CHAPTER 7

CHAPTER 7

OIL, GREASE AND GRIT TRAPS

7.1 INTRODUCTION

Oil, grease and grit are common urban-derived contaminants conveyed in stormwater. There have been a number of research studies which have identified the association of metals and polycyclic aromatic hydrocarbons (PAH) to fine sediment particles. Main source areas for oil, grease and grit are roads and highways, garages and petrol stations, commercial transportation precincts. Oil, grease and grit traps are essential for pre-treatment of stormwater for effective treatment of other pollutants including gross pollutants and coarse sediment removal. Oil / Water Separators have limited application in stormwater treatment because their treatment mechanisms are not well-suited to the characteristics of stormwater runoff (i.e., highly variable flow with high discharge rate, turbulent flow regime, low oil concentration and high suspended solids concentration).

If an oil / water separator is used primary for treatment it should be located off-line from the primary conveyance / detention system. The contributing drainage area should be completely impervious and as small as necessary to contain the sources of oil. Non-source contributing areas only increase the size (and cost) of the separator and do not improve effectiveness. Under no circumstances should any portion of the contributing drainage area contain disturbed pervious areas which can be sources of sediment.

7.2 OVERVIEW OF OIL, GREASE AND GRIT TRAPS

There are currently a number of oil and grease separators on trial in the stormwater industry with varying success. Most of these systems utilise a form of chamber or detention tank with an inverted pipe outlet system to enable the clearer stormwater to be discharged from below the floating oil and grease. As reported by NSW-EPA (1996), these systems do not provide a high level of performance generally due to infrequent maintenance and the passage of high flows. The separation of oil and grease in such systems rely on near-quiescent flow conditions and are most appropriate when used in treating runoff from clearly isolated oil and grease source areas. Incidental export of oil and grease from urban catchments may be better treated by small ponds and wetlands with appropriate boom facilities which can be activated with relative ease. Often these ponds and wetlands form part of a larger receiving waters system which is used as an emergency oil spill containment facility. Source areas of high pollution potential (eg. petrol stations and garages, car wash areas etc) should ideally be isolated and local runoff diverted to wastewater treatment facilities or to purpose-built oil and grease traps.

Oil and grease traps are generally ineffective in high flow conditions and they can introduce high energy losses to the drainage system if they are inappropriately designed and located. Their application should therefore be carefully considered and their locations should be such that the catchment area is relatively small. For the Putrajaya project, regular occurrences of high intensity rainfall storm events further heighten the need for careful sizing and location of these devices.

The mechanism for trapping oil and grease is to convey the stormwater runoff into a containment chamber where near-quiescent flow conditions allowed these and other bouyant material to float to the surface of the water where they are retained by the use of baffles. The quiescent flow conditions also facilitate the settlement of fine particles and this is aided by the use of baffles and by appropriate design and location of the outlet device in the containment chamber. In order to promote quiescent flow conditions, the size of most oil, grease and grit traps are comparatively much larger per unit area than gross pollutant traps. The difference in the size of these traps can be of an order of magnitude and as a consequence, the design discharge for oil, grease and grit traps often corresponds to a higher average recurrence interval or units are installed to serve much smaller catchment areas (down to 0.1 ha).

A means for by-passing above-design flow around the containment chamber is considered a necessary design criterion for these traps. This is the only means by which trapped material and floating oil and grease contained within these traps are prevented from being re-mobilised during above-design events. Regular maintenance is also an important pre-requisite for effective utilisation of oil, grease and grit traps. Removal of trapped oil, grease and grit will be undertaken using a vacuum system and the frequency of clean-out required can often be as high as once a week, depending on the catchment area and the landuse activity.

In general most oil, grease and grit separators are often combined with some capability for sediment and floating debris trapping as well. Oil and grease separation in these units are based on the use of baffles to trap floating debris, oil and grease. Four types of oil, grease and grit interceptors are discussed in this document.

