davis report "Laboratory Testing of Gross Solids Removal Devices" for additional guidance on dynamic head losses.

Table 3-4. Linear Radial GSRD Elevation Drop

LR ¹	Wall Ht.	Inside Vault Length ²	Inlet Pipe Cover ³ Min. Elevation Drop	Inlet Pipe Cover ³ Max. Elevation Drop	Drop between Inlet and Outlet Inverts Min.	Drop between Inlet and Outlet Inverts Max.	Max. Elevation Drop ⁴
1	4	16.8	1.00	1.00	0.42	0.42	0.25
1	6	16.8	3.00	1.00	0.42	2.42	2.25
1	8	16.8	5.00	2.00	0.42	3.42	3.25
2	4	21.8	1.00	1.00	0.47	0.47	0.25
2	6	21.8	3.00	1.00	0.47	2.47	2.25
2	8	21.8	5.00	2.00	0.47	3.47	3.25
3	4	26.8	1.00	1.00	0.52	0.52	0.25
3	6	26.8	3.00	1.00	0.52	2.52	2.25
3	8	26.8	5.00	2.00	0.52	3.52	3.25
4	4	31.8	1.00	1.00	0.57	0.57	0.25
4	6	31.8	3.00	1.00	0.57	2.57	2.25
4	8	31.8	5.00	2.00	0.57	3.57	3.25
5	4	36.8	1.00	1.00	0.62	0.62	0.25
5	6	36.8	3.00	1.00	0.62	2.62	2.25
5	8	36.8	5.00	2.00	0.62	3.62	3.25
6	4	41.8	1.00	1.00	0.67	0.67	0.25
6	6	41.8	3.00	1.00	0.67	2.67	2.25
6	8	41.8	5.00	2.00	0.67	3.67	3.25

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-inch 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 Height	Inside Vault Length h ² L1	Inside Vault Length h ² L2	Inside Vault Length h ² Total	Inlet Pipe Cove r ³ Min. Drop	Inlet Pipe Cove r ³ Max. Drop	Drop between Inlet and Outlet Inverts Min.	Drop between Inlet and Outlet Inverts Max.	Max. Elevation Drop ⁴
1	4	15.3	4.0	19.3	1.00	1.00	0.60	0.60	0.25
1	6	15.3	4.0	19.3	3.00	1.00	0.60	2.60	2.25
1	8	15.3	4.0	19.3	5.00	2.00	0.60	3.60	3.25
2	4	20.3	4.0	24.3	1.00	1.00	0.65	0.65	0.25
2	6	20.3	4.0	24.3	3.00	1.00	0.65	2.65	2.25
2	8	20.3	4.0	24.3	5.00	2.00	0.65	3.65	3.25
3	4	25.3	4.0	29.3	1.00	1.00	0.70	0.70	0.25
3	6	25.3	4.0	29.3	3.00	1.00	0.70	2.70	2.25
3	8	25.3	4.0	29.3	5.00	2.00	0.70	3.70	3.25
4	4	30.3	4.0	34.3	1.00	1.00	0.75	0.75	0.25
4	6	30.3	4.0	34.3	3.00	1.00	0.75	2.75	2.25
4	8	30.3	4.0	34.3	5.00	2.00	0.75	3.75	3.25
5	4	35.3	4.0	39.3	1.00	1.00	0.80	0.80	0.25
5	6	35.3	4.0	39.3	3.00	1.00	0.80	2.80	2.25
5	8	35.3	4.0	39.3	5.00	2.00	0.80	3.80	3.25
6	4	40.3	4.0	44.3	1.00	1.00	0.85	0.85	0.25
6	6	40.3	4.0	44.3	3.00	1.00	0.85	2.85	2.25
6	8	40.3	4.0	44.3	5.00	2.00	0.85	3.85	3.25

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-inch 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 GSRD is a function of the wall opening size and the pipe wall thickness. For example, a 24-inch Corrugated Steel Pipe (CSP) might require a 27-inch wall opening, while a 24-inch Reinforced Concrete Pipe might require a 30-inch wall opening. In order for the GSRD Detail Drawings 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.

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. Another reason for limiting the inlet pipe to 24-inches is because the maximum flow rate of the device is 21.9 cfs. A slope of 0.0125 is calculated using the following parameters: n value of 0.015, flow of 21.9 cfs, and a pipe diameter of 24 inches. This slope is within the allowable footprint confinements of the device.

The Linear Radial (HV) GSRD comes in three wall height configurations: 4-, 6-, and 8-ft. The Linear radial (HV) supports variable screen heights. At the minimum screen height, the maximum inlet wall opening for the 4-ft model is 27 inches. The maximum inlet wall opening for the 6- and 8-ft models is 50 inches. Whereas the Linear Radial inlet pipe connects directly to the 24-inch 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. For the outlet pipe, the maximum pipe opening for the 4-ft model is 27 inches, and the maximum opening for the 6- and 8-ft models is 50 inches. A summary of the maximum Linear Radial (HV) wall openings is presented in Table 3-6. The actual relationship between the screen height and the maximum inlet wall opening is presented in Figure 3-2.

