

Screens and Racks



United Stormwater Screen Cover™ (courtesy of United Stormwater, Inc.).

Summary

Screens and racks can be used at the start of the storm drain system (catch basin screens), within stormwater pipes (in-line screening devices) and at outfalls (end-of-pipe screening devices). Catch basin screens are mesh wire or perforated plates that cover the openings of catch basins. They are inexpensive (prices start at \$400) and help prevent gross solids¹ from entering the storm drain system. Instead, gross solids accumulate on the street until they are removed by street sweeping activities. In-line screening devices are vaults that contain some configurations of screens that filter gross solids from stormwater and hold it in the surrounding chamber. Caltrans developed and pilot tested a range of these devices. Gross solid removal devices capture between 9% to 100% of all loaded materials. Installation costs vary from ~\$50,000 to ~\$300,000. Two of these devices have been certified as full capture by the Los Angeles Regional Water Quality Control Board (LARWQCB). End-of-pipe screening devices, which include mesh baskets, bar racks, and horizontal screens, remove solids by direct straining of all objects larger than the screen openings and by filtering smaller particles through the larger objects accumulated on the screen. Capital costs for this type of device are relatively low. The City of Los Angeles installed five end-of-pipe screening devices at a total cost of \$40,000.

Description/Design

Screens and racks are used to prevent large debris and trash from moving through the storm drain system. Various designs exist including catch basin screens, in-line screening devices and end-of-pipe screening devices.

¹ Gross solids are defined as "litter, vegetation and other particles of relatively large size" (Caltrans 2003 Phase 1 Pilot Study). Litter is subsequently 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". This definition is understood to be consistent with the LA River Trash TMDL definition of litter.

TC-4 Treatment Control

Catch Basin Screens

- REM Curb Protector™
- United Stormwater Screen Cover™
- Flogard Debris Curb Guard
- Surf-gate
- Opening Screen Cover

Inline Screening Devices

- Linear Radial Screens
- Inclined Screen
- Baffle Boxes
- V-Screens
- StormScreens™

End-of-Pipe Screening Devices

- ROMAG™ automatic mechanic screen
- Structural plastic trash racks and debris cages
- Trash Racks

Implementation Point

- | | |
|---------------|---|
| In Street | |
| Start of Pipe | ✓ |
| In Pipe | ✓ |
| End of Pipe | ✓ |
| In Creek | |
| Dispersed | |

Catch Basin Screens

Catch basin screens are perforated screens or evenly spaced bars that are designed to fit outside or immediately within the storm drain curb opening. They either manually or hydraulically open when storm flow is detected. Catch basin screens can be fitted with filters to capture oils. Water passes between the screen bars, while debris, trash and litter are prevented from entering the device. These screens are typically used to prevent storm drain pipe blockages (RBF Consulting 2003). Regular street cleaning is necessary to keep debris from clogging the face of the screens and to prevent standing debris from blowing away (Gordon and Zamist 2006). Some examples include:

- REM Curb Protector™ (Revel Environmental Manufacturing)
- United Stormwater Screen Cover™ (United Stormwater, Inc.)
- Flogard Debris Curb Guard (Kristar)
- Surf-gate (American Stormwater)
- Opening Screen Cover (Practical Technology)

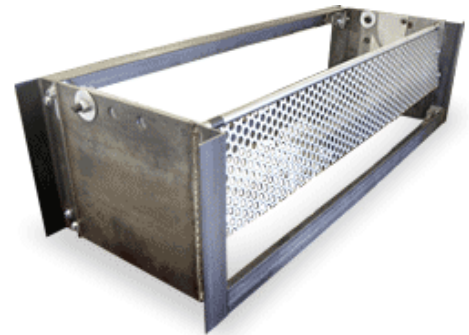


Figure 1. Surf-gate (courtesy of American Stormwater).

Inline Screening Devices

Storm drain systems can also be modified with vaults configured with screens to hold gross solids for later removal. Examples include a series of inline screening devices developed by Caltrans. These devices, which were named Gross Solids Removal Devices (GSRDs), were developed in response to the trash TMDL instituted in the Los Angeles and Ballona Creek Watersheds. These devices include: Linear Radial Screens, Inclined Screens, Baffle Boxes and V-Screens. Multiple configurations were designed for each device and pilot tested at various sites.

