CHAPTER 10 GROSS POLLUTANT TRAPS

10.1 INTRODUCTION

This Chapter presents design procedures for gross pollutant traps (GPTs) which are installed to remove litter, debris, coarse sediment and hydrocarbon from stormwater. They may be used as pre-treatment BMPs for flow into a pond or wetlands or to remove coarse sediment before the flow enters infiltration devices. Most GPTs will provide some reduction in other associated pollutants that are attached to the trapped sediments for subsequent removal.

10.2 TYPES AND APPLICATION

There are a wide range of devices used for the trapping of gross solids. Selection of suitable devices depends on many factors including catchment size, incoming pollutant load, type of drainage system and whole life cost. Table 10.1 provides three main types of GPTs for practice, each with its function, suitable catchment areas and installation option. Figure 10.1 presents typical configuration of built GPTs Type 1, 2 and 3 assets.

Table 10.1: GPTs Types and Application

Class		Function	Catchment Area	Installation
Type 1	- Floating Debris Traps	Litter capture on permanent waterbodies	> 200 ha	Proprietary and purposely built
	- Trash Racks & Litter Control Devices	Litter capture on drainage conveyance	2 – 40 ha	Purposely built from modular components
Type 2	- Sediment Basin and Trash Rack (SBTR) Traps	Sediment and litter capture on drainage conveyance	5 – 200 ha	Purposely built
Type 3	- Oil and Grease Interceptor	Oil, grease and sediment capture on drainage conveyance	< 40 ha	Purposely built and Proprietary

a) Floating Debris Trap - Type 1

b) Trash Rack - Type 1

c) SBTR Traps - Type 2

d) Oil and Grease Interceptor – Type 3

Figure 10.1: Typical GPTs Types

10.2.1 Floating Debris Traps

Floating debris traps or booms should be a main component of GPTs Type 1. They are installed primarily on streams, slow moving main drainage and pond inlets where there is permanent water body. Booms are only effective as a control measure for floatable pollutants under certain conditions. The requirements for a suitable site include the followings (Willing & Partners, 1989):

- Favourable currents;
- Location relative to major sources, such as tributary stormwater drains;
- Availability of access for maintenance;
- Ability to handle the effects of water level changes; and
- Suitable locations for attachment and anchorage.

Booms are generally not effective unless there is a steady current to force trapped material into the boom. Tidal flow reversals or strong adverse winds may disperse the trapped material, rendering the boom ineffective. They are also not effective when the current velocities are high and turbulent.

Installation of the boom will mainly be governed by site conditions. Sufficient slack must be provided to allow the boom level to rise and fall with water level variations, such in tidal and flooding conditions.

The pollutant materials collected in urban areas are potentially offensive, hazardous or infectious wastes including discarded syringes which necessitate arrangements for mechanical cleaning. Decision to install a boom or a trash rack is governed by a number of factors including (Nielsen and Carleton, 1989):

- Trash types - Booms were found to be effective in retaining floating and partially submerged objects; and
- Hydraulic - The trash retaining performance of booms decreases at higher flows because trash is forced under and over them. The minimum flow velocity at which trash escapes by being forced underneath a boom depends largely on the shape and weight of the boom and has been observed to be as low as 1m/s.

10.2.2 Trash Racks and Litter Control Devices

Trash racks is another component of GPTs Type 1. Trash racks range from relatively small screens installed at the outlets of stormwater pipes to large steel trash racks on main drains and open channels and more recently "soft" trash racks (litter control devices) that are installed in open channels and at the outlets of piped drains. The consideration of implementing either a boom or trash rack depends on the characteristic of the floating debris and the site suitability.

The preferred trash rack arrangement, suggested by a number of researchers, is that a trash rack with horizontal bars set at an angle to the flow should be self-cleansing, since the flow would push debris towards the sides of the rack. The effectiveness of such an approach would appear to depend on the shape and surface finish of the bars and their angle relative to the flow.

The litter control devices collect litter, as do trash racks. This "soft" trash rack are a series of nylon mesh "socks" which are attached to a rectangular metal frame that is mounted vertically and perpendicular to the flow. The socks are cleaned by removing each sock in turn, undoing the tie at the base of the sock and dumping the collected material into a truck. The base of the sock is then re-tied and it is slotted back into place. Due to the effectiveness of the socks it has been found that during periods of rainfall the soft trash racks may need to be cleaned every two to three days. These types of devices require a high maintenance and on-going cost. If not maintained, the upstream storm flow capacity is greatly compromised.

10.2.3 Sedimentation Basin and Trash Rack

Sedimentation basin functions by providing an enlarged waterway area and/or reduced hydraulic gradient to reduce flow velocities and allow bedload sediment to be trapped and suspended sediments to settle out of suspension. They do not provide litter removal. In urban areas, the presence of litter makes it preferable to build a Sedimentation Basin and Trash Rack (SBTR) type GPTs.

SBTR traps, GPTs Type 2, combine the functions of a sedimentation basin and a fixed trash rack. The trap is a major basin designed to intercept litter, debris and coarse sediment during storm flows and to act as an efficient retarding basin. This trap draws on the experience of sedimentation basins with incorporation of additional features to intercept trash and debris.

Major SBTR traps are typically located in trunk drainage channels and engineered waterways to intercept medium to high stormwater flows from large urban catchments. They are visually unattractive and generally should be placed away from residential areas. Indicative arrangement of major SBTR traps is shown in Figure 10.2.

Minor SBTR traps, covered in-ground, are used at the downstream end of pipe or open drains. They are less visually intrusive and hence are more suitable for residential areas. Due to the cost of the structure they are usually smaller in size and are only suitable for treating small catchment areas. Typical arrangement of minor SBTR traps is illustrated in Figure 10.3.