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

GSRD Configuration	Wall Height (ft)	Max. Wall Opening (in) Inlet	Max. Wall Opening (in) Outlet
LR(HV)-1	4	27	28
LR(HV)-2	4	27	28
LR(HV)-3	4	27	28
LR(HV)-4	4	27	28
LR(HV)-5	4	27	28
LR(HV)-6	4	27	28
LR(HV)-1	6	50	50
LR(HV)-2	6	50	50
LR(HV)-3	6	50	50
LR(HV)-4	6	50	50
LR(HV)-5	6	50	50
LR(HV)-6	6	50	50
LR(HV)-1	8	50	50
LR(HV)-2	8	50	50
LR(HV)-3	8	50	50
LR(HV)-4	8	50	50
LR(HV)-5	8	50	50
LR(HV)-6	8	50	50

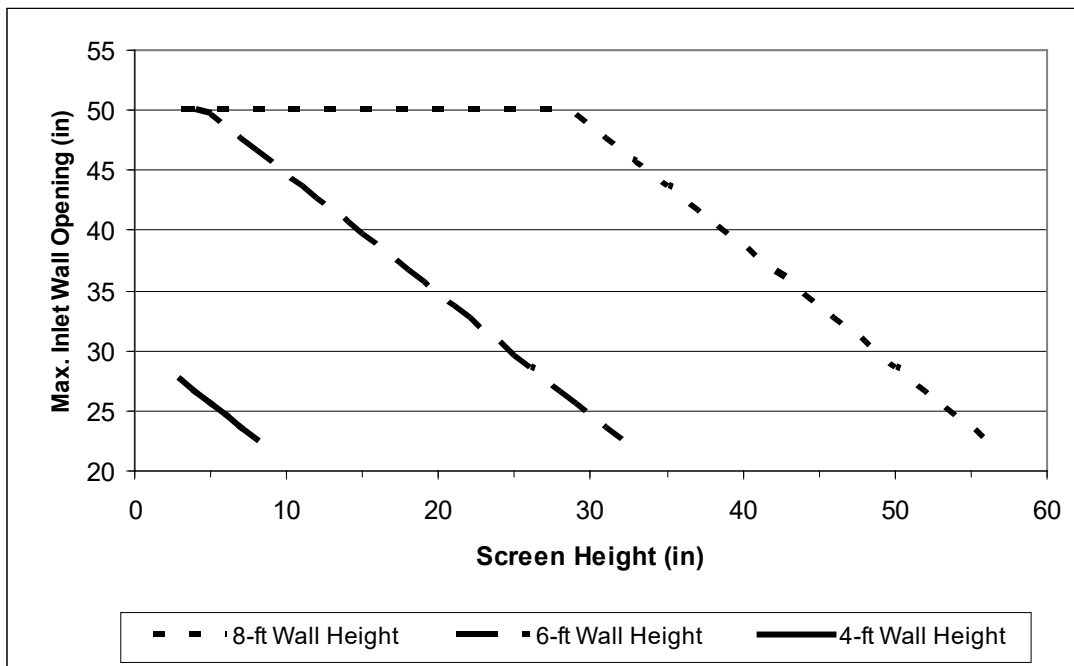


Figure 3-2. Linear Radial (HV) Screen Height vs. Inlet Wall Opening

The Inclined Screen GSRD comes in six types (A, B, C, D, E and F). The maximum inlet and outlet wall opening is 30 inches. The size of the wall opening is limited due to the flow limitation of the device, which is 20.4 cfs. A slope of 0.0108 is calculated using the following parameters: n value of 0.015, flow of 20.4 cfs, and a pipe diameter of 24 inches. This slope is within the allowable footprint confinements of the device.

3.2 Preliminary Calculations

In order to utilize the GSRD Detail Drawings and select the appropriate GSRD, the following calculations/analyses need to be performed:

1. Existing site conditions
2. Design Flow Rate/Velocity
3. Debris Area
4. Available Space Requirements
5. Available Grade (for elevation drop)
6. Wall Heights
7. Pipe Wall Openings

This calculations are described next in Section 4 as Steps 1 – 6.

This page intentionally left blank.



Section 4

BMP 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 GSRD Detail Drawings assume that the GSRD is configured inline. Additionally, alternative sizing calculations may be used to refine the BMP size. When an offline configuration or alternative sizing calculations are used a Special Design may be necessary, see Section 8.

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 debris area. Using Tables 3-1 and 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 a debris area of 3.6 acres, then either the Linear Radial LR-5 or the Inclined Screen 2-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 debris area is greater than 7.74 acres), 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 Tables 2-1, 3-4, and 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 2-2 can be satisfied.

Note that for a retrofit, 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.