Caltrans Devices

Linear Radial Screens. This device uses a modular and linear screen cage constructed of rigid mesh or louvered well casing contained in a vault. Flows enter the device through a screen cage aligned parallel to the direction of flow and exit the device by passing through the cage screen and into the surrounding vault. The screen cage and interior volume are sized to accommodate specified storm discharge volumes from the tributary drainage area. The vault has sufficient volume to reduce flow velocities which allows solids to settle. It is sloped towards the outlet to provide positive drainage. Its linear configuration and low head requirements make it ideal for many typical highway right-of-way applications (Endicott et al 2002). Three configurations were developed (Caltrans 2003a).

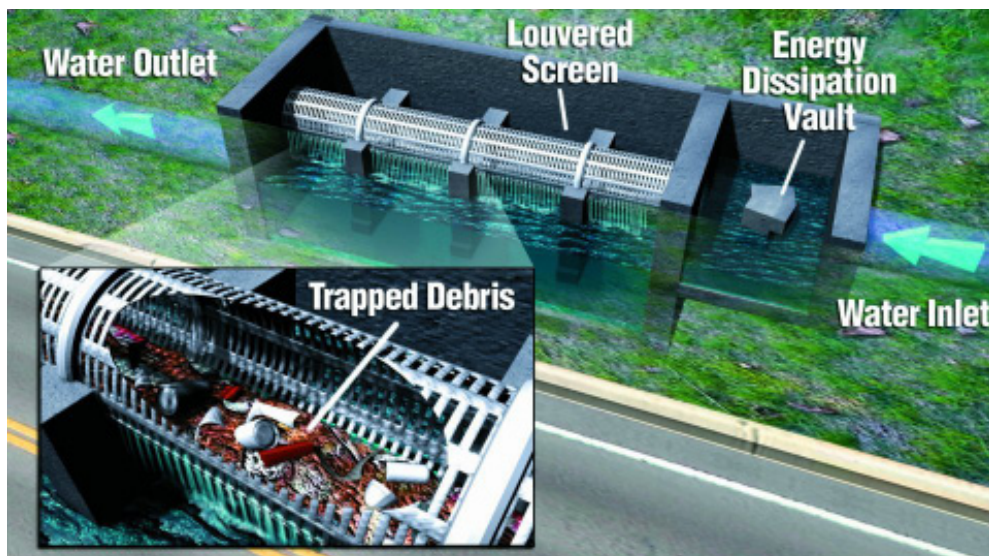


Figure 2. Cut away view of Linear Radial Configuration #1 (LR-1) screen (courtesy of American Society of Civil Engineers Publications).

Inclined Screen. This device uses an inclined screen constructed of parallel wires or bars contained in a vault. Gross solids are retained in a storage area of the vault located at the bottom of the inclined screen. Flows enter the device through a trough and weir which distribute inflow across the top of the inclined screen. The trough captures the heavier solids (e.g., gravel and sand). Flows exit the device by passing through the inclined screen. The gross solids storage area is sized to accommodate a once per year removal cycle and sloped towards a grate-covered drain pipe. Caltrans developed four configurations of this device.