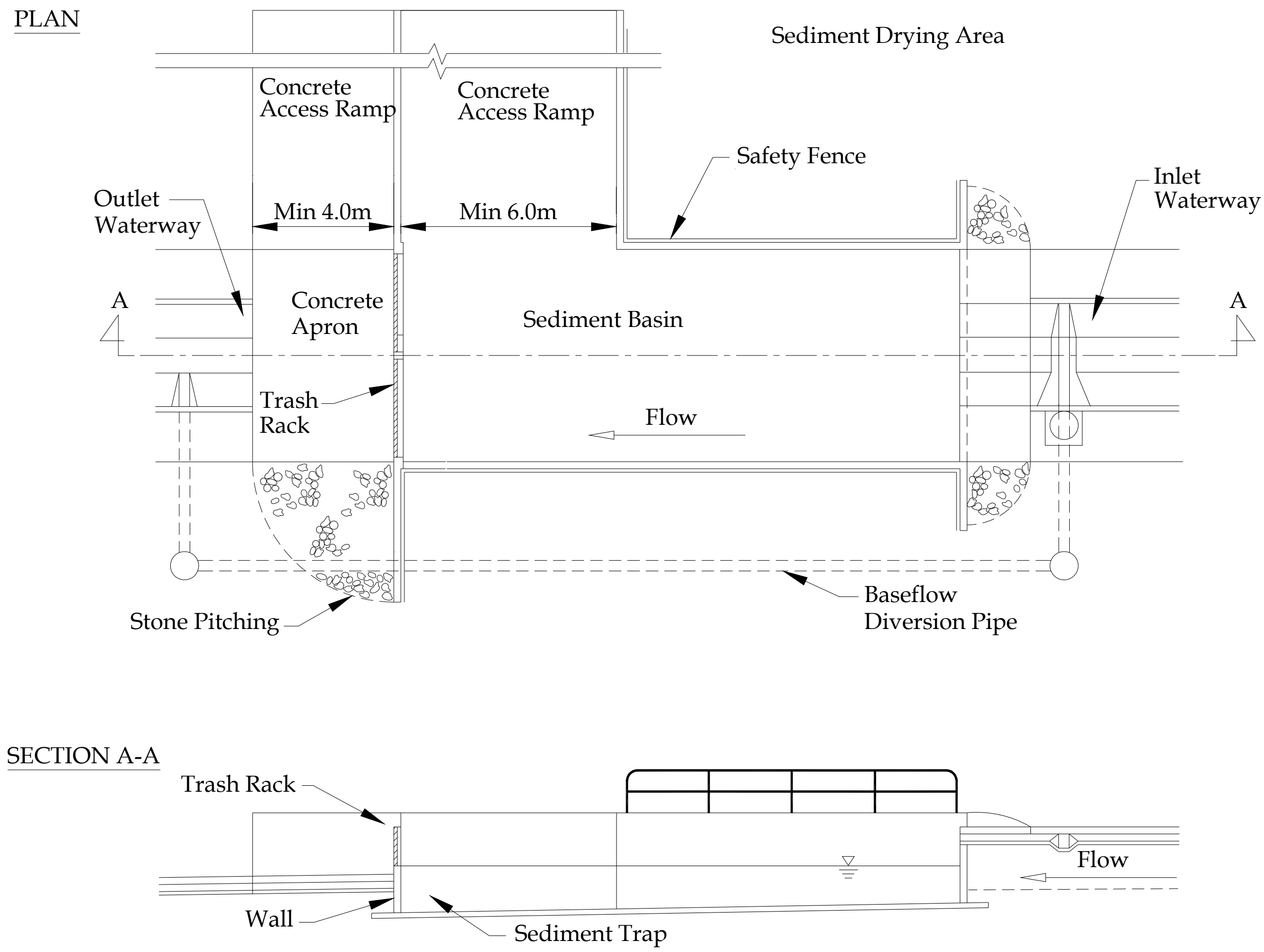


Figure 10.2: A Typical Major SBTR Trap Arrangement

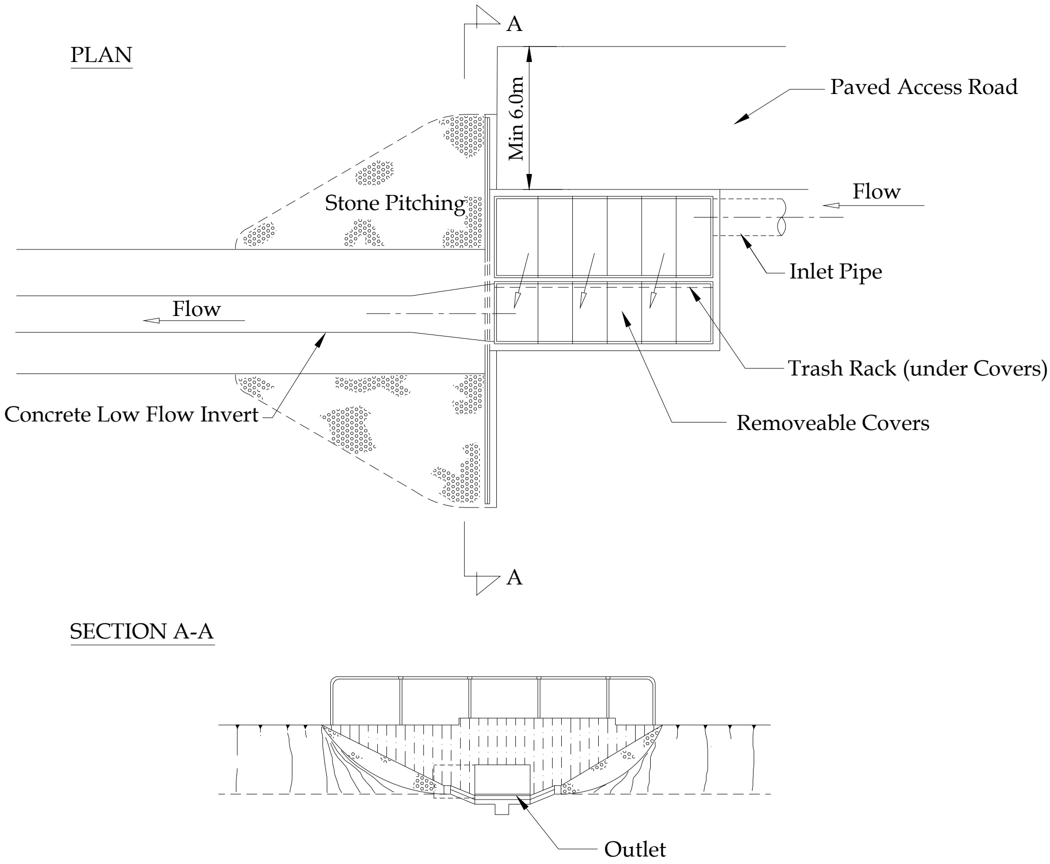


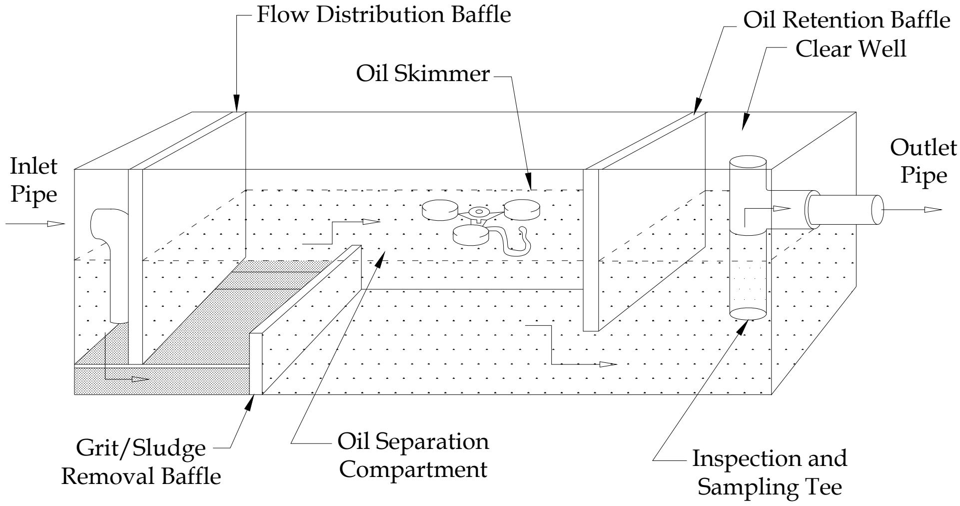
Figure 10.3 : A Typical Minor SBTR Trap Arrangement