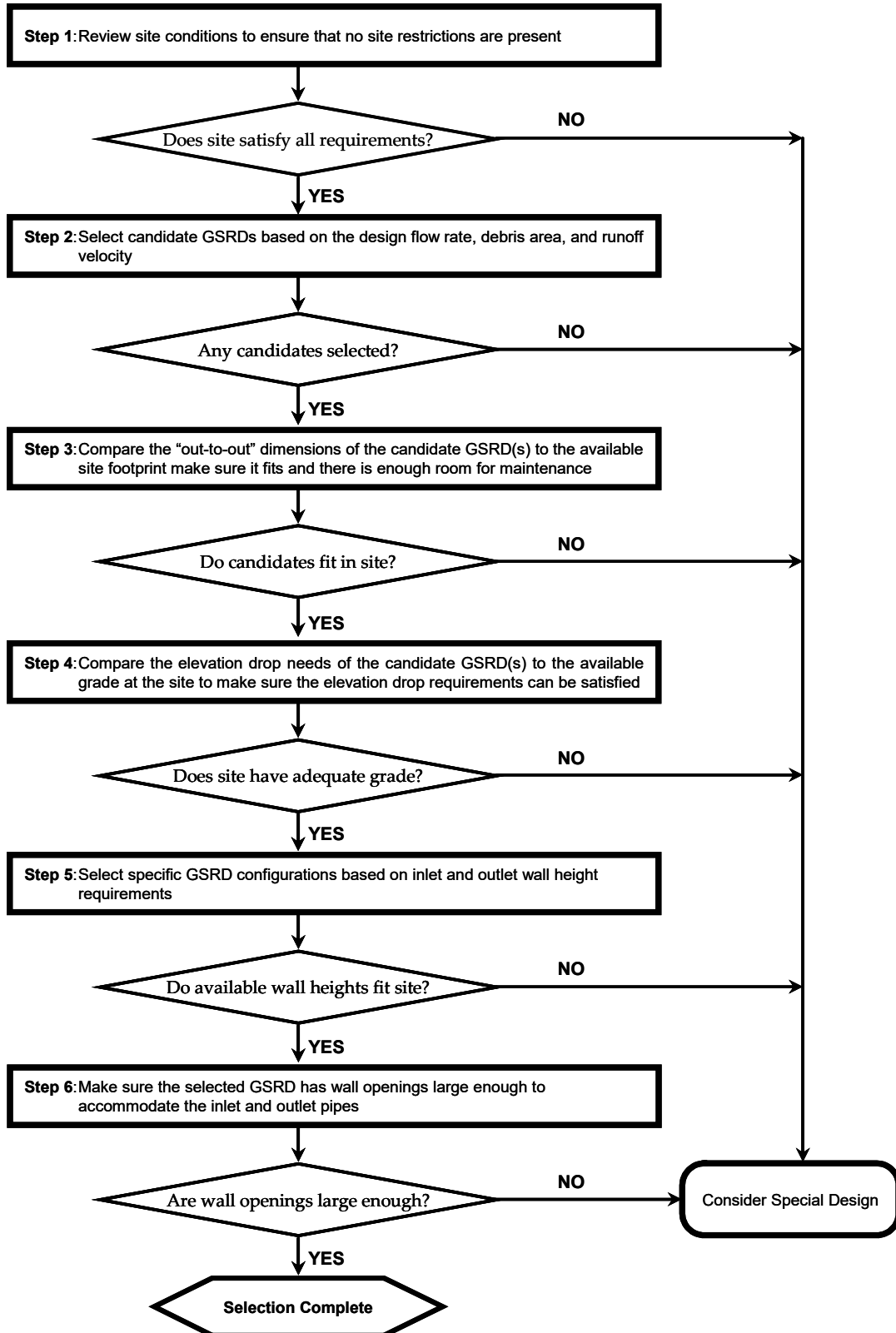


Figure 4-1. Typical GSRD Selection Flowchart

4.5 Step 5: Select GSRD Configuration

Specific GSRD configurations are then selected based on inlet and outlet wall height requirements. Figures 4-2, 4-3, and 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 inches (6 inches for the wall segment above finished grade, and 3 inches for the gap between the structure floor and the inlet pipe invert).

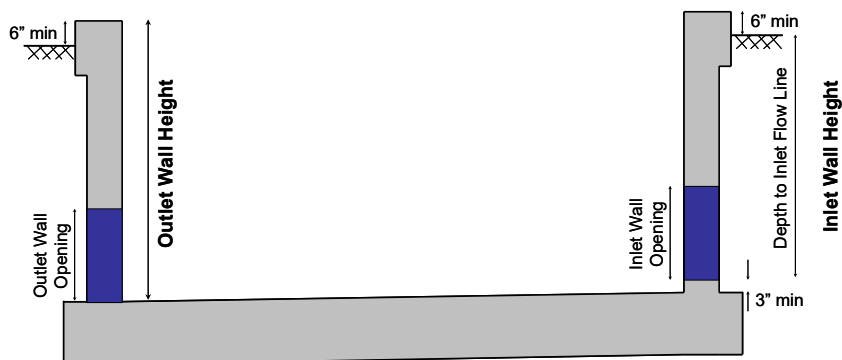


Figure 4-2. Linear Radial GSRD Structure Cross Section

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 inches (6 inches for the wall segment above finished grade, 6 inches for the floor slope of the energy dissipation chamber, and 3 inches 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 inches 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.

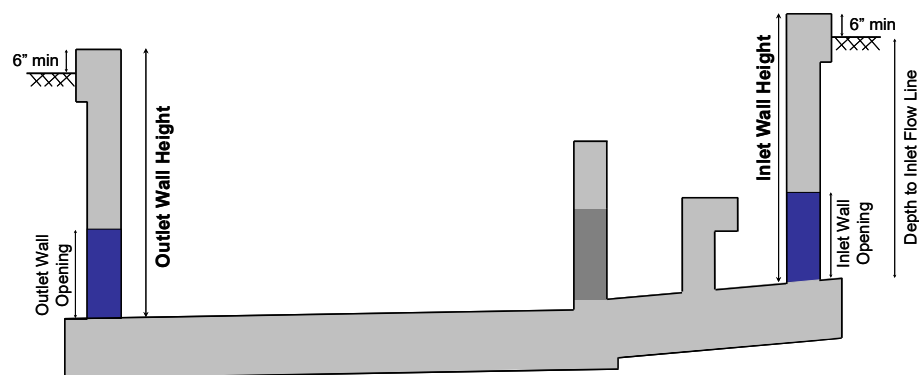


Figure 4-3. Linear Radial (HV) GSRD Structure Cross Section

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 inches
- Depth between finished grade and top of inlet pipe
- Depth of 24-inch pipe plus pipe thickness
- Depth between inlet and outlet flowline elevations (1 inch for the gap between inlet pipe invert and the top of the energy dissipation slab plus 65 inches 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 inches above finished grade. The outlet pipe invert to top of the energy dissipation slab is 65 inches. 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 inches to proposed top of wall. The greater of these dimensions is used for the outlet wall height.

