EVOLUTION OF TRASH MANAGEMENT FOR CALTRANS FREEWAYS

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ABSTRACT

Trash is a water quality problem throughout the Los Angeles Basin. The Los Angeles Regional Water Quality Control Board has determined that current levels of trash exceed the existing water quality objectives necessary to protect the beneficial uses of the Los Angeles River and Ballona Creek. As a result, the Regional Board placed reaches of these water bodies on the 303 (d) list as being impaired due to trash. The Board then developed a total maximum daily load (TMDL) designed to attain the water quality standards for trash in these reaches of the river. Trash has been defined in the TMDL as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm mesh screen." In response to these TMDLs, the California Department of Transportation (Caltrans) initiated the Gross Solids Removal Devices (GSRDs) Pilot Program. The pilot study included conceptual design of non-proprietary trash removal devices, site selection, development of device design criteria, construction, monitoring, and assessment of the performance of each device. Two devices studied in the pilot program proved to meet Caltrans goals for storage capacity and maintenance, and Caltrans' criteria for drainage and hydraulic capacity. Additionally, these devices met the TMDL's criteria for clogging and particle capture. These devices were then considered to meet the TMDL's definition of "full capture treatment systems." The next major hurdle that Caltrans overcame in complying with these TMDLs is transitioning from these pilot studies to large scale implementation. Caltrans has identified numerous locations within the LA River watershed that may be candidates for a retrofit with a full capture GSRD device. The devices recommended from the pilot studies were used as the basis for developing standard details to be used for the design for the Phase I Implementation. The pilot study locations were chosen with ideal site conditions, level ground and easy access for maintenance. However, many of the sites considered to be implemented in Phase I did not exhibit the same characteristics. For example, some of these sites were at locations in a drainage system with excessive velocities. Additionally, most sites required a GSRD to be placed within an embankment with varying slopes. The main challenge to overcome was the development of a range of configurations that met a majority of these hydraulic and siting constraints. Once a set of standard details had been developed, inserting the right detail in a set of design drawings is no simple task. Caltrans has a regimented and thorough process to develop a Plans, Specification and Estimate (PS&E) package for highway construction work. This paper will describe the design criteria for the two pilot GSRDs, results of the pilot program, and the challenges overcome for wide scale implementation. Additionally, a step by step process, used by Caltrans project engineers, to incorporate a GSRD into a PS&E will be described.

INTRODUCTION/REGULATORY BACKGROUND

Trash is currently a significant water quality problem throughout the Los Angeles River (LA River) and Ballona Creek. The Los Angeles Regional Water Quality Control Board (RWQCB) determined that current levels of trash in the LA River exceed the existing water quality objectives necessary to protect the beneficial uses of the river. There are several existing beneficial uses that are impaired by trash including contact recreation, non-contact recreation such as fishing, warm fresh water habitat, wildlife habitat, estuarine habitat and marine habitat. These beneficial uses in the river are impaired by large accumulations of suspended and settled debris throughout the river system. The problem is even more acute in the City of Long Beach where debris flushed down from the upper reaches of the LA River collects. Common items that have been observed include plastic cups, plastic food containers, glass and plastic bottles, toys, balls, motor oil containers, antifreeze containers, construction materials and cans. Heavier debris such as tires and shopping carts can be transported during storms as well.

Trash in Long Beach Harbor after a storm.

As part of California's 1996 and 1998 303 (d) list submittals, the RWQCB identified reaches of the LA River as being impaired due to trash and the Total Maximum Daily Load (TMDL) process was initiated. This Trash TMDL is a requirement of the Clean Water Act. It was initiated by the RWQCB in response to a consent decree between the USEPA and several environmental groups led by the NRDC. The consent decree specifically called for a Trash TMDL to be completed for the LA River by March 2001. Trash has been defined in the TMDL as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm mesh screen." The Trash TMDL for the LA River was approved by the Environmental Protection Agency on August 1, 2002. A similar TMDL was approved for Ballona Creek. Enforcement of these TMDLs will be performed by the RWQCB through the NPDES permits of all tributary permit holders. The "permittees" are identified in the TMDLs as the California Department of Transportation (Caltrans) and the 84 co-permittees of the Los Angeles County Municipal Storm Water Permit. The Caltrans NPDES permit covers all statewide storm water discharges from their facilities and activities.