10.2.4 Oil and Grease Interceptor

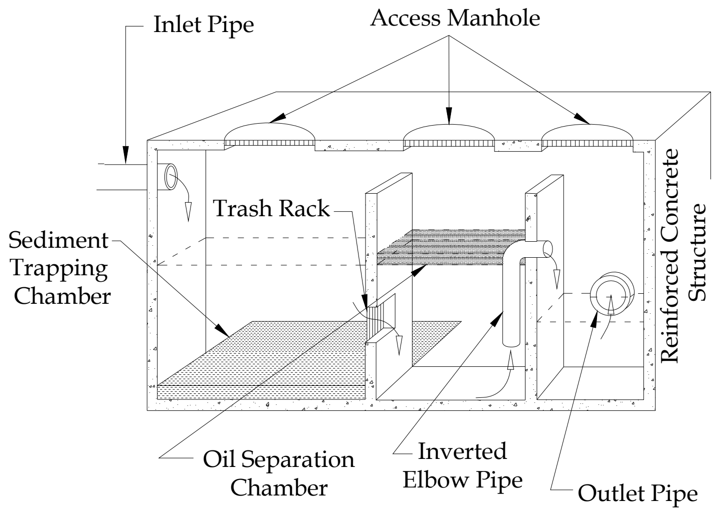
Oil and grease interceptor (OGI), GPTs Type 3, is intended to separate out oil and other hydrocarbons, grit, and coarse sediments from runoff. They are often used to pretreat runoff from parking lots and other impervious surfaces before it enters stormwater system. Because of the short runoff retention time, they are effective only in reducing the amounts of coarse-grained sediments, debris, oil and grease present in runoff. They must be cleaned out frequently, as needed, to remove collected grit and pollutants for disposal.

Schematic diagrams of typical three-chamber OGI are shown in Figure 10.4. Runoff enters the first chamber through a storm drain pipe or curb inlet, passes through screened orifice opening/baffle to the second chamber, then passes through another baffle or an inverted pipe elbow to the third chamber. Flow exits the third chamber through a storm drain outlet pipe.

The first chamber is used to trap floatable debris and settle coarse particles such as sediment. The second chamber is used to separate out oil, grease and other hydrocarbons that float to the water surface while the runoff is withdrawn from the opening of the baffle or elbow. The floating hydrocarbons remain in this chamber until removed at clean-out or adsorbed by sediment and settled out. The third chamber will have a permanent pool if the outlet pipe is elevated above the floor. Additional sediment may settle out in this chamber. An overflow opening is included in each chamber for large stormwater flows to bypass the orifice openings between chambers. Clean-out access is available through manhole openings.



a) Conventional Gravity Separator (CDM, 1993)



b) Water Quality Inlet (Dewberry & Davis, 1966)

Figure 10.4: Typical Oil and Grease Interceptors Arrangement

OGIs are applicable to situations where the concentration of oil and grease related compounds will be abnormally high and source control cannot provide effective removal. The general types of activity where this situation is likely are truck, car and equipment maintenance and washing business, as well as a business that performs maintenance on its own equipment and vehicles. Public facilities where OGIs may be required include marine ports, airfields, fleet vehicle maintenance and washing facilities and mass transit park-and ride lots. Conventional OGIs are capable of removing oil droplets with diameters equal to or greater than 150 microns.

10.3 GENERAL DESIGN CONSIDERATIONS

Design of GPTs requires information on the hydrology and hydraulics of the drainage system. For each GPT, considered as part of a "treatment train", a primary treatment objective or performance criteria related to a specific pollutant shall be defined. This is the target pollutant that is to be reduced to a recommended level.

10.3.1 Hydrology and Hydraulics

Peak inflows shall be computed using the Rational Method or Rational Hydrograph Method. Normally these calculations will be done as part of the hydraulic design of the drainage system. More important for GPT design is the magnitude of sediment and other pollutant loads that will determine the frequency of cleaning.

The pollutant reduction performance must be maintained up to the design discharge. If design flows are exceeded, the GPT should not allow any significant re-mobilisation of trapped material. The GPT must be designed so as to prevent any additional surcharge in the stormwater system in the event of partial or complete blockage. Tidal influence and backwater effects must be considered.

10.3.2 Ease of Maintenance

Problems with maintenance can be partly overcome by appropriate design. Considerations should be addressed during the preliminary design stage of a GPT. This includes adequate provision of road access to the site for maintenance vehicles and equipments. Suitable walkways, ladders, manholes and plinths shall be provided within the structure for access.

10.3.4 Health and Safety

Open GPTs can present a safety hazard from the followings:

- Raised structures that children can fall off and sudden drops into deep water; and
- Sudden changes in flow velocities or water levels.

Therefore GPTs should be fully fenced off, if possible. Such fencing should be designed so that it does not interfere with the hydraulics of the flow structure.

Provision shall be made to minimise mosquito hazard as follows:

- Keeping the sediment trap wet with a low or trickle flow; and or
- Using biodegradable slow release larvicides (note: full environmental impact assessment of the larvicide would be needed prior to the adoption of this alternative).

10.4 DESIGN OF SEDIMENT BASIN AND TRASH RACK

The major SBTR traps are designed as open traps on large open drains or engineered waterways where they are installed at or below ground level and serve the catchment area in the range of 5 to 200 ha. Whereas, the minor SBTR trap is enclosed and installed below ground with contributing catchment area of less than 5 ha. SBTR traps permit coarse sediment to settle to the bottom by decreasing the stormwater flow velocity through increased width and/or depth of the drain.

The trash rack is intended to collect floating and submerged debris. Experience has shown that it should be located at the downstream end of the sediment basin compartment.

10.4.1 Design Standard

The SBTR type GPTs should be designed to retain all sediments, litter and debris based on the water quality design storm of 3 month ARI that has been described in Chapter 3 and to comply with the size requirements of Design Chart 10.A1 in Appendix 10.A.

Traps designed according to these criteria are expected to remove, on an annual average basis, 70% of the sediment with a grain size ≥ 0.04mm. This sizing criterion may not be attainable in the case of very fine-grained soils (silts and clays).

10.4.2 Design Parameters

The SBTR trap relies on reducing the flow velocity sufficiently to allow settling by gravity. These principles apply to both major SBTR and minor SBTR traps. The design parameters are given below:

- The ratio of length: width of the sediment basin should be between 2 and 3;
- Velocity through the sediment basin should not exceed 1.0m/s, to minimise re-suspension;
- For a sediment trap volume greater than $5m^3$, a sediment drying area with a minimum area equal to $1.5m^2$ for each m^3 of trap volume shall be provided, where sediment may be dried prior to transportation. The drying area shall be surfaced with 300mm of compacted gravel or other approved surfacing;
- Trash rack shall have maximum bar spacing 50mm to retain a small plastic bottle or an aluminium drink can;
- Trash racks shall be sized to operate effectively whilst passing the design flow without overtopping and with 50% blockage;
- Trash racks shall be structurally stable when overtopped by flood events up to the major design storm when fully blocked. Trash racks and their supporting structures shall be designed to withstand impact of a large floating object together with its drag loads or debris loads (100% blocked);
- The design must allow water to flow past or over the trash rack when the trash rack is blocked; and
- Vehicular access must be provided for maintenance.