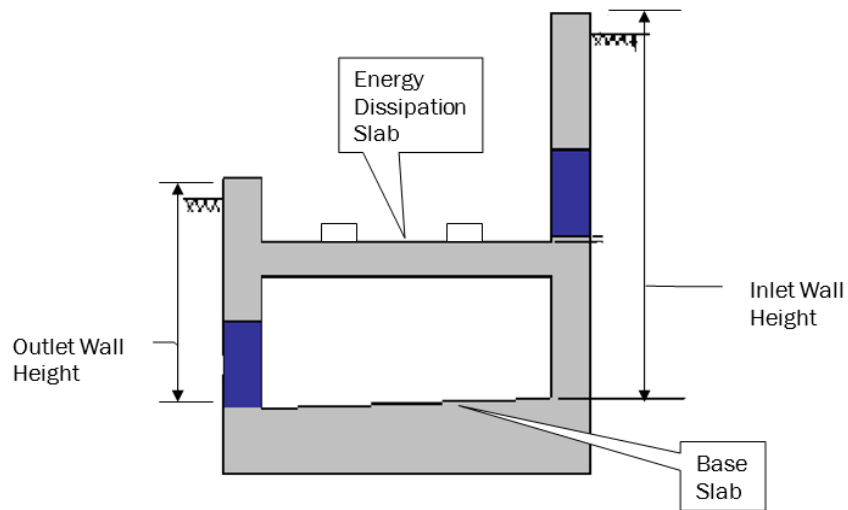


Figure 4-4. Inclined Screen Structure Cross Section

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 parameter 8 “Size and Material of Inlet/Outlet Pipes”.

Section 5

BMP 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 GSRD Detail Drawings 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 8.



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 GSRD Detail Drawings. 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-inch (5 mm) in size. Larger openings may result in 3/16-inch (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-inch (5 mm), thereby preventing gross solids larger than 3/16-inch (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-inch (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 GSRD Detail Drawings 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 HDM³.

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
- 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 2020d).

6.4 Energy Dissipation

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

³ 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.

Section 7

PS&E Preparation

This section provides guidance for incorporating GSRDs 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 2019c).

7.1 Plans

This section provides guidance for incorporating the GSRD Detail Drawings 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 GSRD Detail Drawings 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 GSRD Detail Drawings. These drawings should be included with the Drainage Details section of the PS&E. 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 BMPs 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 will include a combination of Standard Specifications, Standard Special Provisions (SSPs), and may include non-Standard Special Provisions (nSSPs). In some cases, specific nSSPs have been developed by OHSD.

Special provisions for the various items of work needed to construct the GSRD could be organized under an umbrella 'GSRD' nSSP with the required items listed as subheadings. Payment would be by 'each' GSRD. 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

SSPs may be included for a project that constructs a GSRD. Additional SSPs may be required depending on the types of appurtenant facilities and materials proposed for the project. Consult the current index of SSPs available on the Office of Construction Contract Standards section of the Caltrans website to assist in preparing the Contract Special Provisions.

7.2.3 Non-Standard Special Provisions

OHSD developed the following nSSP for the GSRD screens for use with the GSRD Detail Drawings and is available by request. This nSSP needs to be included in the special provisions for the project:

- Gross Solids Removal Systems (Linear Radial and Inclined Screen)

A Fiberglass Reinforced Plastic (FRP) Grating (Alternative to Steel Grating) nSSP was also developed by OHSD and may be added to the special provisions if the PE determines the use of the product meets the project's needs. This nSSP is available by request.

GSRD nSSPs are recommended, so the costs and location of GSRD can be captured and tracked for compliance with the NPDES permit.

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:

<http://www.dot.ca.gov/design/pjs/index.html>

This website includes links to Chapter 20 Project Development Cost Estimates of the Project Development Procedures Manual and Caltrans Cost Estimating Guidelines. In addition to Chapter 20, this website includes other useful cost estimating information on project cost escalation, contingency and supplemental work, and cost estimating templates for the planning and design phases of the project. These templates may be used to track estimates relating to costs for incorporating TBMPs.

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 Basic Engineering Estimating System (BEES). 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 Treatment BMP 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 District 8 Cost Data Base 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.

7.5 Plan Sheet Approval

When using standard sized vaults, the GSRD Drawings may be used. At this time, the plans are not "X-S" sheets and must be coordinated through OHSD. These standard drawings shall be signed and sealed by OHSD. 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 BEES.

- 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



This page intentionally left blank.



Section 8

Special Designs

This section provides guidance for situations where the specific project requirements do not meet the design parameters as specified in the GSRD Detail Drawings. The following recommendations are provided as alternatives to expand the applicability of the GSRDs beyond the design elements and constraints shown in the GSRD Detail Drawings. Note that any of the following design approaches may 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 GSRD Detail Drawings, and how the design may be revised for values outside the range presented in Sections 2 and 3.

8.1 Flow Rate (Linear Radial and Inclined Screens)

If the design flow rate exceeds the maximum values presented in Tables 2-1 and 2-2, the GSRD screen specified in the GSRD Detail Drawings is not long enough. If this is the case, either a modified GSRD with a longer screen may be designed, or a flow splitter may be used to either distribute the runoff to multiple smaller, standard GSRDs operating in parallel, or divert runoff that exceeds the TMDL-established design flow.

If the 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 8-1.

GSRD	Screen Capacity (gpm/ft)	Screen Capacity (CF/s/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 computed, 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 GSRD Detail Drawings) 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 and debris area 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 divert 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.

8.2 Debris Area (Linear Radial and Inclined Screens)

If the design debris area exceeds the maximum values presented in Tables 2-1 and 2-2, the GSRD gross solids storage area is not large enough to hold one year’s worth of gross solids. If this is the case, 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 (e.g., two or more times per rainy season) and cleanout (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. The relationship between debris area and screen length is as follows:

$$\text{Percent Full} = \text{Gross Solids Loading Rate} * \text{Debris Area/GSRD Volume}$$

Where Percent Full is the percentage of the pipe screen occupied by gross solids prior to cleaning, Gross Solids Loading Rate is the amount of gross solids generated per acre of debris area, and GSRD Volume is the total volume of the louvered

screen pipe. Assuming 50 percent full (the same value used in the development of the GSRD Detail Drawings), a maximum Gross Solids Loading Rate of 10 CF per acre (in accordance with Section 3.1), and a screen pipe diameter of 2 ft, the above formula may be rearranged to solve for the required Screen Length:

$$\text{Screen Length (ft)} = 20 * \text{Debris Area (acre)} / \pi$$

The structure length and width are then computed using the formulas presented in Section 8.1.1.