The TMDL identifies the numeric target as 0 (zero) trash in the water and calls for a 14 year implementation period. The first 2 years are optional baseline monitoring with the start of trash load reductions in year 3. A 10% reduction of the baseline trash load is required each year until 100% reduction is achieved.

The LA River watershed has an "urbanized" area of 584 square miles. Caltrans occupies about 9 square miles of that area, with predominantly major freeways. The LA River TMDL identifies a total baseline Waste Load Allocation of 57,069 cubic feet/year of uncompressed Trash. Caltrans is responsible for eliminating 7,944 cubic feet/year of this volume while the 84 co-permittees of the Los Angeles County Municipal Storm Water Permit are responsible for the remainder.

Compliance can be achieved via 3 strategies:

> **Full Capture Treatment Systems** are any device(s) or system that will capture particles retained by a 5 mm mesh screen from all runoff generated from a 1-year storm (0.6" per hour). The TMDL mentioned vortex separation systems (VSS), floating debris traps, end-of-pipe nets and trash racks.
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> **Institutional Controls** include enforcement of litter laws and more frequent street sweeping.
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> **Partial Capture Control Systems with Institutional Controls** includes utilizing devices that are not certified by the RWQCB as full capture systems (such as catch basin inserts) in combination with Institutional Controls.

The permittees are free to select whichever method of compliance they choose. The Caltrans facilities tributary to the LA River and Ballona Creek include park and ride lots, maintenance stations, and State Highway Systems. Caltrans has evaluated and will continue to evaluate each of the three methods of compliance for each land use within their jurisdiction. Major, multi-lane freeways represent the majority of Caltrans land use that is tributary to the LA River and Ballona Creek. It was realized that some form of full capture device would be needed as part of the Caltrans plan to comply with the TMDL requirements. As a result, a pilot program was initiated.

PILOT PROGRAM BACKGROUND

In 2000, Caltrans initiated the Gross Solids Removal Devices (GSRDs) Pilot Program to develop and evaluate the performance of non-proprietary, full capture treatment devices that can capture gross solids and be retrofitted into existing highway drainage systems or implemented into future highway drainage systems. The term "gross solids" includes litter, vegetation, and other particles of relatively large size. As previously mentioned, litter is defined as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm (0.2 in nominal) mesh screen."

The GSRD Pilot Program consists of multiple phases with each phase representing one pilot study. A pilot study consists of one or more devices that will be developed from concept, advance through design and installation, and will conduct two years of pilot testing for overall performance. To date, five phases have been constructed and monitored covering eleven designs.

PILOT PROGRAM DESIGN CRITERIA

All concepts developed for the GSRD Pilot Program were designed to meet the criteria set by the TMDL for trash in the LA River Watershed and the criteria and goals set by Caltrans. The six design objectives listed below represent criteria and goals applied to the concepts. For this pilot study, meeting criteria held a higher importance than meeting goals.

The following two criteria were set by the TMDL for an approved full capture treatment system:

- The device or system will capture all particles retained by a 5 mm mesh screen from all runoff generated from no less than a one-year, one-hour storm.
- The device or system is designed to prevent plugging or blockage of the screening module.

The following two criteria were set by Caltrans for a GSRD:

- The device or system will pass the design flow as specified in the Caltrans Highway Design Manual.
- The device or system will drain within 72 hours to avoid vector breeding.

Additionally, the following two goals were set by Caltrans for a GSRD:

- The device or system will hold the estimated annual load of gross solids, based upon one cleaning per year.
- The device or system will not require any maintenance other than inspections throughout the storm season.