10.4.3 Sizing Steps

The efficiency of the trap will vary with soil type and adjustment factors for different soils are given in Design Chart 10.A2 in Appendix 10.A The chart shows typical soil gradations and the relevant adjustment factors F_1 and F_2.

Sizing for SBTR trap involves the steps set out below:

Step 1: Determine the required removal efficiency of coarse sediment ≥ 0.04mm diameter, $P_{0.04*}$.

Step 2: Determine the catchment area A_c (m^2) served by the sediment trap and the applicable degree of urbanisation [*U*] within that catchment. Allow for future catchment development, if appropriate.

Step 3: Select an initial trial trap area ratio *R*:

$$R = \frac{A_t}{A_c} \tag{10.1}$$

where,

A_t = Area of trap (m^2); and
A_c = Area of catchment (m^2).

Step 4: Find $P_{0.04}$ for the reference soil and degree of urbanisation [*U*] from the appropriate Design Chart 10.A1 and Factor F_1 from Design Chart 10.A2. Calculate the actual trap removal efficiency for the site soil:

$$P_{0.04*} = P_{0.04} \times F_1 \tag{10.2}$$

where,

F_1= Factor from Design Chart 10.A2.

Adjust *R* if necessary by trial and error to obtain the required performance.

Step 5: Select the length L_t (m) and width W_t (m) of the sediment trap to give the required area A_t such that the length to width ratio is between 2 and 3, and the width is not less than 2m.

Step 6: Determine the average annual TSS load L (tonnes) using Equation 3.2 then estimate sediment load, M (tonnes) with grain size ≥ 0.01mm.

Step 7: Determine the average annual percentage retention $P_{0.01}$ of sediment ≥ 0.01mm for the reference soil from the applicable Curve B in Design Chart 10.A1 for the selected trap area ratio (A_t/A_c). Then determine the adjusted average annual percentage retention $P_{0.01*}$ of sediment ≥ 0.01mm from the equation:

$$P_{0.01*} = P_{0.01} \times F_2 \tag{10.3}$$

where,

F_2 = Factor from Design Chart 10.A2.

Step 8: The required sediment trap volume is a function of the average frequency of cleaning. Assuming that the trap is cleaned two times per year and that it is half full when cleaned, the required depth D_w is given by:

$$D_w = 0.0065 \times P_{0.01*} \times M / A_t \tag{10.4}$$

where,

D_w = Depth of the sediment trap below trash rack (m); and

M = Annual sediment load (tonnes).

This relationship is based on a sediment density of 2.65 tonnes/m^3 and a sediment porosity of 0.42.

Step 9: Determine the design flow in the water quality design storm of 3 months ARI, $Q_{0.25}$.

Step 10: Determine the trash rack height, based on the rack not being overtopped in the water quality design storm when the rack is 50% blocked.

The presence of a downstream hydraulic control can lead to the downstream submergence of the trash rack and an increase in the pool level upstream of the trash rack. Under these conditions the trash rack height should be sized by a hydraulic analysis of the site and the trash rack. The sizing method for a standard vertical-bar trash rack is presented herein (Willing & Partners, 1992).

Under unsubmerged conditions, the required height of the trash rack [H_r] is twice the depth at critical flow [y_c] through the unblocked trash rack.

$$H_r = 2y_c$$

$$= 2\left(\frac{{Q_{0.25}}^2}{g \cdot {L_e}^2}\right)^{1/3} \tag{10.5}$$

where,

H_r = Required height of trash rack (m);

$Q_{0.25}$= The design flow (m^3/s), of 3 month ARI;

g = Gravitational acceleration, 9.8m/s^2; and

L_e = The effective length of flow through an unblocked trash rack (m).

Using a standard design of vertical 10mm galvanised flat steel bars at 60 mm centres and a coefficient [C_c] of 0.8 to account for contraction of flow through the trash rack, gives:

$$H_r = 1.22\left(\frac{Q_{0.25}}{L_r}\right)^{2/3} \qquad (10.6)$$

where,

L_r = Actual length of the trash rack (m)

Adjust the sediment trap dimensions to ensure that the velocity through the sediment trap when it is full does not exceed 1.0m/s in the water quality design storm, to minimise the re-entrainment of deposited sediment.

Determine the nominal design flow velocity $V_{0.25}$ in the water quality design storm using,

$$V_{0.25} = \frac{Q_{0.25}}{(D_w + H_r)W_t} \qquad (10.7)$$

in which W_t is the width of the sediment trap, normal to the direction of flow. Increase the dimensions of the sediment trap pool or increase the track rack height if the resulting velocity is greater than 1.0m/s.

Step 11: An additional step is necessary for covered (minor SBTR traps) to minimise the potential for upstream surcharge. Provide a minimum overflow clearance above the trash rack that is sufficient to discharge the flow of the inlet pipe even if the trash rack is fully blocked. The required clearance, B, is given by Equation 10.8 must be a minimum of 0.35m.

$$B = \left(\frac{Q_p}{1.7\,L_r}\right)^{2/3} \qquad (10.8)$$

where,

L_r = Length of trash rack (m); and
Q_p = Inlet pipe capacity (m^3/s).

Where possible a step shall be incorporated at the outlet of the SBTR trap to minimise submergence effects at any trash rack provided. The step should be determined using hydraulic principles but should desirably be 80 mm or greater.

An energy dissipation device shall be provided at the inlet to the SBTR trap where the velocity of the inflow stream under design flow conditions exceeds 2m/s. Excessive inlet velocities and turbulence will inhibit sedimentation action in the trap.

10.4.4 Special Design Considerations

(a) Major SBTR Traps

The longitudinal axis of the trap should be as close as possible to the centreline of the incoming drain or engineered waterway. Eliminate unnecessary angles in the flow, thus, it is proposed to have a long, straight basin.

For major SBTR traps as in Figure 10.2, a base flow bypass shall be provided around the sediment trap to divert low flows during cleaning. The bypass shall operate under gravity and shall have a minimum diameter of 300 mm to prevent blockage. The design parameters are given below:

- The floor of the sediment trap shall be graded to a dewatering sump located at the side of the sediment trap but clear of vehicle or equipment paths;
- Side walls shall be provided to reduce scour of the surrounding banks when the trash rack is overtopped. The minimum level of the top of the side walls shall be the greater of: (i) the level of the 3 month ARI flow when the trash rack is fully blocked, or (ii) 300mm higher than the top of the trash rack;

- Provision shall be made for a plinth or access walkway 800mm wide immediately upstream of the trash rack to allow access for cleaning or raking of collected material from the trash rack;
- Reduce the effect of wind-induced turbulence. Large open water surfaces are affected by wind, which produces cross-and counter currents that hinder settling and may resuspend bottom deposits; and
- Suitable landscaped screening should be considered.