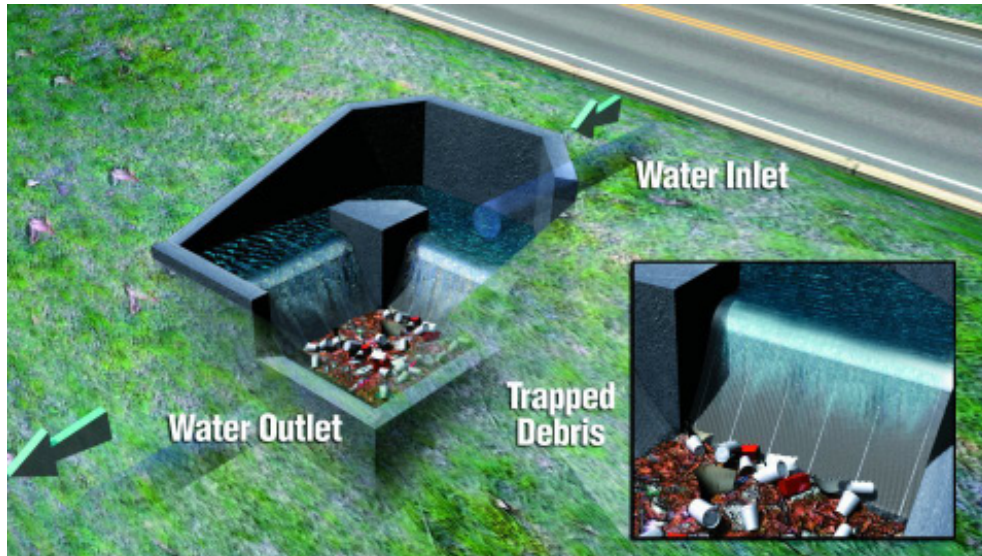


Figure 3. Inclined Screen Configuration #1 (IS-1) (courtesy of American Society of Civil Engineers Publications).

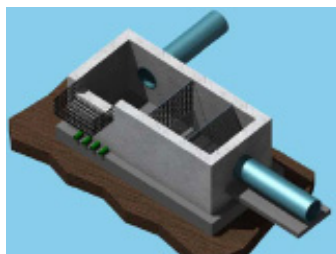


Figure 4. Baffle box (courtesy of Caltrans).

Baffle Boxes. This device has two chambers, one that uses an underflow wire to trap floatables and a second chamber that uses a bar rack to screen out any material that passes from the first chamber (Caltrans 2003a). As inflow enters the first chamber, solids are allowed to settle. A hinged chain-link screen allows high flows to pass and keeps the majority of floatables in the first chamber. Baffle boxes also have an overflow weir to convey bypass flow. An overflow basket is attached to capture any solids that flow over the weir (Caltrans 2003a).

V-Screens. This device use two sections of a V-shaped wedge wire screen and a 5 mm (0.2 in. nominal) spaced wedge wire sloped screen with the slotting to remove gross solids. Flow passes through the reverse sloping screens and drops to the outlet pipe. Gross solids collect in the solids storage area behind the screen. The solids storage area is sloped to allow for effective drainage. Sufficient screen area and volume are provided to accommodate an estimated once per year maintenance cycle without plugging (Caltrans 2005a). Currently, there are two configurations of V-Screens, which differ between the direction of screen slope (forward or backward) (Caltrans 2005a).

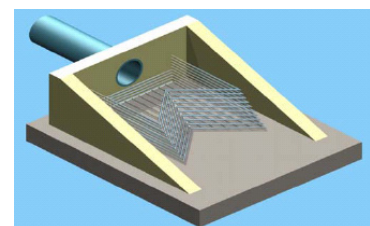


Figure 5. V-screen (courtesy of Caltrans).

Non-Caltrans Devices

StormScreen™. This device is a passive, high-flow screening™ system used for removal of trash and debris and some TSS by combining direct screening and settling. The system uses a float-actuated, radial flow cartridge

constructed of stainless steel screen. In addition, the StormScreen™ system uses a patented self-cleaning mechanism that prevents binding of the screen surface and also incorporates a high flow bypass. It can be installed into small catch basins or incorporated into large, cast-in-place facilities (Caltrans 2004). The StormScreen™ system maybe used for treating flows inline or end-of-pipe .

End-of-Pipe Screening Devices

End-of-pipe screening devices, which include wire baskets, bar racks, and perforated screens, are a common and simple method for removing gross solids from stormwater flow. These devices are made of galvanized steel or high density polyethylene and fiberglass and are placed at the end of stormwater pipes or at the entrance to a wet well of a stormwater pump station. Bar racks are often placed at an angle (up to 45° from the vertical) in the water flow. These devices remove gross solids through two basic mechanisms:

- Direct straining of all particles larger than the screen openings; and
- Filtering of smaller particles by straining flow through the mat of solids already deposited on the screen (USEPA 1999a).

There is no industry standard for classifying screens based on width of aperture. However, trash racks tend to have relatively large spaces between bars (~1.5 - 3.0 in) while baskets and screens are designed with a range of spacings to capture smaller particles (0.3 - 1.3 in) (USEPA 1999a). Apertures must be large enough so that partial plugging will not adversely restrict flows reaching the control outlet (Knox County 2007). Spacing of the rack bars or screen aperture should be wide enough to avoid hydraulic interference, but close enough to provide the desired level of clogging protection (Knox County 2007). Some designs (e.g., ROMAG™) incorporate rake mechanisms that automatically clean the deposited material to prevent screen blinding (USEPA 1999a). Some design examples include:

- ROMAG™ automatic mechanical screen (Parkson Corporation)
- Structural plastic trash racks and debris cages (Plastic Solutions)
- Trash Racks (Shurtleff Stormwater Treatment Products)



Figure 6. Trash Racks (courtesy of Shurtleff Stormwater Treatment).