PILOT PROGRAM RESULTS

Four general types of GSRDs have been developed to date: linear, inclined screen, baffle box, and v-screen. Each general type of GSRD consists of 1 to 4 variations. Linear GSRDs consist of either a louvered modular well casing or a long rectangular rigid cage containing nylon mesh collection bags. Runoff enters the pipe or cage where gross solids are captured. Runoff then exits the pipe or cage into a shallow concrete vault and is routed back into the drainage system. These GSRDs are intended to be installed in-line with existing pipe systems and require little hydraulic head. Inclined screen GSRDs are concrete vaults equipped with a screen through which runoff drops vertically. Gross solids are captured on the top of the inclined screen and fall or are pushed down to a storage area. Both 3-mm (0.125 in) spaced parabolic wedge-wire screen and 5-mm (0.25 in) bars have been tested. These GSRDs require a minimum of one meter (3 ft) of hydraulic head. Baffle box GSRDs are concrete vaults with two chambers. The first chamber contains an underflow weir to trap floatable gross solids. The second chamber utilizes a bar rack to capture gross solids that pass through the first chamber. V-screen GSRDs are concrete vaults equipped with a screen through which runoff flows horizontally. Gross solids are captured behind the v-screen and collect in a storage area. The screen module consists of a 3-mm (0.125 in) spaced wedge wire-screen. These GSRDs require less hydraulic head than the inclined screen GSRDs.

To assess the performance of each GSRD, inspections were conducted up to eight times per year. Inspections consisted of observing the GSRDs before, during and after various storm events. Collection bags were installed in the drainage system just downstream of the GSRD to collect material that had bypassed through the screen module and/or overflowed out of the GSRD.

Visual observations were made to see: (1) how the gross solids were accumulating within the GSRD; (2) if there were bypassed or overflowed gross solids; (3) whether the screen module was self-cleaning, i.e., no plugging or clogging; and (4) if the GSRD was draining properly. Each GSRD was cleaned at least once at the end of the wet season and more if needed, i.e., an interim cleaning was performed if a GSRD became full prior to the end of the wet season. During each cleaning, the gross solids were measured for weight and volume. Gross solids captured in the collection bags were measured separately.

The overall performance of each GSRD was assessed by evaluating how well the GSRD met the design criteria, i.e., the criteria set by the TMDL and the criteria and goals set by Caltrans. Of the many configurations tested, the most promising devices, based on considerations of particle capture, clogging, passing design flow, drainage, stage capacity and maintenance requirements, were the Linear Radial (louvered modular well casing), the Inclined Screen (parabolic wedge-wire screen) and the Inclined Screen (sloped flat wedge-wire screen). These devices were selected for further development into standard details to be utilized by Caltrans District 7 (LA Basin) project engineers to incorporate into future and ongoing projects to comply with the TMDL.

TRANSITIONING FROM PILOT STUDY TO FULL SCALE IMPLEMENTATION

The District's implementation strategy for full capture devices will be carried out in 10 phases. Each phase encompasses site investigation and screening; preparation of design plans, specifications and estimates (PS&E); and construction of GSRDs. The linear radial and inclined screen devices have been certified by the RWQCB as being full capture devices. Standard designs were developed for these screen systems that provided the best solids removal performance in the pilot tests.

Linear Radial Screens: The linear radial screen is basically a water well screen with 5 mm slotted openings installed on its side and installed in a concrete vault. This device is shown in Figure 1. The debris laden storm water flows into the casing pipe. The water flows out of the screen and the debris remain inside. The casing is sized to contain one year's volume of debris. The concrete vault collects the screened flow and provides maintenance access to clean the inside of the screens.
Characteristics of the linear radial GSRD are:

- Requires minimal available head to utilize this device. This device is typically installed in level areas.
- Structure is long and narrow, with flow entering one end and exiting the other end which may limit placement in areas with narrow right of way availability.
- An integral overflow weir is incorporated to minimize concerns on screen plugging.
- Standardized screen sizes of 300 mm diameter by 1.5 m long minimize replacement inventory requirements.
- Size selection typically based on debris area instead of flow rate.
- Six standard sizes provided, ranging in design area from 0.32 to1.92 hectares in design area.