7.2.1 Catch Basins

Traditionally, catch basins are stormwater pits with a depressed base that accumulates sediment as shown in Figure 7.1. They are installed below ground and are therefore unobtrusive. More recent designs introducing the use of baffles and an elbow outlet have led to efficient removal of oil and sediment from stormwater and the unit stores them safely for easy removal. Catch basins may be used upstream of other stormwater treatment measures to enhance performance. They may be appropriate for retrofitting into existing areas, particularly on roads with high traffic volumes. Current designs are capable of removing 80% of the total sediment load when properly applied as a source control for

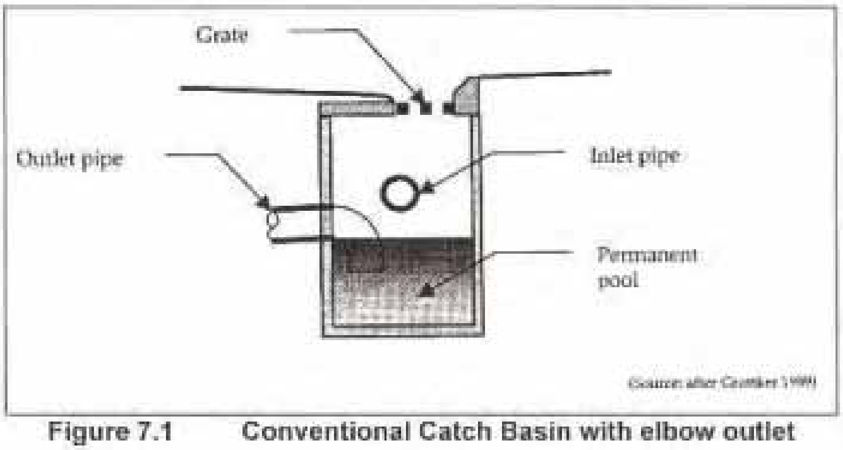

Figure 7.1 Conventional Catch Basin with elbow outlet

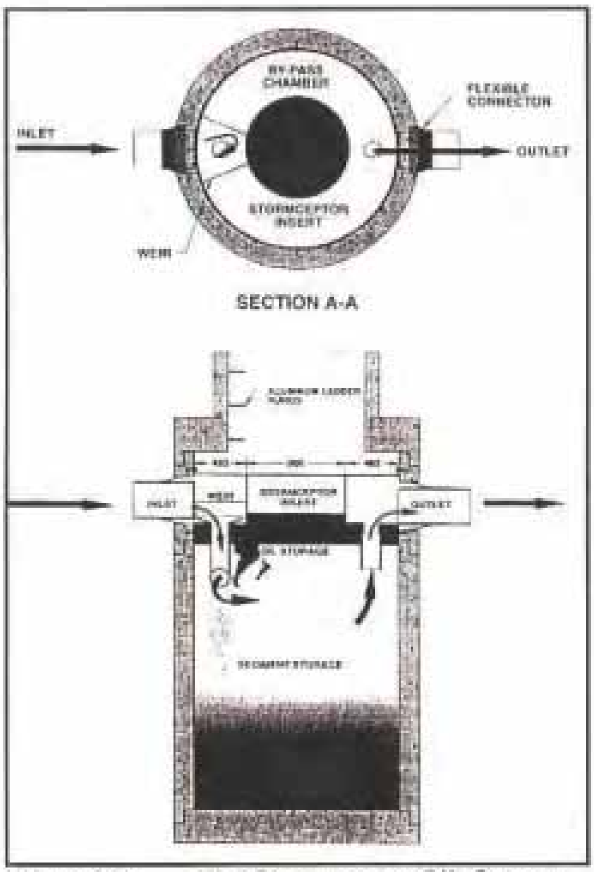

Figure 7.2 **The Stormceptor Oil, Grease and Grit Trap**

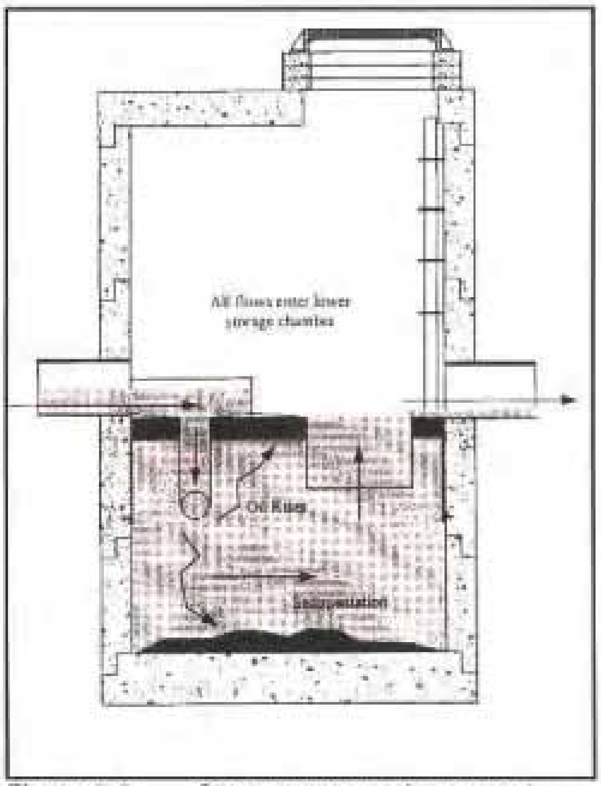

Figure 7.3 **Stormceptor under normal operating conditions**

small areas, with 85 % classified as silt or clay. Under low flow conditions they are capable of removing up to 98% of free oil from stormwater. Recent designs which incorporate a high flow by-pass will not scour or resuspend trapped pollutants. For source and nonpoint source pollution applications with impervious drainage areas of 5 hectares or less (eg parking lots, service stations, airports, redevelopment of the urban core) catch basins can be implemented as part of the treatment train.

7.2.2 Stormceptor Device

More recent design developments have addressed a number of concerns, particularly in relation to the provision for high flow by-pass of the containment chamber. One such improvement is the Stormceptor device, which incorporates two major components, a bypass chamber and a treatment chamber as shown in Figure 7.2.

Stormwater flows into the by-pass chamber via the stormwater pipe. Under below-design flow conditions, stormwater inflows are diverted into the treatment chamber by a weir and drop pipe arrangement. The drop pipe is configured to discharge water radially from the pipe outfall in the containment chamber. As shown in Figure 7.3, water flows through the containment chamber to the decant pipe which is submerged similar to the drop inlet pipe. Oil, and liquids with a specific gravity less than water, will rise in the containment chamber and become trapped since the outlet pipe is submerged. Water flows back up through the decant pipe to the by-pass chamber owing to the pressure differential created by the inlet weir in the by-pass chamber.

The downstream section of the by-pass chamber is connected to the outlet stormwater pipe, oil and other substances with a gravity less than water will rise in the treatment chamber and become trapped since the decant pipe is submerged. Sediment will settle to the bottom of the chamber by gravity and centrifugal forces. The circular design of the treatment chamber