Applicability/Siting

Catch Basin Screens

Catch basin screens should be located in areas that are prone to storm drain pipe blockages or are known to contribute large amounts of gross solids. Examples include shopping centers and other busy commercial areas (RBF Consulting 2003).

Inline Screening Devices

Caltrans recommends the use of the Gross Solids Removal Devices (GSRDs) in the following situations:

- Receiving water bodies which are 303(d) listed for gross solids (litter/trash);
- Where recommended by Caltrans Maintenance (if trash persistently affects the storm drain system); and
- Where TMDLs require gross solids removal.

GSRDs are best suited at sites that have sufficient space to safely allow construction and maintenance (Endicott et al 2002). GSRDs require very little head and are well suited for narrow and relatively flat areas (RBF Consulting 2003). They can also be used at the end of storm water pipes.

End-of-Pipe Screening Devices

Baskets, screens, and racks can be installed on nearly any stormwater outfall, and can also be used at stormwater management impoundment structures.

Performance and/or Effectiveness

Catch Basin Screens

The City of Los Angeles has experimented with the installation of catch basin screens. In 2000, city engineers did not observe any clogging at coarse screens installed in the experimental area (City of Los Angeles 2002a).

Inline Screening Devices

As a response to the trash TMDLs instituted in Southern California, Caltrans undertook a multi-year pilot study to develop and test various devices to capture trash. To be certified (by Caltrans) as meeting the trash TMDL requirements, devices had to meet the following criteria: capture 100% of material greater than 5 mm; no clogging of screens; ability to convey a 25-year peak flow; and drain within 72 hours. In addition, Caltrans required that the device only need one clean-out per year (i.e., has a capacity to hold the total annual load of gross solids) and did not require additional maintenance (Caltrans 2003a).

Effectiveness was calculated as:

$$\text{Effectiveness} = \frac{(\text{Solids Caught in GSRD})}{(\text{Solids in GSRD} + \text{Bypass Solids})} * 100\%$$

To calculate this percentage, the amount of gross solids (i.e., litter and debris) and the total amount loading to each device was measured annually. The litter fraction was then manually separated from each component. The amount of captured gross solids was defined as the total mass and volume of gross solids removed from within the device during the annual cleaning or, if necessary, incremental cleanings. The total loading was the sum of the captured gross solids and the bypassed gross solids (those gross solids that bypassed by way of overflow or by material passing through the device screen and that were captured in a mesh bag and/or mesh screen box located downstream of the pilot device) (Endicott et al 2002).

Caltrans tested the following four devices: Linear Radial (LR), Inclined Screens (IS), V-Screen (VS), and Baffle Box (BB), each with a range of configurations (3 LR, 4 IS, 2 VS and 2 BB). Two of the Linear Radial devices (LR 1 and 2), both Baffle Boxes, and three of the Inclined Screens (IS 1, 2, and 3) were tested over two years (2000 - 2002). The remaining devices have only one year of data.

Effectiveness for the devices and their various configurations differed widely over the test period (Table 1). Effectiveness values ranged from 8.9% by weight (66.7% by volume) to 100% (by weight or

Table 1. Observed effectiveness for Caltrans screening devices. Effectiveness was determined over the course of several pilot studies (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).

Device-Configuration	Effectiveness	
	% by weight	% by volume
IS-1	100	100
IS-2	73 - 100	69 - 100
IS-3	90 - 96	90 - 95
IS-4	46	66.7
LR-1	100	100
LR-2	87 - 100	56 - 100
LR-3	8.9	43.7
VS-1	98	88
VS-2	93 - 98	91 - 95
BB-1	93 - 97	87 - 90
BB-2	100	97 - 100

volume). These differences cannot be solely attributed to differences in loading. Although some loading values exceeded the design capacity, in general, there was no relationship between loading and effectiveness (Caltrans 2003a,b and Caltrans 2005 a, b). The very low values of LR-3 were due to one design element - LR-3 was the exact same design as LR-1 except for the slope of the vault. LR-1 was designed to have a 2% slope, while LR-3 had a 70% slope. Therefore, the large momentum of the stormwater runoff forced the gross solids out of the device and into the bypass chamber (Caltrans 2005b).