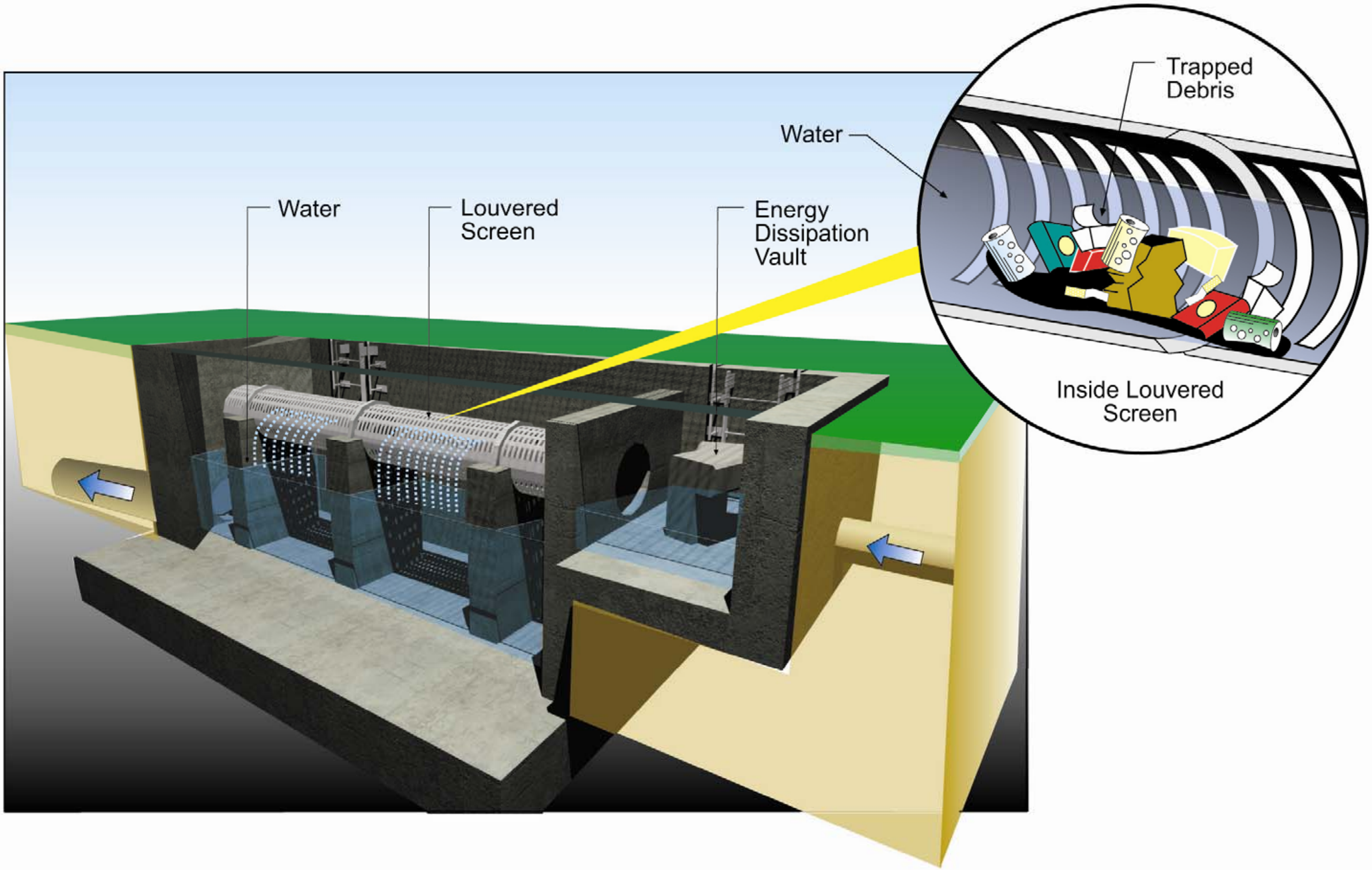

Figure 1. Linear Radial

Inclined Screens – Type 1: The Type 1 inclined screen design is a curved wedge-wire screen design (hydrasieve) with 5 mm spacing. The debris laden storm water flows into a distribution chamber, over a flow distribution weir and onto the face of the curved screen. The water flows through the screen into a collection channel and the debris collects in a concrete vault area. Two arrangements were designed to allow the Type 1 inclined screens to be installed in both flat areas and sloping areas up to a 2 to 1 slope. Figure 2 shows the sloped configuration. Characteristics of the Type 1 Inclined Screen are:

- Requires at least one meter of head to utilize this device. Typical locations utilize the head available from elevated highways.
- Structure is generally square in shape and is covered with grating to keep debris from blowing out of the structure.
- Draining the inlet distribution chamber requires screened weep holes.
- Standardized screen sizes of 1 meter high by 1 meter long were used to minimize replacement inventory requirements.
- Larger debris storage area results in size selection based on inlet flow rates instead of debris area.
- The square layout configuration is more compact than the linear radial design and may be better suited for areas with limited distance to the right of way.
- Three standard sizes provided, ranging in design flow ratings from 0.25 to 0.49 m^3/sec.

Inclined Screens – Type 2: The Type 2 inclined screen (referred to as the Configuration #4 in the Phase III of the GSRD Pilot Program) design is a sloped flat wedge-wire screen design with 5 mm spacings. This device is shown Figure 3. The debris laden storm water flows onto a energy dissipating slab and over the sloped screen. The water flows through the screen to the outlet sewer and the debris collects in a concrete vault area. The screens were designed for installation in sloping areas up to a 2 to 1 slope. Characteristics of the Type 2 Inclined Screen are:

- Requires at least one meter of head to utilize this device. This GSRD is typically placed at the toe of an elevated roadway embankment.
- Structure is generally square in shape with maintenance access from the downslope side.
- Standardized screen sizes of 1 meter high by 1 meter and 0.5 meter widths were used to minimize replacement inventory requirements.
- The debris storage area arrangement results in size selection based on inlet flow rates instead of debris area.
- Four standard sizes provide, ranging in design flow ratings from 0.06 to 0.15 m^3/sec.