For the Inclined Screen GSRD, the gross solids are also stored in an area at the bottom of the inclined screen. To accommodate a larger debris area, the volume of this area must be increased. This may be accomplished by lowering the slab, extending one or both of the sidewalls, or a combination of the two. The storage volume is defined as follows:

$$V = (0.326 * 2hw) * C$$

Where:

- V = Required storage volume (includes using bottom 25 percent of screen, measured along the length of screen, for trash storage), CF
- h = Height from slab to bottom of inclined screen, ft
- C = Length of Screen, ft
- w = Width of storage area, ft

The above equation takes into account the following assumptions (all of which are built into the values in Table 3-2:

- Screen Length of 56.9 inches
- Allowable Screen Blinding of 25 percent

The above equation is solved to select desired screen lengths, storage area widths, and storage area depths. Note that a change in any of these three values will require a structural analysis.

8.3 Pipe Diameter (Linear Radial and Inclined Screens)

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. Therefore, 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.

8.4 Customizing the GSRD Detail Drawings

When using a Special Design, the GSRD Detail Drawings must be modified to show any changes relative to the following:

- **Design Flow Tables:** If different design flow rates and debris area values are used, these new values are to be reflected in the appropriate design chart on the Legend sheet of the GSRD Detail Drawings.
- **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 GSRD Detail Drawings. 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 not "X-S" sheets and must be coordinated through OHSD.

Section 9

Design Example

9.1 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 405 and Constitution Avenue (Outfall No. 405-3190). An aerial photograph of the site is provided in Figure 9-1, and the As-Built Drainage Profile is provided in Figure 9-2.