Over the course of testing, many of the devices experienced high bypass proportions, screen clogging, and/or required too much maintenance to meet the approval criteria set by Caltrans. Only three units consistently met the criteria, IS-1, IS-4, and LR-1. IS-4 merited recommendation for approval despite its low initial effectiveness, as all the material in the bypass bag was sediment. Since sediment was smaller than the mesh size of the screen, this configuration was still considered 100% effective for removing trash and debris.

In general, Caltrans found that these devices can be effective to very effective in removing litter from discharges of highway stormwater runoff. Screen clogging and subsequent bypass was found to be the most common cause of failure. Therefore, a device must incorporate a screen of adequate size to prevent clogging and litter bypass during overflow events (Endicott et al 2002). Design loading rates should also consider total trash, including solids, vegetation and litter to help prevent clogging. Trash and debris storage and screen clogging prevention must be individually considered during design (Endicott et al 2002).

Prior to the pilot studies, Caltrans developed a set of goals that had to be met for devices to merit Caltrans requesting full capture certification by the LARWQCB. Three of the device configurations met all the criteria and goals outlined by Caltrans and two devices (LR-1 and IS-1) have now been certified full capture by the LA RWQCB (LARWQCB 2004).

End-of-Pipe Screening Devices

During December 2001, the City of Los Angeles installed screens at five stormwater outlets within the Los Angeles River watershed (City of Los Angeles 2002a). As part of this study, it was required that the devices would not overflow during intense storms. This was evaluated by visual inspection. The study also measured the total amount of trash and debris held by the various screens. Visual observations made during the first three months of installation indicated that several of the devices had experienced overflow and four of the devices were substantially clogged by trash and debris. Trash and debris was also observed to be escaping underneath the screens at two of the locations. The devices were cleaned during the spring of 2002. A total of 21,355 pounds of trash was removed (Table 2).

Table 2. Cleanout results of five trash screening devices installed by the City of Los Angeles (City of Los Angeles 2002a).

Site	Design	Dimensions (ft)	Volume (cf)	Weight (estimated lbs) ²
1	Screen	3	6.8	135
2	Screen	8x6	35	700
3	Screen	14	370	7,500
4	Basket	2.75x3.75x2.25	1	20
5	Basket	15.5x7.5x3	640	13,000

The City of Los Angeles concluded that while the screens could hold large amounts of trash and litter, the design of the screens would have to be modified to maximize performance without compromising hydraulics.

In addition, a British study of the effectiveness of the ROMAG™ found that the average solids loading rate before the ROMAG™ screen was 2369 g/min, while the solids concentration after the screen was 3.5 g/min, equaling a 98.5% deflection rate (USEPA 1999a).

² The text of the report does not explain how weight of gross solids was estimated and if the weight reflects all gross solids or just trash and litter.

Maintenance

Catch Basin Screens

Removal of accumulated trash occurs during regular street sweeping activities. Additional maintenance may be required in areas where flooding is a potential problem (RBF Consulting 2003). Fixed catch basin opening screen covers should be removed or opened prior to the rainy season. Hydraulically retractable designs may require additional maintenance to ensure that they work properly and do not jam (open or closed) (Gordon and Zamist 2006).

Inline Screening Devices

Caltrans GSRDs were designed to be cleaned on an annual basis and to use maintenance equipment that is commonly available in the Caltrans maintenance fleet (Endicott et al 2002). During the pilot studies, Caltrans maintenance staff spent on average 8 to 24 hrs/person cleaning each device (Table 3). However, it should be noted that the cleaning effort required for the pilot project was much greater than expected for normal cleaning. Monitoring of the devices greatly increased the maintenance effort during the pilot studies. The majority of the devices are designed to use a vacuum truck or boom truck for cleaning (Caltrans 2003a, Caltrans 2005a) with the exception of the IS-3, which is designed to be cleaned with a front-end loader (Caltrans 2003b). The LR-2 configuration also requires the manual removal of mesh bags and shoveling of gross solids collected in the concrete vault (Caltrans 2003a). Inspections (visual observation) of the devices should occur regularly. The inspection schedule should be as follows:

- One inspection thirty days prior to beginning of rainy season (Oct 1- May 1);
- A few inspections during the rainy season. Preferably, after a rain event 25.4 mm (1 in) or greater; and
- One inspection at the end of the rainy season in conjunction with the annual cleaning (Caltrans 2003a).