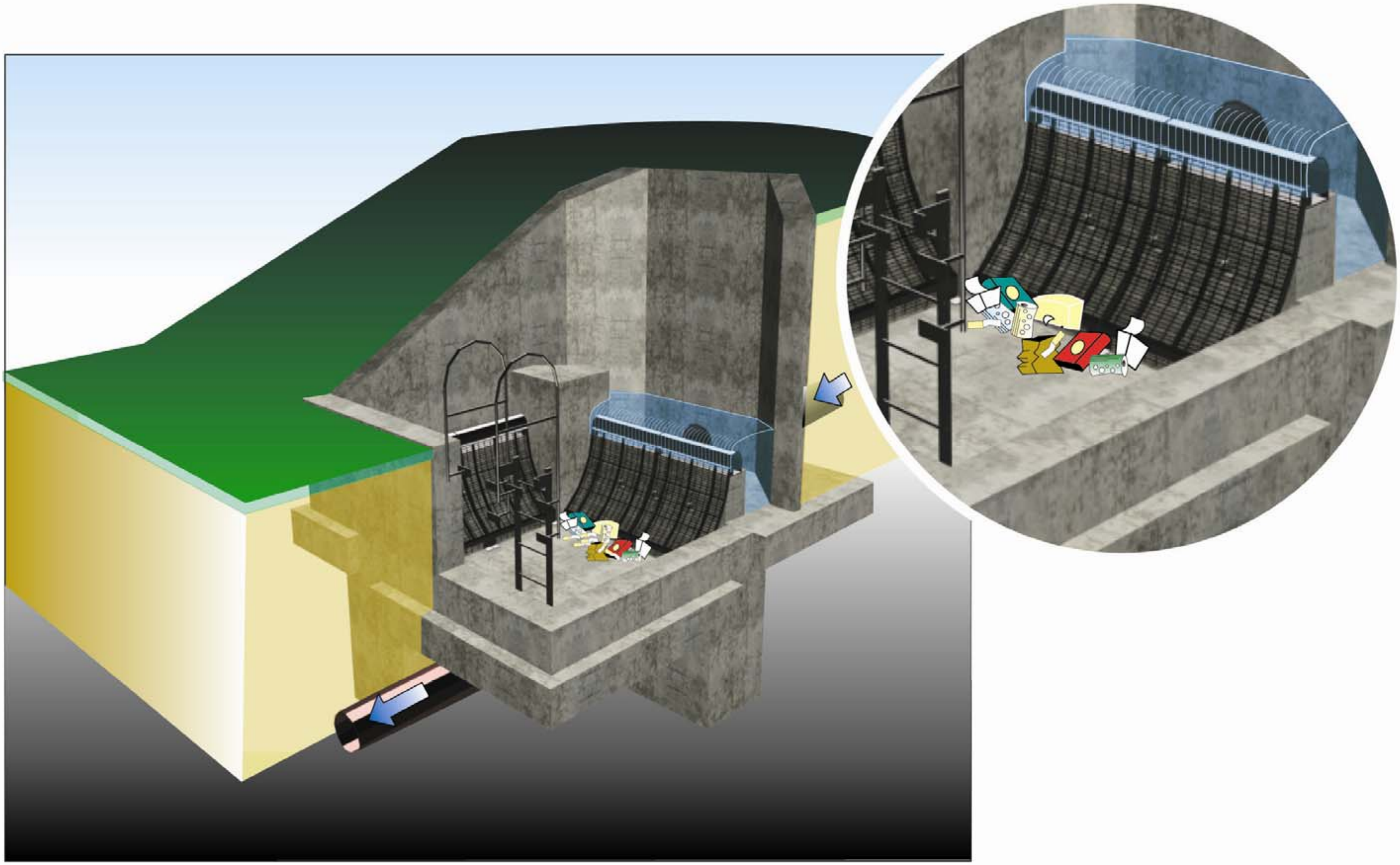

Figure 2. Inclined Screen - Type 1

Figure 3. Inclined Screen –Type 2

HYDRAULIC CRITERIA

Screen sizing was based on screening the 25 year design storm as the design rating condition and also to be able to convey the 100 year design storm event discharge. The flow ratings through the screens were based on full scale hydraulic tests for the linear radial screens. Flow ratings for the inclined screens were based on manufacturer's flow test data for similar screens and conservative hydraulic design assumptions. Several years of Caltrans studies provided the basis for sizing the debris storage area. Each GSRD was designed for a gross solids loading rate of 0.7 m^3/ha/year (10 ft^3/ac/year) and annual removal of gross solids.

Designs for five linear radial sizes, three inclined screen type 1 sizes and four inclined screen type 2 sizes were prepared during development of the standard design drawings. The flow ratings and debris area ratings for each size and type GSRD are summarized in Table 1.

Table 1 GSRD Design Capacity Ratings

GSRD Type	Total Screen Length (m)	Design Flow Rating (m^3/sec)	Design Debris Area (hectares)
Linear Radial - Type LR-1	1.5	0.10	0.32
Linear Radial - Type LR-2	3.0	0.20	0.64
Linear Radial - Type LR-3	4.6	0.31	0.91
Linear Radial - Type LR-4	6.1	0.41	1.28
Linear Radial - Type LR-5	7.6	0.52	1.60
Linear Radial - Type LR-6	9.1	0.62	1.92
Inclined Screen Type 1 – Type 1-A	4.0	0.25	1.45
Inclined Screen Type 1 – Type 1-B	6.0	0.37	3.26
Inclined Screen Type 1 – Type 1-C	8.0	0.49	5.81
Inclined Screen Type 2 – Type 2-A	1.0	0.06	0.41
Inclined Screen Type 2 – Type 2-B	1.5	0.09	0.61
Inclined Screen Type 2 – Type 2-C	2.0	0.12	0.81
Inclined Screen Type 2 – Type 2-D	2.5	0.15	1.01

GSRD DESIGN DEVELOPMENT PROCEDURE DURING PHASE I DESIGN

Two projects in Los Angeles County (as part of Phase I implementation) were selected to be the basis for developing the standardized GSRD designs. A total of 52 drainage sites were initially selected by District 7 staff. These sites are along Interstates 405, 710 and State Route 60. The design process proceeded with the District 7 engineering staff initiating the layout plans for the selected sites.