(b) Minor SBTR Traps

For minor SBTR traps in Figure 10.3, the design parameters are given below:

- Pipe entries shall, where possible, be either parallel (preferred) or perpendicular to the major axis of the sediment trap;
- Low-flow bypasses are not normally required;
- The maximum allowable depth from the top of the surround to the lowest level of the sediment trap is limited by the reach of the equipment that will be used for cleaning. For an extended-arm backhoe, this is approximately 4.5m;
- The top of the structure should be at least 150mm above the surrounding ground level and/or protected by barriers to prevent vehicles from being driven over the trap;
- Lockable, removable covers shall be provided for access and maintenance; and
- Step irons shall be provided for access, in a position, which will not interfere with the operation of the cleaning equipment.

10.5 DESIGN OF OIL AND GREASE INTERCEPTOR

10.5.1 Design Criteria

OGI is typically an engineered precast tank designed to separate oil and grease from water through the use of baffled compartments and corrugated plates. Sizing determinations must be based on relevant information regarding the facility site, characteristics of the oil and grease loading in the stormwater flow, and upstream/downstream drainage network. Sizing must allow for adequate retention time and workable maintenance schedule.

OGI shall be constructed of impervious materials capable of withstanding abrupt and extreme changes in temperature. They shall be of substantial construction, watertight and equipped with easily removable covers which, when bolted in place, shall be gastight and watertight.

It must be located where maintenance can be easily performed. The installation should allow the cover to be visible and easily removable for cleaning, and clearances should be such that the internal baffling can be serviced. With the cover removed, all wetted surfaces should be visible. This is necessary not only for access to clean the interceptor, but also to have the capability to easily inspect the interior for potential problems such as damaged baffles and blocked air relief bypasses.

Sizing is related to anticipated influent oil concentration, water temperature and velocity, and the effluent goal. To maintain reasonable interceptor size, it should be designed to bypass flows in excess of 3 month ARI storm.

The sizing of OGIs is based upon the rise rate velocity of oil droplet and rate of runoff. However, with the exception of stormwater from oil refineries there are no data describing the characteristics of petroleum products in urban stormwater that are relevant to design; either oil density and droplet size to calculate rise rate or direct measurement of rise rates. Further, it is known that a significant percentages of the petroleum products are attached to the fine suspended solids and therefore are removed by settling.

10.5.2 Sizing for Conventional Gravity Interceptor

With small installations, a conventional gravity OGI has the general appearance of a septic tank, but is much longer in relationship to its width. Larger facilities have the appearance of a municipal wastewater primary sedimentation tank.

The sizing of a conventional gravity interceptor is based upon the calculation of the rise rate of the oil droplets using the following equation (API, 1990):

$$V_r = (g\, d_o^2(\rho_o - \rho_w))/18\, \mu \tag{10.9}$$

where,

V_r = Oil droplet rise rate (cm/s);
μ = Absolute viscosity of the water (poise);
ρ_o = Density of the oil (g/cm^3);
ρ_w = Density of the water (g/cm^3);
d_o = Diameter of the droplet to be removed (cm); and
g = Gravitational constant, 980 cm/s^2.

A water temperature must be assumed to select the appropriate values for water density and viscosity from Table 10.3. There are no data on the density of petroleum products in urban stormwater but it can be expected to lie between 0.85 and 0.95. To select the droplet diameter the designer must identify an efficiency goal based on an understanding of the distribution of droplet sizes in stormwater. However, there is no information on the size distribution of oil droplets in urban stormwater. The designer must also select a design influent concentration, which carries considerable uncertainty because it will vary widely within and between storms.

Table 10.2: Water Viscosities and Densities (Daugherty & Franzini, 1977)

Temperature °C	Density g/cm^3	Viscosity Poises
25	0.997	0.0008972
26	0.997	0.0008756
27	0.997	0.0008540
28	0.997	0.0008324
29	0.996	0.0008107
30	0.996	0.0007891
31	0.996	0.0007675
32	0.996	0.0007458
33	0.996	0.0007242
34	0.996	0.0007026
35	0.995	0.0006810

Sizing conventional gravity OGI (API, 1990), is based on following equation:

$$D = \sqrt{\frac{1}{2}\frac{Q}{V}} \tag{10.10}$$

where,

D = Depth (m), which should be between 1.0 - 2.5;
Q = Design flow rate (m^3/s); and
V = Allowable horizontal velocity (m/s) which is equal to 15 times the design oil rise rate (V_r) but not greater than 0.015m/s.

If the depth exceeds 2.5m, design parallel units dividing the design flow rate by the number of units needed to reach the maximum recommended depth of 2.5m. Equation 10.10 is simplified from equations in API (1990) based on a recommended width to depth ratio of 2. The constant in Equation 10.10 can be changed accordingly if a different ratio is assumed. Some engineers may wish to increase the facility size to account for flow turbulence.

Then, estimate length (L) and width (W) using the following equations:

$$L = VD/V_r \tag{10.11}$$

$$W = Q/(VD) \tag{10.12}$$

Note that the width should be 2 to 3 times the depth, but not to exceed 6m and baffle height to depth ratio of 0.85 for top baffles and 0.15 for bottom baffles. Locate the distribution baffle at 0.10L from the entrance, add 300mm for freeboard and install a bypass for flows in excess of the design flow.

Determining the design flow, Q, requires identification of the design storm. The OGI is expected to operate effectively at all flow rates equal to or less than the peak runoff rate of the design storm. If sized to handle a storm frequency between the 3-month to 1-year ARI, the facility will effectively treat the vast majority of stormwater that occurs overtime. For the design storm selected, calculate the peak runoff rate using the Rational Method.

10.6 PROPRIETARY DEVICES

A number of proprietary designs for gross pollutant traps have been developed. Most of the proprietary devices developed to date are intended for use on piped drainage systems, rather than open channels.

This Manual seeks to encourage the development and application of suitable proprietary devices in Malaysia. Manufacturers seeking to market GPTs in Malaysia should provide full details, together with design guidelines and testing to DID or the local authority.

This may require the supplier to provide information on the catchment area, conduit size and its depth, estimated ARI flow capacity of the system, pollutant loading, and the required performance (% removal). Most of the devices include an internal bypass arrangement designed by the manufacturer.