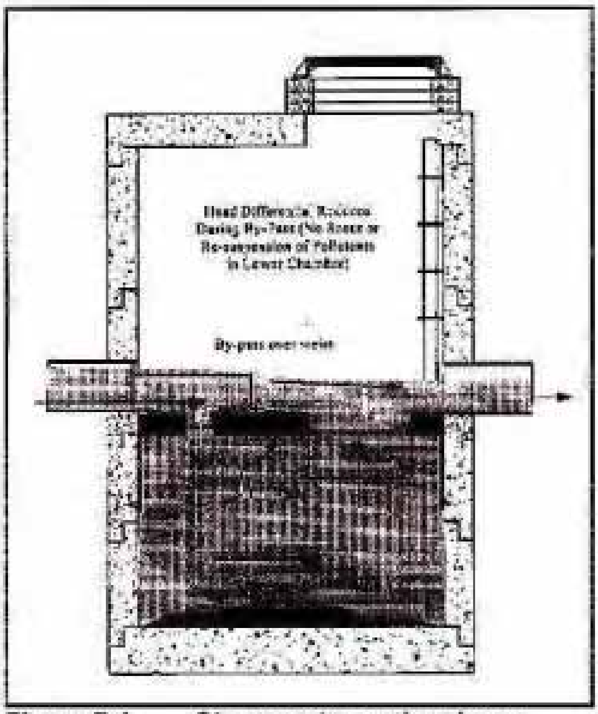

Figure 7.4 Stormceptor under above-design flow operation

Figure 7.5 Laying the containment chamber of the Stormceptor Device

Figure 7.6 Installing the By-pass Chamber

is critical to prevent turbulent eddy currents and to promote settling.

During high flow conditions, stormwater in the bypass chamber will overtop the weir and be conveyed to the outlet stormwater directly as shown in Figure 7.4. Water which overflows the weir creates a backwater effect on the outlet pipe ensuring that excessive flow will not be forced into the treatment chamber which could scour or resuspend the settled material.

The Stormceptor units come in precast section and are readily installed on site as shown in Figures 7.5 and 7.6. Units can be as large as 3 m diameter and they generally treat runoff fromcatchment areas of less than 2 ha.

7.2.3 Spill Control (SC) Separators

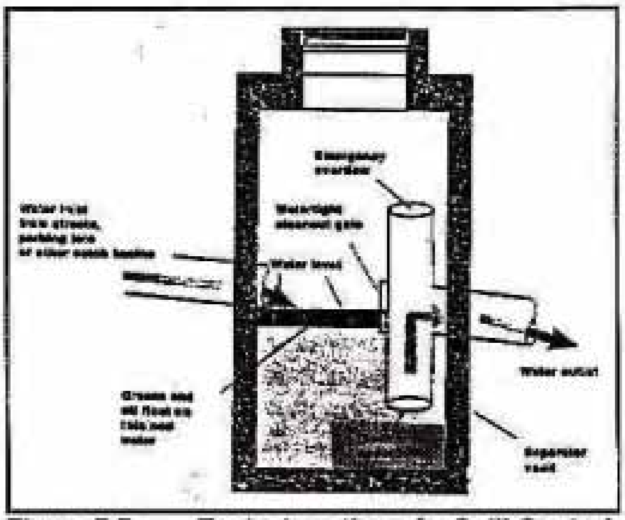

Figure 7.7 Typical section of a Spill Control Separator device

The Spill Control (SC) Separator is a simple underground vault or manhole with a "T" outlet, allowing the oil to float to the top of the chamber, while letting water out through the submerged orifice. A typical section of a spill control device is shown in Figure 7.7. These types of oil and grease separators are effective for intercepting illicit dumping or accidental oil spills, coarse sediment and debris. They are particularly well suited as a hydrocarbon control method. They are typically used for catchments of up to 0.1 ha and are unobtrusive since they form part of the streetscape and are totally underground except for a surface grate. These kind of units are most suitable as a pre-filter prior to vegetative filtration.

As with most of these devices, regular maintenance in terms of clean out is necessary to ensure their effective operation. They must be cleaned at the end of the dry period to remove material that has accumulated during the dry season as well as after a significant storm.

Oil spills collected in the device should be pumped out as soon as possible to prevent oil emulsification. Appropriate removal covers must be provided to allow access for observation and maintenance.

Targetting of high source areas is fundamental to the use of these devices owing to their relative low flow operating range. Stormwater that is not likely to be contaminated by oil should not discharge to the separator.