- The tributary areas were defined as the basis for hydraulic and gross solids sizing
- Record drawings for existing storm drains were accumulated as the basis for existing pipe size, capacity and velocity calculations.
- Each site was visited to verify physical site constraints that may limit the structure configuration that could be installed due to site specific conditions.

With the existing data available for the initial 52 sites, issues began to be identified that defined real world implementation constraints for development of standardized GSRDs. Examples of the issues and the actions taken to proceed with design development are as follows:

- At one site with minimal grade, the distance between the highway and the storm pipe outlet was too short for installation of the relatively long linear radial design. This site was replaced with another site with adequate space.
- Several of the sites were at the bottom of steep embankments with design storm velocities that greatly exceeded 2.5 m/sec, often as high as 6.0 m/sec. It was recommended that energy dissipation be incorporated into the GSRDs that would be installed at these locations with high velocity. Energy dissipation provisions were incorporated into the linear radial and the type 2 inclined screen GSRDs. It was determined that the type 1 inclined screen design had inherent energy dissipation due to the flow distribution weir used in that design.
- An initially proposed site with the largest drainage area was also the site with the deepest storm drain (4.0 hectares and 6.0 meters deep). This site was deleted from the project and replaced with another site since the size and depth were not typical of standard conditions and a site specific design was needed due to the storm drain depth.
- Several of the sites were at the base or in the side slope of relatively steep elevated highway embankments. A maximum embankment slope of 2 horizontal to 1 vertical was recommended as the steepest slope for a standard condition. Site specific geotechnical investigations and recommendations were suggested for locations with steeper slopes.
- Several of the linear radial GSRDs were located at the base of an embankment slope. For some locations the preferred layout was construction partially in the embankment and partially in the flat area at the toe of the embankment. The structural design was modified to incorporate provisions for construction partially in the embankment.

CHALLENGES IN DEVELOPING RANGE OF SIZES

The challenges addressed under this project resulted in development of tools for engineers to use in implementing best management practices in meeting water quality objectives. These challenges have direct application to anyone undertaking development of similar water quality tools and are summarized as:

- Define the range of conditions that can reasonably be incorporated into a typical design as well as the conditions that warrant a site specific design.
- Drainage from elevated highway embankments will have high velocities and energy dissipation must be considered.
- The structures must be designed for a wide variety of side slope conditions and a wide variety of soil conditions. Both the hydraulic and structural designs must identify and account for all identified side and cross slope conditions.

Design Condition Definition - The challenge of developing the range of GSRD sizes was establishing what conditions should be covered by a "standard" design and what conditions needed a custom design. Some of the criteria established to determine when the "standard" design should be used were:

- Maximum side slope conditions of 2 to 1. Steeper slopes should be reviewed as a custom design.
- Maximum installation depth of 2.4 meters for the linear radial screens
- Maximum incoming storm drain depth of 3.8 meters for the type 1 inclined screens
- Maximum incoming storm drain depth of 2.3 meters for the type 2 inclined screens
- When sites are identified that require larger GSRDs than the present project, evaluate if several sites are affected and the standard sizes expanded or is a single site specific design needed.

Energy Dissipation Requirements - The conditions at many of the GSRD locations result in very high velocities flowing from the elevated roadways (up to 6 m/sec). Energy dissipation was determined to be needed for the linear radial design when approach velocities were greater that 2.5 m/sec. The inlet flow distribution on the Type 1 inclined screens provided inherent inlet energy dissipation for the range of flows in the standard designs and no additional features were needed. An inlet slab was added to the Type 2 inclined screen design since they were intended to be principally located at the toe of slope on elevated roadways and high inlet velocities would be normal. This inlet slab dissipates the energy to ensure a longer service life of the screen.

Side Slope Design Conditions Identified and Addressed - The Type 1 inclined screen was pilot tested at a flat location. When the design was adapted to the various identified sloping conditions, the height of the front wall had to be adjusted to prevent overflow from the basin as well as adjusting the structural design for the wide variety of loading conditions. The sloping wall condition also required development of grating system designs that met all of the numerous side slope design conditions. Sliding concerns in the wide variety of side sloping design conditions also required incorporation of keyway sizes and configurations to meet the wide range of soil and loading conditions The design depth and length of the deeper linear radial design required incorporation of a stiffening beam at the top edge of the concrete structure to reduce wall thickness for the deeper structures. Partial construction of a linear radial GSRD into the toe of a roadway embankment required modifying the grating design to be supported from a bracket on the side wall instead of supported on a notch at the top of the concrete wall.