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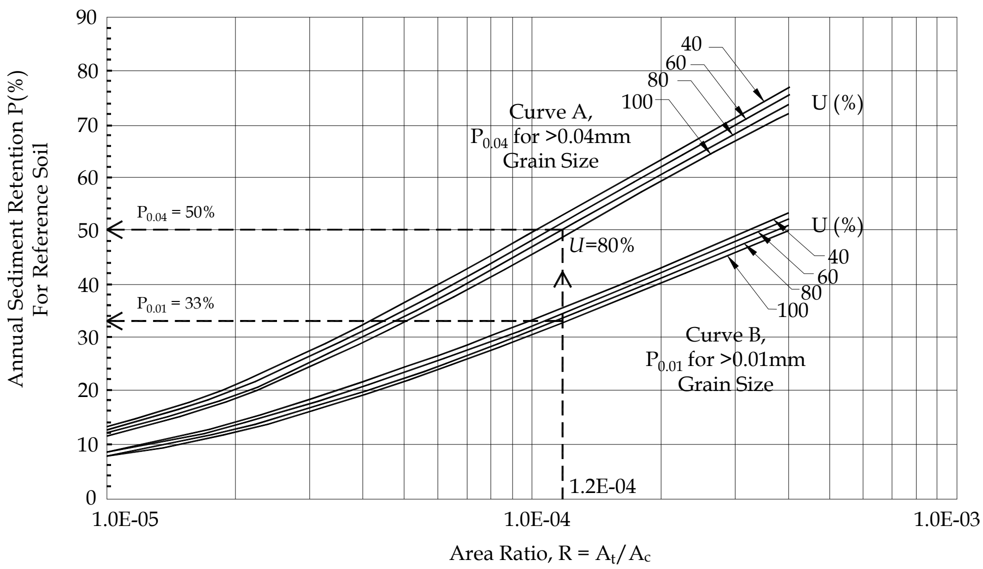
APPENDIX 10.A DESIGN CHARTS FOR SBTR TRAPS

10.A1 Average Sediment Retention against Area Ratio R

Design Chart 10.A1 shows the average annual sediment retention percentage as a function of the trap area ratio *R*, and the degree of urbanisation (*U*) in the catchment. Curve group (A), for particles ≥ 0.04mm is used to select the trap area A_t in order to achieve the specified design criteria. Curve group (B), for particles ≥ 0.01mm is used in calculating the trap volume for the sediment storage. In each case use the curve appropriate to the catchment urbanisation factor, *U*.



Design Chart 10.A1: Average Annual Sediment Retention against Area Ratio for Reference Soil (DID, 2000)

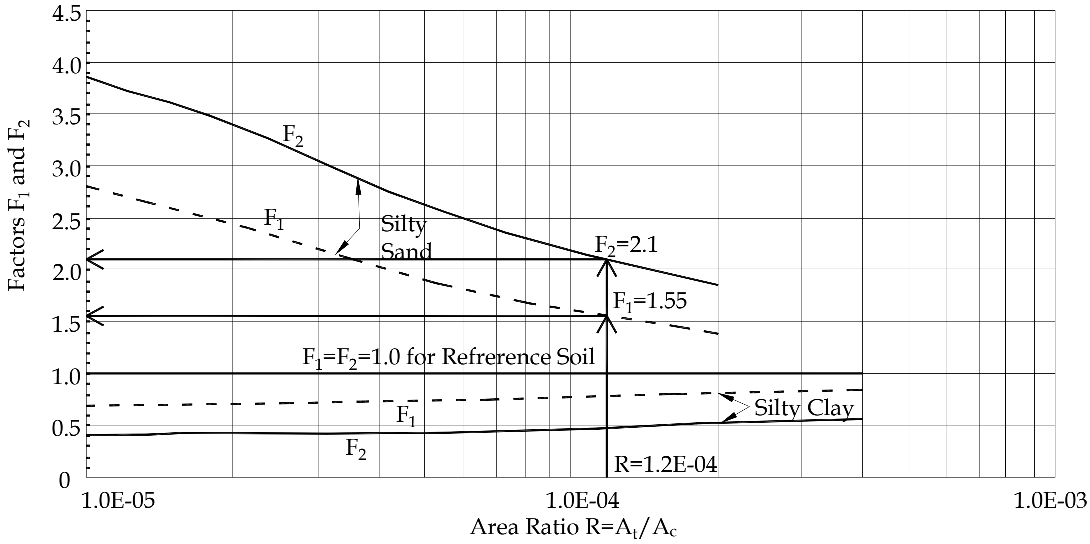
<u>How to Use the Chart</u>

An example is shown where *U* = 80% and the trap area ratio *R* = 1.2 E-04, the predicted removal of sediment for particle size ≥ 0.01mm is $P_{0.01}$ = 33% and ≥ 0.04mm is $P_{0.04}$ = 50%.

10.A2 Soil Type Adjustment Factors F_1 and F_2

Design Chart 10.A2 gives recommended values for the soil type adjustment factors F_1 and F_2 *as* a function of the soil type in the catchment.

These factors have been derived by repeating the calculations for Design Chart 10.A1, for other typical soil gradings.



Design Chart 10.A2: Soil Type Adjustment Factors for Trap Area and Sediment Volume (DID, 2000)

<u>How to Use the Chart</u>

Read factors F_1=1.55 and F_2=2.1 from the curves for the chosen trap area ratio R=1.2E-04.

APPENDIX 10.B EXAMPLE – SIZING OF SBTR (MAJOR)

Problem:

Determine the size required for a major SBTR GPT to be constructed in the Sg. Rokam, Ipoh, Perak with catchment area 113.8ha, 80% urbanisation and silty sand soil. It is an example of a community-level stormwater system as shown in Figure 10.B1.

Figure 10.B1: Site Plan

Solution:

Reference	Calculation	Output
	Step 1 : Determine the required removal efficiency. =	70%
Table 10.2	Step 2 : Detemine the catchment area, % urban area and soil type in the catchment.	
	Catchment Area, A_c =	113.8ha
	% Urban Area, U =	80%
	Soil Type =	Silty Sand
	Step 3 : Select trial trap area ratio *R*. First use trial area ratio *R* = 2.0 E-4	
	Step 4 : Calculate the required trap area by trial and error :	
Design Chart 10.A1	From Design Chart 10.A1, Curve A, $P_{0.04}$ value obtained =	61%
Design Chart 10.A2	From Design Chart 10.A2,F1 value obtained =	1.40
Equation 10.2	$P_{0.04*}$ = 61% x 1.40 = = (This is more than required so the trap size can be reduced)	85.4%