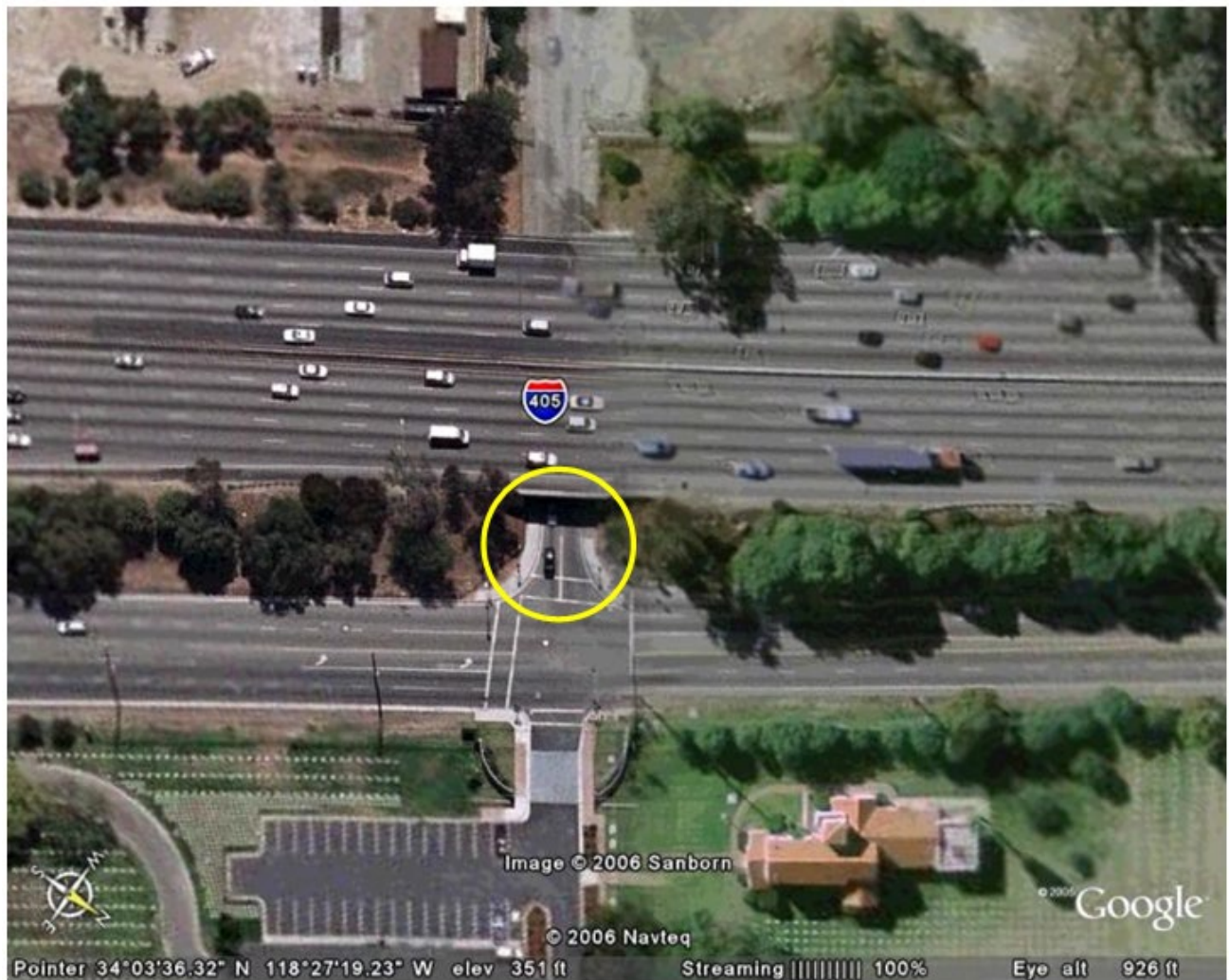
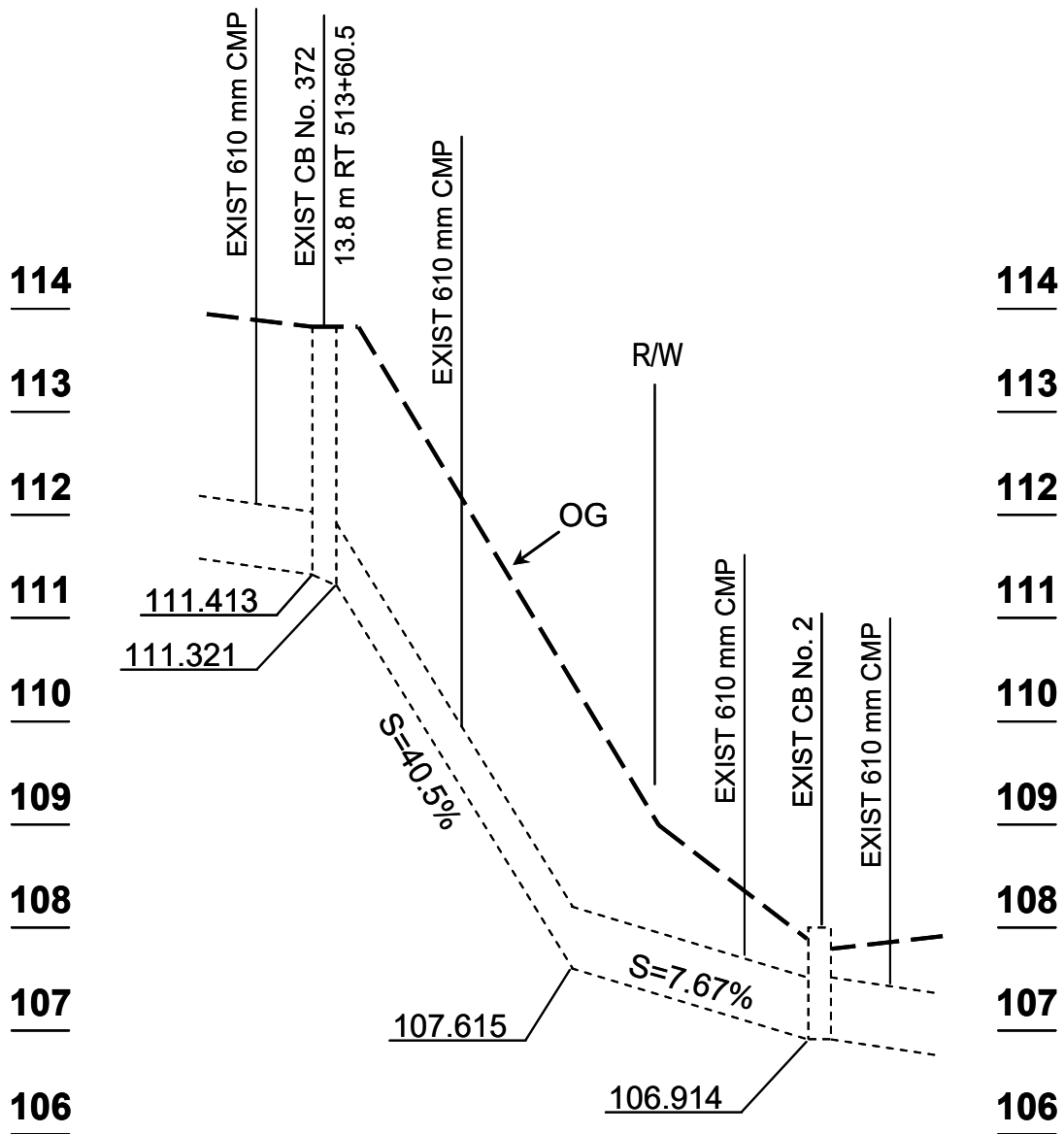


Figure 9-1. Aerial Photograph Outfall 405-3190



SCALE: HORIZ 1:200
 VERT 1:50

Figure 9-2. As-Built Drainage Profile – Outfall 405-3190

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 Tables 3-1 and 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.

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

- Debris Area: 2.40 acres
- Flow Rate (Q_{25}): 7.9 cfs
- Velocity: 12.4 ft/second

Comparing these values to those in Tables 3-1 and 3-2 result in two candidate GSRDs: a Linear Radial Type LR-4 or an Inclined Screen Type B. Although a Linear Radial Type LR-3 will support the design flow rate, it will not support the design debris area. Given that the runoff velocity is greater than 8.2 ft per second, the Linear Radial (HV) will be necessary.

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 corner of Sepulveda Boulevard and Constitution Avenue. The roadway (Route 405) 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 Sepulveda Boulevard and does not require access from the roadway. The perpendicular distance between the roadway and the right-of-way fence along the existing outfall is approximately 40 ft. The “out-to-out” concrete dimensions of the LR (HV) – 4 are 38.3 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 B are 6.0 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 elevation drop requirements presented in Table 2-1 and 3-4 can be satisfied. If one of the candidate GSRDs is an Inclined Screen, make sure the minimum elevation drop requirements presented in Table 2-2 can be satisfied.

The existing system consists of a catch basin at the roadway shoulder connected to a 24-inch CSP at a 40.5 percent slope, which is connected to another 24-inch CSP at a 7.67 percent slope that discharges into a second catch basin. The right-of-way fence is located approximately midway along the second CSP. The flow line at the outlet of the first catch basin is 111.321 meters (m) (365.2 ft) and the flow line at the right-of-way fence is approximately 107.4 m (352.4 ft), resulting in 12.8 ft of available grade.