INCORPORATING A GSRD INTO A CALTRANS PS&E

Caltrans is currently requiring it's project engineers to consider installing GSRDs in all locations subject to a trash TMDL or in locations where the project discharges to a 303(d) listed waterbody for trash. This consideration occurs at all phases of the project development process. It is particularly critical at the Plans, Specifications and Estimate (PS&E) phase where the project engineer prepares the final design. Caltrans project engineers need tools at their disposal to prepare a PS&E package for all facets of roadway projects, including GSRDs. Currently, standard details have been developed for these devices to include into a PS&E, with the ultimate goal of developing Standard Plans.

Regardless of whether the project engineer is using a standard detail or a Standard Plan, the process to incorporate a GSRD is similar:

1. Determine the flow rate and debris area for the proposed location. The flow rate value represents the peak flow rate anticipated during the Design Storm. The Design Storm is a particular storm event which contributes runoff which the drainage facilities are designed to handle. This storm is selected for design on the basis of its probability of exceedance or average recurrence interval. The Design Storm is typically one with a return period of 25 years for Roadway Drainage (HDM Table 831.3). The project engineer should consult with District Hydraulics for determination of the design storm and peak flow rates. The debris area represents the area which is tributary to the proposed GSRD location. This area typically consists entirely of impervious roadway surface, which generates the greatest amount of trash.
2. Determine the GSRD type. Based upon hydraulic conditions and available space at the proposed site, the project engineer should determine which of the three types (Linear Radial, Inclined Type 1, inclined Type 2) is most applicable for the proposed site.
3. Using the flow rate and debris area, select the GSRD size identified in the Hydraulic Criteria table (located on Sheet No. 1 of the standard detail sheets). This step may require some iteration to identify the GSRD type and size that best fits the site.
4. Check to ensure that the pipe sizes for the proposed site match those allowable for the selected GSRD type and size.
5. Check to ensure the footprint of the selected GSRD type and size fits within the confines of the proposed site, or whether additional Right-of-Way in needed.
6. Check to ensure that the inlet and outlet pipe elevations will match the profile of the proposed (or existing) drainage pipe. Some adjustment or modification to the existing pipes may be needed to fit the GSRD to the site and to ensure that proper flow conditions are established.
7. Determine the wall heights for the inlet wall and outlet wall. This should be based on the topography of the proposed site location.
8. The project engineer will then include only those details sheets that are applicable to the GSRD type and size that was selected for the proposed site location. These detail sheets shall be incorporated into the PS&E plans for the project.

After completion of these steps, the project engineer may determine that none of the standard configurations of GSRDs will work at the proposed site. At the present time, this situation will require a site specific design. Guidance on developing site specific designs are currently in draft stages and will be published shortly.

CONCLUSION

Trash is a significant water quality problem throughout Los Angeles County. Caltrans initiated compliance with the Trash TMDLs for LA River and Ballona Creek by evaluating and implementing compliance options. The first part of their compliance will be the installation of full capture treatment devices that will screen all gross solids larger than 5 mm nominal diameter. Pilot studies have been conducted and proved the effectiveness of two devices that meet the full capture requirements. Caltrans District 7 developed a 10 phase implementation strategy for the installation of these full capture devices. The first phase included 52 sites which will provide the basis for future standardized GSRD plans which are not currently part of the Caltrans book of Standard Plans. The details developed for this first phase are expected to be used for the majority of sites throughout all phases of planned implementation. As such, these details provided configurations that met a majority of the hydraulic and siting constraints that are anticipated. Constraints were also realized during this process that identified siting conditions that would require site specific designs. Projects using the standardized designs are soon to be in construction. Information from these first projects will provide valuable feedback to refine and improve the Gross Solids Removal Devices as Caltrans continues in its effort to meet trash discharge reduction goals.

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