Reference	Calculation		Output
	Try R = 1.5 E-4. For this value of R, Design Chart 10.A1, Curve A gives $P_{0.04}$ = 54% for the reference soil and Design Chart 10.A2 gives F1 = 1.50; so the calculated removal efficiency $P_{0.04*}$ for the site soil is :		
	$P_{0.04*}$ = 54% x 1.50 (This is more than required so the trap size can be reduced)	=	81.0%
	Try R = 1.0 E-4. For this value of R, Design Chart 10.A1, Curve A gives $P_{0.04}$ = 47% for the reference soil and Design Chart 10.A2 gives F1 = 1.65; so the calculated removal efficiency $P_{0.04*}$ for the site soil is :		
	$P_{0.04*}$ = 47% x 1.65 (This is more than required so the trap size can be reduced)	=	77.6%
	Try R = 0.7 E-4. For this value of R, Design Chart 10.A1, Curve A gives $P_{0.04}$ = 44% for the reference soil and Design Chart 10.A2 gives F1 = 1.60; so the calculated removal efficiency $P_{0.04*}$ for the site soil is :		
	$P_{0.04*}$ = 44% x 1.60	=	70.4% (acceptable)
	Therefore the required minimum trap size is: $A_t = R \times A_c$ $=0.7 \times 10^{-4} \times 113.8 \times 10^4 m^2$	=	79.7m^2
	Step 5 : Determine the trap length and width to give a ratio L_t/W_t of between 2 and 3		
	The following trial dimensions are selected: L_t = 13.0m, W_t = 6.5m. Then the trap length and width ratio is equal to 2.0, and actual trap area A_t = 84.5m^2.	=	84.5m^2
	Step 6 : Determine the average annual sediment export with grain size ≥ 0.01mm: (assumed 75% of TSS)		
Equation 3.2 Table 3.2	The TSS load estimated by EMC method is $L = R.EMC.A.C_v/100$ = 3000 x 128 x 113.8 x 0.80 / 100	=	349594 kg @ 350 tonne
	Sediment export M = 0.75 x 350tonne	=	262.5tonne
Design Chart 10.A1B & Design Chart 10.A2	Step 7 : Determine $P_{0.01}$, the average annual pollutant retention ≥ 0.01mm diameter for the reference soil from the relevant Curve B in the lower part of Design Chart 10A.1, and Volume Factor F_2 from Design Chart 10A.2:		
	Pollutant retention for reference soil $P_{0.01}$ = 29%, and F_2 = 2.2.		
Equation 10.4	Pollutant retention for site soil $P_{0.01*}$ = 29% x 2.2	=	63.8%
	Step 8 : Determine the required minimum sediment trap depth		
	$D_w = 0.0065 \times P_{0.01^*} \times M / A_t$ = 0.0065 x 63.8 x 262.5/84.5	=	1.30m

Reference	Calculation		Output
	Step 9 : Determine the rainfall in the *water quality design storm* (usually 3 month ARI, then find $Q_{0.25}$		
	using the data of Politeknik Ungku Omar, Ipoh in Table 2.B2, rainfall intensity can be calculated :		
Equation 2.2	$i = \dfrac{\lambda T^{\kappa}}{(d+\theta)^{\eta}}$ $= \dfrac{62.9315 \times 0.25^{0.3439}}{(1 + 0.1703)^{0.8229}}$	=	34.33mm/hr
Equation 2.3	$Q = \dfrac{C.i.A}{360}$ $= \dfrac{0.8 \times 34.33 \times 113.8}{360}$	=	8.68m³/s
	Step 10 : Determine the trash rack height from Equation 10.6. Try a trash rack length L_r = 7.5m to match the height of the sediment trap:		
Equation 10.6	$H_r = 1.22\left(\dfrac{Q_{0.25}}{L_r}\right)^{2/3}$ $= 1.22 \times \left(\dfrac{8.68}{6.5}\right)^{2/3}$	=	1480mm
	Trash rack length L_r of 6.5m gives H_r = 1.48m which is reasonable		
	Determine the nominal flow velocity $V_{0.25}$ in the water quality design storm. Increase the dimensions of the sediment trap pool or increase the track rack height if the flow velocity V is greater than 1.0m/s, to minimise the re-entrainment of deposited sediment		
Equation 10.7	$V_{0.25} = \dfrac{Q_{0.25}}{(D_w + H_r)W_t}$ $= \dfrac{8.68}{(1.30 + 1.48)\ 6.5}$	=	0.48m/s (which is acceptable)
	For a major SBTR, determine required clearance above the trash track from Equation 10.8.		
	The open trash rack will be overtopped in floods greater than the 3 month ARI flood (if 50% blocked) and the open channel must be designed accordingly.		
	The resulting 'theoretical' concept design for the SBTR trap is as shown below. In reality, the concept and dimensions may have to be adjusted if required to suit site conditions.		