The minimum elevation drop for the Linear Radial (HV) - 4 is 0.77 ft, and the maximum is 3.77 ft. The distance over which this drop loss must occur is 35.8 ft. This is the total inside vault length. Refer to Table 3-5. Given the available distance at the project site (40 ft), the embankment slope, and the existing pipe slopes, it is not possible to limit the drop to 3.77 ft over a distance of 35.80 ft. Therefore, the Linear Radial (HV) is rejected as a candidate.

The required elevation drop for the Inclined Screen Type B is 66 inches, which must occur over 5 ft, and a wall height of between 9 and 13 ft. As a result, the Type B is retained as a candidate GSRD.

Step 5: Select GSRD Configuration

Specific GSRD configurations are then selected based on inlet and outlet wall height requirements. Figures 4-2, 4-3, and 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 3 ft away from the right-of-way fence. If it is desired to directly connect the existing pipe to the inlet wall, the dimensions provided in the GSRD Detail Drawings require the connection to occur at a flow line of 107.452 m (352.53 ft). At the inlet wall, the depth to finished grade is 2.5 m (8.2 ft). A minimum wall height of 9 ft will work. Some minor grading will be necessary around the device to meet the 6 inches 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 2-2 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 inches. These are both large enough for the existing 24-inch CSPs.

9.2 PS&E Preparation

For the above example, the incorporation of the GSRD into the PS&E package would be reflected in the following drawings:

- **Layout:** Show the location of the GSRD structure and its stationing. Figure 9-3 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 9-4.
- **Drainage Profile:** Show the GSRD profile with the existing and proposed drainage conveyance system, including pipes and inlets. An example is presented in Figure 9-5.

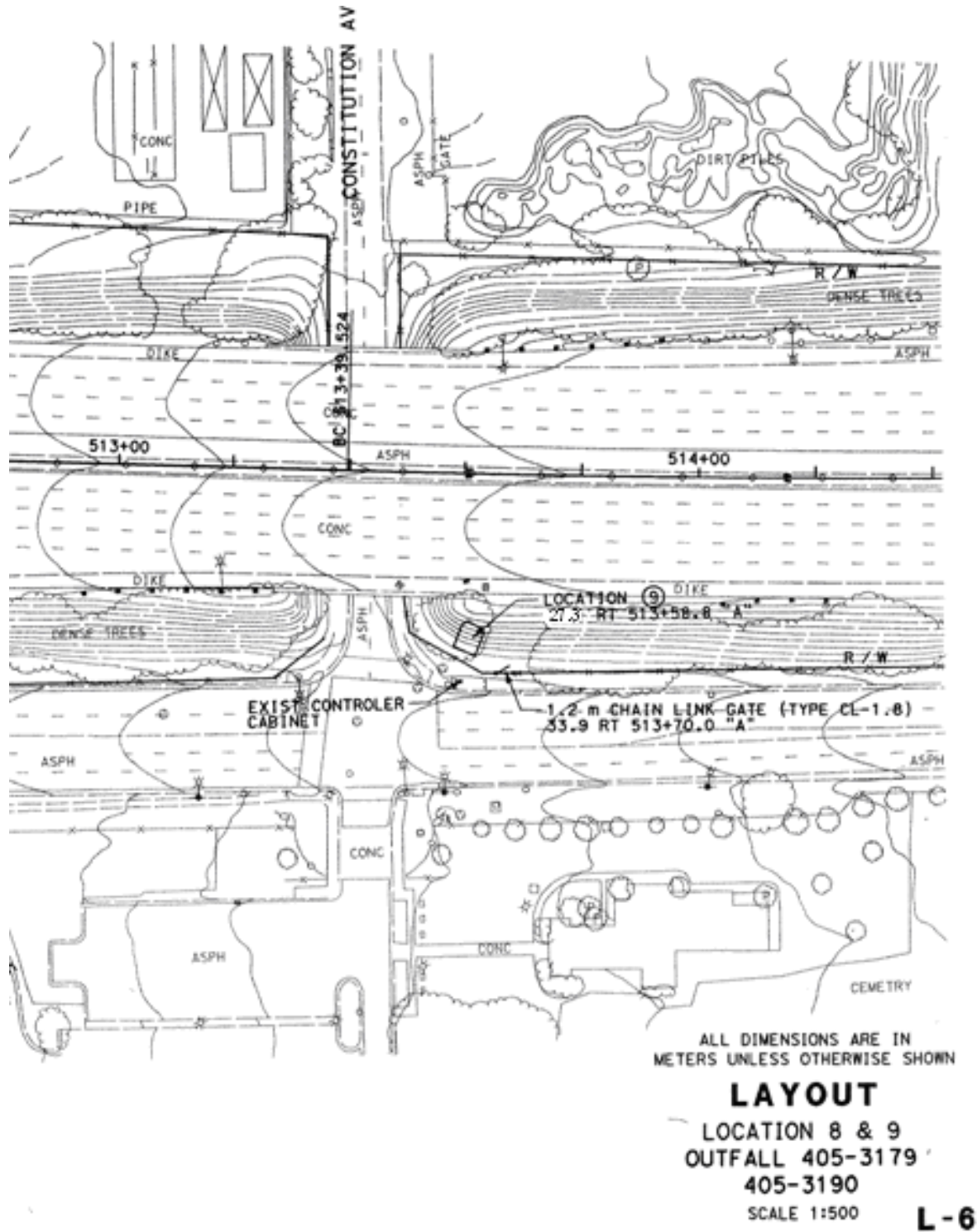
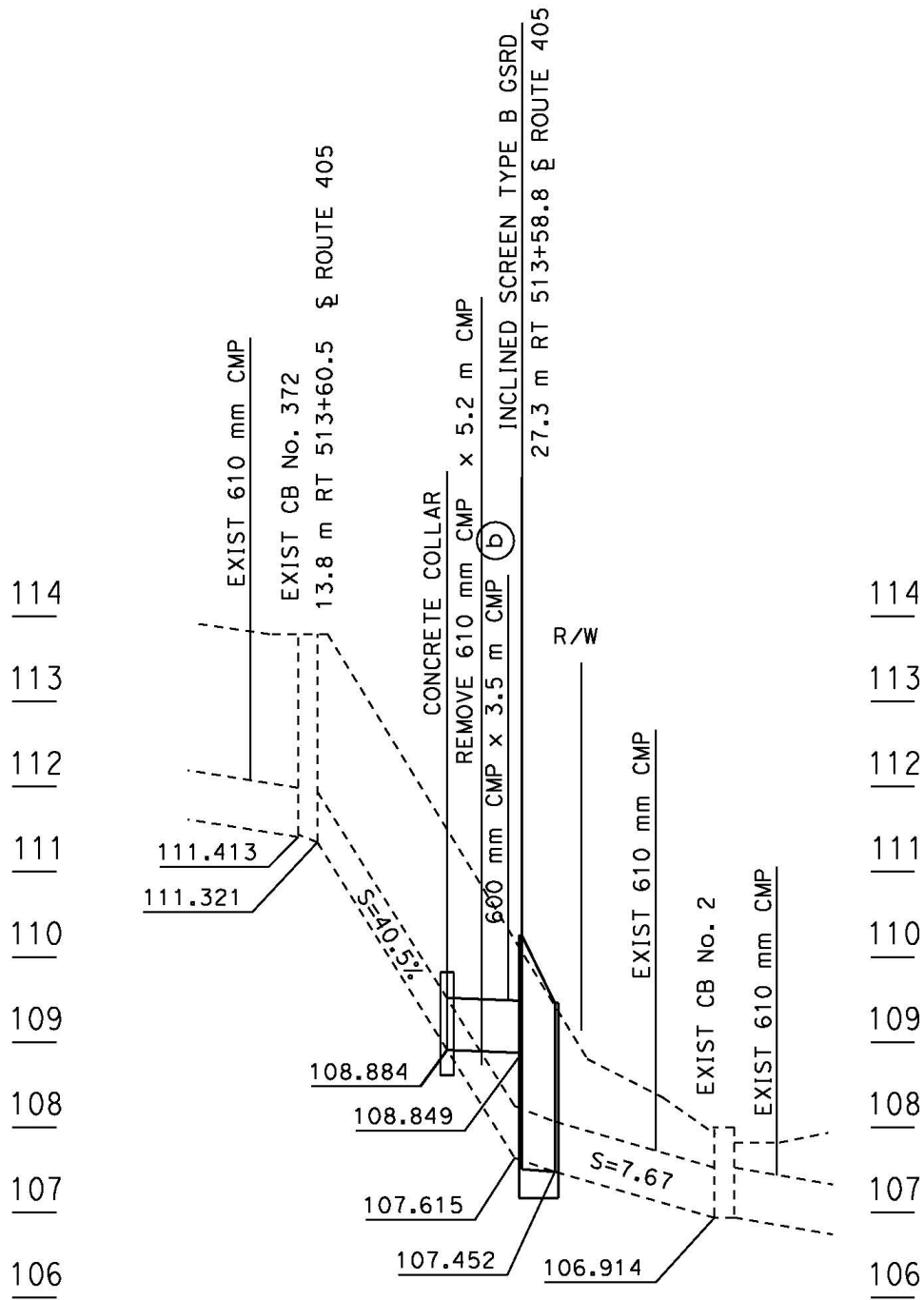