7.2.4 Coalescing Plate Separators (CPS)

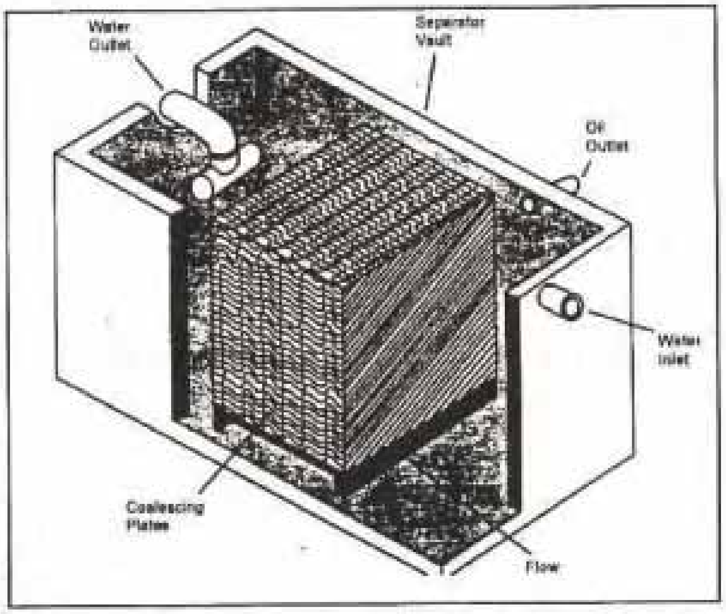

Figure 7.8 Schematic Diagram of a CPS (ref. Romano, 1990).

The Coalescing Plate Separator (CPS) contains a bundle of plates made of fibreglass or polypropylene as shown in Figure 7.8. The plates are closely spaced and depending on the manufacturer and/or application, the plates may be positioned in the bundle at an angle of 45° to 60° from the horizontal. The CPS is probably most applicable in situations where oil has a high likelihood of being accidentally dispersed in the stormwater system. These include industrial areas where there are high oil and grease loadings. Single units can service catchments up to 0.4 ha and are appropriate for retrofitting into existing high source areas such as garages, petrol stations, industrial parks etc. They are unobtrusive and are usually installed underground or concealed. These form of devices are not recommended where erosion or traffic is expected to supply large quantities of sediments and their use is restricted to sites that have high oil and grease loadings.

CPS are the most expensive treatment measure for oil and grease removal in terms of cost per volume of runoff treated, as this facility can only treat relatively small, frequent storms of low intensity.

The use of coalescing plates facilitates a more rapid flow rate through the device. Grease and oil which has not been emulsified, dissolved or attached to sediment will be present as oil droplets or as a surface slick. In conventional traps, higher than desirable flow rates results in only large droplets being removed and small droplets will pass through the device and into the receiving water body. With the coalescing plates, small droplets can be removed resulting in improvement in the effluent quality without requiring a slower passage of stormwater through the device.

Separators must be cleaned frequently to stop accumulated oil escaping during storms. They must be cleaned at the end of the dry period to remove material that has accumulated during the dry season as well as after a significant storm. Oil absorbent pads should be replaced as needed but shall always be replaced prior to the wet season and in spring. The effluent shutoff valve is to be closed during the cleaning operations. Waste oil and residuals shall be disposed in accordance with current local government regulations. Any standing water removed shall be replaced with clean water to prevent oil carry-over through the outlet weir or orifice. The water removed during maintenance must be discharged to a place approved by the local government.

7.2.5 Oil & Grit Separators

Oil/grit separators are generally underground retention chambers designed to separate coarse sediment and hydrocarbons from stormwater water and the units store them for later removal. Figure 7.9 shows a typical section of such a device. These devises are appropriate for source and nonpoint source pollution applications with impervious drainage areas of 5 hectares or less, particularly for treating stormwater from areas expected to have