Table 3. Total number of times devices were cleaned during Caltrans pilot studies and average hours required to clean the devices.

Device (Site)	Total # Cleanings		Avg Person Hrs/storm season	Avg person hrs/cleaning
	Year 1	Year 2		
LR-1 (I-10)	1	1	24	24
LR-2 (I-210)	1	2 ^{XY}	36	24
LR-2 (I-5)	2 ^X	2 ^Y	16	8
LR-3 (US-101)	3		12.25	
IS-1 (SR-170)	1	1	12	12
IS-2 (US-101)	2 ^Y	1	12	8
IS-2 (I-210)	2 ^Y	2 ^Y	24	12
IS-3 (I-10)			24	
IS-4 (I-210)	1	1	4	
BB (I-405)	2 ^Y	2 ^Y	12	24
BB (I-210)	2 ^Y	1	12	18
VS-1 (I-405)	1	n/a	4	n/a
VS-2 (SR 91)	1	1	6	n/a

^XDevice cleaned because it was >85% full; ^YDevice cleaned due to observed clogging and overflow. Phase 1 GSRDs Pilot Study (Caltrans 2003a). LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

End-of-Pipe Screening Devices

In general, screens and trash racks have moderate maintenance requirements (USEPA 1999b). Self-cleaning units have very low maintenance requirements (USEPA 1999b). Based on their pilot study results, the City of Los Angeles recommends that manual screening devices should be maintained after every rain event that is 0.25 in or greater (City of Los Angeles 2002a).

Costs

Catch Basin Screens

Installation costs of entrance grate and screens are low. If cleaning can be incorporated into regular street cleaning, no additional maintenance costs will apply (RBF Consulting 2003). According to the City of Los Angeles, the price for catch basin screens ranged from \$400 for a typical, manually removable unit up to \$1,500 for the hydraulic-open types (City of Los Angeles 2002b). The City of Los Angeles, Department of Watershed Protection, estimated that it would require ~34,000 inlet catch basin screen covers, which would cost ~\$44,200,000 over ten years (Table 4) to meet its trash TMDL requirements (Kharaghani 2003).

Table 4. Estimated costs for implementing catch basin screens within the City of Los Angeles (Kharaghani 2003).

Capital Costs \$	Total O & M/yr \$	Capital Labor \$	Total/10 yr \$	Total/year \$
34,000,000	3,400,000	6,800,000	44,200,000	4,420,000

Inline Screening Devices

The cost of installing various inline screening devices developed for the Caltrans pilot study ranged from \$61,560 to \$345,000 (Table 5). Installation time ranged from one to two calendar months, depending on the device (Table 6). The additional installation of monitoring equipment/structures increased the final costs, but these would not likely be included for non-pilot installations. The variation in costs was related to differences in conditions at the chosen pilot

Table 5. Costs associated with the installation of Caltrans pilot devices. (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).

Device Configuration (Site)	Drainage Area ha (ac)	Total Cost ¹ \$	Cost ² \$	Cost/ha	Cost/ac
IS-1 (SR-170)	1 (2.5)	100,800	82,800	82,800	33,120
IS-2 (US-101)	1.4 (3.4)	150,425	134,351	95,965	39,515
IS-2 (I-210)	0.8 (2.1)	151,337	135,263	169,078	64,411
IS-3 (I-10)	1.3 (3.3)	370,059	345,000	265,385	107,400
IS-4 (I-210)	1.0 (2.5)		113,640	113,640	45,989
LR-1 (I-10)	1.5 (3.7)	66,200	48,300	32,200	13,054
LR-2 (I-210)	2.5 (6.2)	172,009	155,935	62,374	25,151
LR-2 (I-5)	0.4 (0.9)	110,462	94,388	235,970	104,876
LR-3 (US-101)	0.8 (2.1)	n/a	n/a	n/a	n/a
BB-1 (I-405)	1.2 (3.0)	129,422	113,348	94,457	37,783
BB-2 (I-210)	0.9 (2.3)	135,629	119,555	132,839	51,980
VS-1 (I-405)	1.2 (3.0)		61,560	51,300	20,761
VS-2 (SR 91)	0.8 (2.0)		75,881	94,851	38,386

¹Total costs includes monitoring equipment; ²Costs do not include monitoring equipment. LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

study sites (Caltrans 2003a).