Figure 9-3. Example Layout Plan



Figure 9-4. Example Drainage Plan



DRAINAGE SYSTEM NO 9
NO SCALE

...xxxxxib01.dgn 6/10/2009 11:15:25 AM

Figure 9-5. Example Drainage Profile

Section 10

References

- American Association of State Highway and Transportation Officials (AASHTO), 2014. AASHTO LRFD Bridge Design Specifications 6th ed. published 2012, with California Amendments published 2014
- California Department of Transportation (Caltrans), 2019a. Stormwater Quality Handbooks: Project Planning and Design Guide (PPDG), April 2019
- California Department of Transportation (Caltrans), 2019b. Statewide Trash Implementation Plan, April 2019
- California Department of Transportation (Caltrans), 2019c. Construction Contract Development Guide, Version 5.0, July 2019
- California Department of Transportation (Caltrans), 2019d. Review of Design Guidance for Sizing Media Filters for Stormwater Quality Treatment, CTSW-TM-16-314.17.1, January 24, 2017, Revised September 17, 2019
- California Department of Transportation (Caltrans), 2020a. Highway Design Manual 6th Edition, March 2020
- California Department of Transportation (Caltrans), 2020b. Caltrans GSRD Detail Drawings, 106GSRDType2Plans.zip and 119GSRDLRPlans.zip, available upon request from OHSD, Accessed June 2020
- California Department of Transportation (Caltrans), 2020c. Stormwater Quality Handbooks: Trash Nets
- California Department of Transportation (Caltrans), 2020d. Stormwater Quality Handbooks: Flow Splitters Design Guidance
- California State Water Resources Control Board ORDER 2012-0011-DWQ, NPDES NO. CAS000003 for State of California Department of Transportation Statewide Storm Water Permit, referred to as "NPDES Permit"
- University of California Davis, 2005. Laboratory Testing of Gross Solids Removal Devices. CTSW-RT-05-7318.1



This page intentionally left blank.