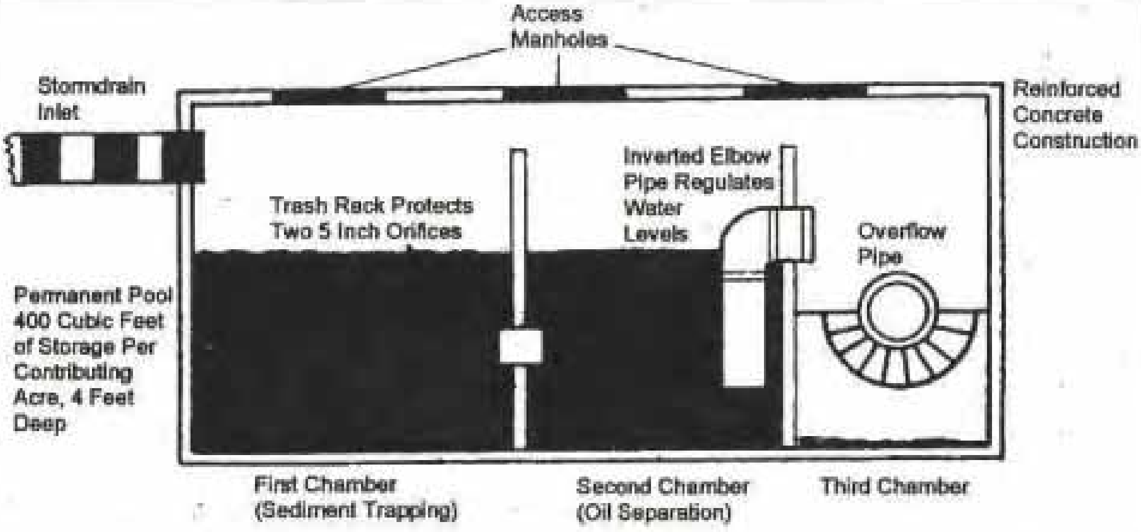

Figure 7.9 Schematic Diagram of an Oil and Grit Separators (Schueler, 1987).

significant vehicular pollution (eg. parking lots). The devises can be used for treating stormwater from areas storing or handling petroleum products (eg. service stations, petroleum depots and airports). Like all other oil, grease and grit separators, the devise is applicable for small catchments and may be appropriate for retrofitting into existing areas. The devise is installed below ground and therefore unobtrusive.

The device has limited capabaility for removal of fine sediment or soluble pollutants. In some cases turbulent stormwater enters the chambers leading to re-suspension of settled particulates and entrainment of floating oil. The device requires the installation of a high flow bypass to faciliate its effective operation.

7.3 STANDARD OIL, GREASE AND GRIT TRAPS FOR THE PUTRAJAYA PROJECT

Apart from the recommended use of the Stormceptor device, a standard type of an oil, grease and grit trap is proposed for the Putrajaya project. This is to facilitate ease of design, construction and maintenance. In designing the Putrajaya Oil, Grease and Grit trap (OGGT), a number of design factors related to the performance of these traps need to be taken into consideration. These factors include:-

- Layout
- Design flow
- Above design flow performance
- Minimum dimensions
- Maintenance

Data available for size distribution of oil droplets in stormwater is limited to that from petroleum products storage terminals. These data indicate that about 80% of droplets are greater than 90 μm and 30 % are greater than 150 μm in diameter (Washington State Department of Ecology, 1990).

The 150 μm separation has been traditionally used, which typically results in an effluent oil and grease concentration of 50-100 mg/l (Meyers, 1980). Standards for industrial discharges in Australia are 10-20 mg/l, which corresponds to the removal of droplets larger than 60 μm (Meyers, 1980). Separation of the 60 μm droplet is often adopted as the basis for design of devices in Australian practice. This corresponds to the lower tail of the droplet size distribution and should result in an effluent quality of 10-20 mg/l at the design flow. Given the water temperature and the density of the soil, the rise velocity for a 60 μm droplet can be calculated. This rise velocity is then used in the sizing calculations for the device. At 15°C and for an oil specific gravity of 0.9, the rise velocity of a 60 μm droplet is 0.62 m/hr and this is the recommended value for Putrajaya.

The following are the general design specifications applicable to the oil, grease and grit trap.