End-of-Pipe Screening Devices

The cost for end-of-pipe screening devices varies according to the size of the screen, flow rate, construction material (steel vs. plastic) and if it is manual or automatic (USEPA 1999). For example, the capital cost for a ROMAG™ automatic screening device ranged from \$55,000 to \$185,000 (USEPA 1999). The five manual screens installed by the City of Los Angeles had a total design and installation cost of \$40,000 (City of Los Angeles 2002b) and an expected maintenance

Table 6. Number of days to install Caltrans devices. (Caltrans 2003a, Caltrans 2003b, Caltrans 2005a, Caltrans 2005b).

Device Configuration (Site)	Working Days
LR	21-35
IS	25-57
VS	38-45
BB	33-37

LR = Linear Radial Screen, VS = V-Screen, IS = Inclined Screen, BB = Baffle Box.

cost of \$20,000/unit/yr (assuming 10 cleanings) (City of Los Angeles 2002b). Construction costs for screen systems include costs for installing a specialized housing unit for the screen within the pipe. This may require costly structural alterations to regulators and outfalls.

Pros

Catch Basin Screens

Catch basin screens are relatively easy to install and are easy to retrofit into existing catch basins. They are relatively inexpensive. Their maintenance can easily be incorporated into regular street sweeping schedules and should not add any additional maintenance costs. They can help reduce or prevent storm drain pipe blockages.

Inline Screening Devices

The Caltrans inline screening devices can be installed in an existing right-of-way (Caltrans 2003a). Based on data gathered by pilot studies, the devices removed nearly all the trash and litter from stormwater runoff with minimal maintenance requirements (i.e., annual cleanouts) (Caltrans 2003a,b, Caltrans 2005a,b). Devices are designed to be cleaned with equipment readily available to maintenance staff. Installations can be shallow and open to air, eliminating need for confined entry. The vaults of the Caltrans devices can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the right-of-way. The devices are relatively moderately priced. Screen openings can be custom sized and end-of-pipe applications have low head loss. Two devices (LR-1 and IS-1) have been certified as full capture by the LARWCQB (LARWCQB 2004). These two units only require one cleaning per year.

End-of-Pipe Screening Devices

The cost of end-of-pipe screening devices is low compared to other structural control devices. Maintenance is relatively simple and does not involve any confined space for maintenance crews. End-of-pipe screening devices are easy to monitor as gross solids are visible. They can be designed in a wide range of sizes and shapes and accommodate a wide range of applications. Installation is simple and devices can be retrofitted into current stormwater systems. Plastic designs are lightweight, ultraviolet resistant and corrosion resistant.

Cons

Catch Basin Screens

Catch basin screens can contribute to flooding problems during high flows. In addition, trash is not held in one location until cleaning, it remains on the street and can be further dispersed by wind. Parked cars can impede street sweeping activities and affect the efficacy of the screen covers. If not designed or installed properly, mechanical versions may prematurely jam (open or closed). Hydraulically retractable designs required more maintenance to ensure that they worked properly and did not jam.

Inline Screening Devices

Capital and installation costs of inlined screening devices can be relatively high. In addition, they require a relatively high surface area. Traffic control may be required during maintenance and installation. Devices should be designed to eliminate standing water which can provide breeding habitat for vectors. Baffle box designs required significant maintenance to remove accumulated sediment. Caltrans did receive complaints about the aesthetics of the baffle box during the pilot study.

End-of-Pipe Screening Devices

Clogging can become a problem with screens. If aperture size is increased to relieve clogging, performance will decrease. Finer meshed screens can trap more material but are more susceptible to clogging. As a result, they required more maintenance. The performance of screening units is reduced significantly by the presence of oil and grease. The performance of the various designs has not been thoroughly tested. Self-cleaning devices have more parts that are susceptible to damage or malfunction.

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