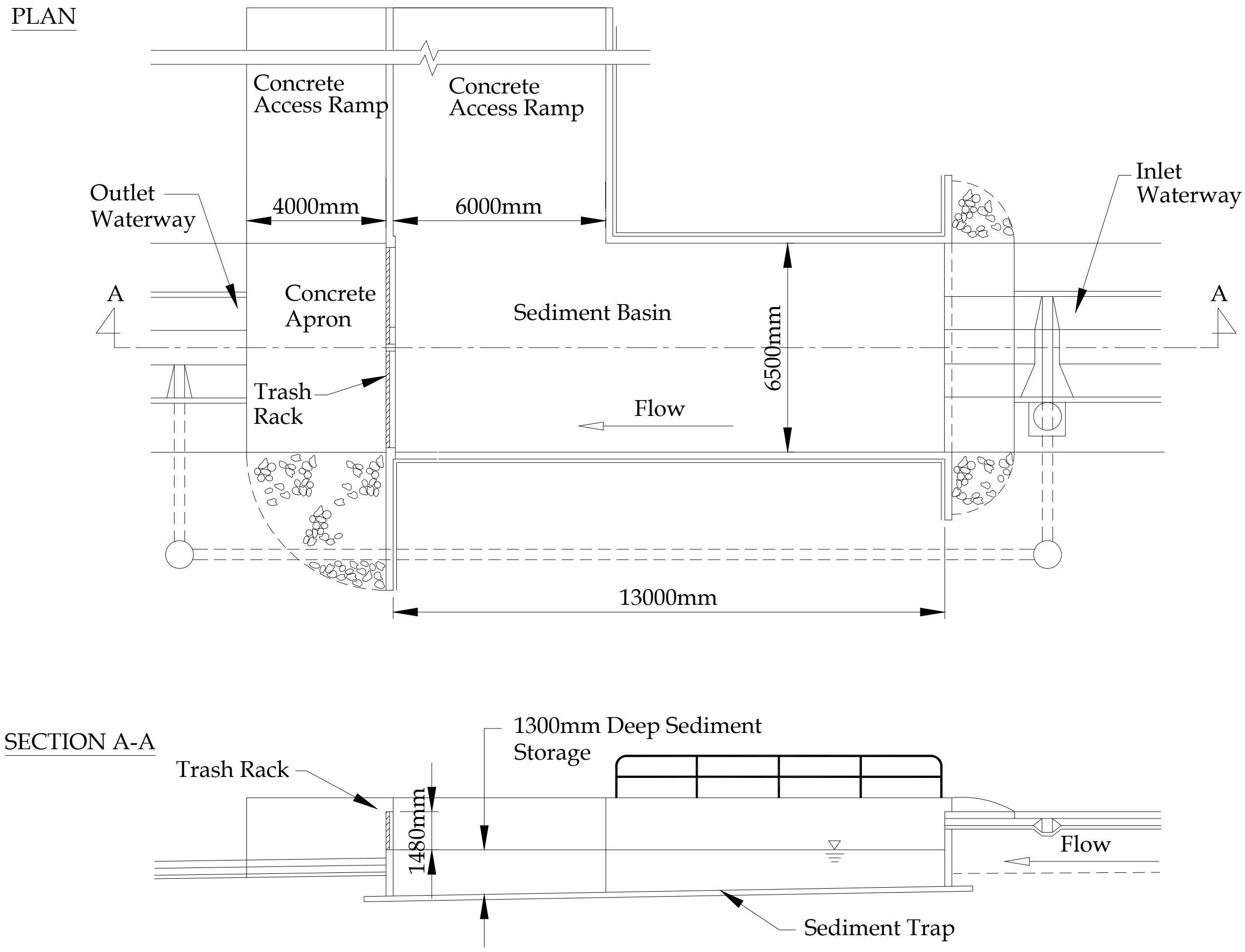


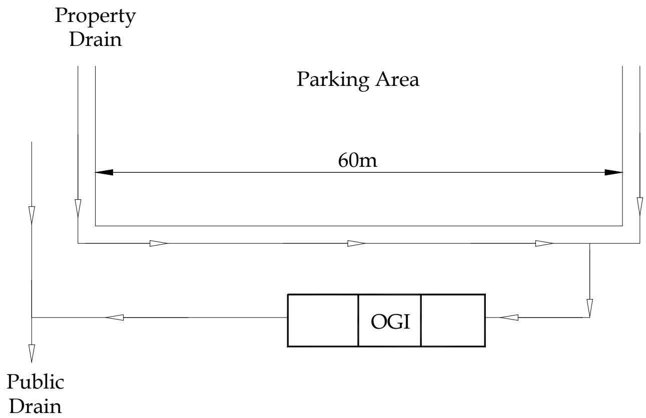
Figure 10.B2: Layout of Proposed Major SBTR

APPENDIX 10.C EXAMPLE – SIZING OF CONVENTIONAL GRAVITY OGI

Problem :

A conventional gravity OGI is to be used to trap oil and grease in runoff from a 0.2 ha parking lot of a factory in Bandar Baru Bangi, Selangor. Assume it is to be sized to treat runoff with flow rate of 0.0702 m^3/s per hectare when the area is 100 % impervious. Given: ρ_o = 0.898 g/cm^3, d_o = 90 x 10^{-4} cm and temperature = 30 °C.

a) Site Plan



b) Layout

Figure 10.C1: Proposed OGI Site and Layout

Solution :

Reference	Calculation	Output
Table 10.3	With the temperature = 30 °C, the water density = 0.996g/cm^3 and μ = 0.0007891 poises	
Eq. 10.9	$V_r = (g\, d_o^2(\rho_o - \rho_w))/18\,\mu$	
	= (980 x (90 x 10^{-4})^2(0.898-0.996))/18(0.0007891)	-0.559cm/s
	the negative symbol of V_r only represent the direction of the particle. Thus the value of V_r =	5.59 x 10^{-3}m/s
	Allowable horizontal velocity is equal to 15 times the design oil rise rate, V_r	
Eq. 10.10	V = 15 x 5.59 x 10^{-3}	0.0838m/s
Eq. 10.10	D = $(Q/2V)^{0.5}$ =$(0.2 \times 0.0702/(2 \times 0.0838))^{0.5}$	0.3m
Eq. 10.11	L = VD/V_r = 0.0838 x 0.3/5.59 x 10^{-3}	4.5m
Eq. 10.12	W = Q/(VD) = (0.2 x 0.0702)/(0.0838 x 0.3) = 0.6m W = 0.6m, since W is equal to 2 x D, so W	0.6m
	Thus, a conventional OGI sized to capture runoff from the parking lot D = 0.3m W = 0.6m L = 4.5m	

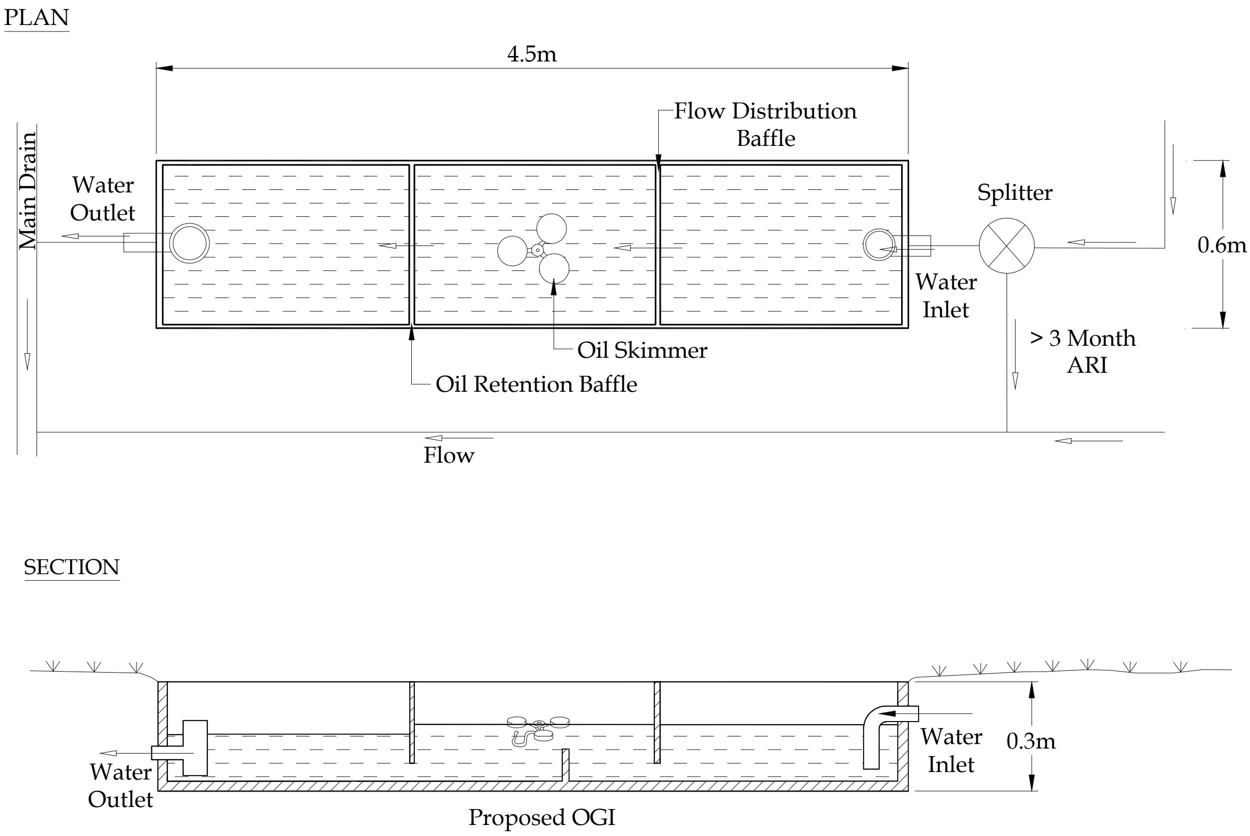


Figure 10.C2: Proposed Size of Conventional Gravity OGI