7.3.1 General Design Specifications

Design Flows (Q_{OGGT})

The appropriate design flow for the OGGT varies from one application to another. Quite often, the determination of the appropriate design flow is unclear. The 1 year ARI peak discharge is often adopted as the design discharge. However, it may often be necessary to reduce the design discharge further when the catchment area becomes excessively large. This clearly highlights the importance of careful isolation of high source area to minimise the catchment area for each of these devices. It is reasonable to adopt design standards as low as the 0.1 year ARI discharge when we consider that a hydraulic structure designed for a peak discharge corresponding to the 0.25 year ARI has a volumetric trapping efficiencies in excess of 95% as shown in Figure 4.6.

Above Design Flow Conditions (Q_{minor})

As is the case with gross pollutant traps, all oil, grease and grit traps are required to operate adequately for larger events up to the discharge capacity of the conveyance system (Q_{minor}) on which the traps are placed without decreasing the discharge capacity of the conveyance system. Generally, $Q_{minor} \leq Q_{100}$. A weir coefficient of 1.7 may be adopted to compute the discharge capacity of the by-pass weir.

Dimensions of the Containment Chamber
The dimensions of the containment chamber can be computed using a similar approach as that used in sediment basin by satisfying the following equation:-

$$\frac{Q_{OGGT}}{v_d} \le \alpha \cdot L_{OGGT} \cdot W_{OGGT} \cdot \frac{D_{OGGT}}{y} \qquad - \qquad 7.1$$

where

	Q_{OGGT}	is the design discharge
	v_d	is the rising velocity of the oil droplet
	L_{OGGT}	is the length of the oil, grease and grit trap
	W_{OGGT}	is the width of the oil, grease and grit trap
	D_{OGGT}	is the depth of the oil, grease and grit trap
	y	is the rise distance of the oil droplet which may be computed as (i) the vertical distance from the obvert of the inlet pipe to the water surface in the containment chamber; or (ii) the vertical distance from the obvert of the inlet pipe and the bottom of the oil baffle (if the baffle is to be utilised)
	α	is a factor to adjust for non-uniform flow conditions

The rising velocity of oil droplets (v_d) is expressed as follows:-

$$v_d = \left(\frac{g}{18} \cdot \mu\right) \cdot \left(d_p - d_c\right) D^2 \qquad - \qquad 7.2$$

where:

v_d	=	rising velocity of oil droplet in m/s
μ	=	Dynamic viscosity of oil at coldest service temperature (use 0.015 poise at 5°C if no other information is available);
d_p-d_c	=	Density difference between oil and water (use 0.1 g/cc if no other information is available);
D	=	Oil drop diameter (use 0.006 cm if no other information is available).need to convert V_p into m/s.
g	=	gravitational acceleration (9.81 m/s^2)

As indicated above, in the absence of any information, a rise velocity of 0.62 m/hr or 1.7 x 10^{-4} m/s may be adopted.

Often, an oil baffle is used to reduce the required length and width of the trap. If the rise distance (y), computed as the difference between the obvert of the inlet pipe into the containment chamber and the toe of the oil baffle, is zero or negative, there is no need to check the design for compliance for equation 7.1.

Maximum Velocity
Flow velocity within the oil and grease trap should be such that flow conditions is not excessively turbulent for entrainment of the oil and grease trapped. The Reynolds Number should therefore be kept ideally to below 10,000; ie.

$$\frac{vR}{\nu} \le 10000 \qquad - \qquad 7.3$$

where v is the flow velocity within the containment chamber, R is the hydraulic radius and ν is the kinematic viscosity of water (ie. $1 \times 10^{-6}\ m^2/s$)

7.4 WORKED EXAMPLE

7.4.1 Introduction

In this worked example, an oil and grease trap is to be located in a residential area where the landuse activities include automobile services (petrol stations and garages) and food centres. The catchment area is 2 ha and the oil, grease and grit trap is to be located next to a junction pit where the inlet pipe is aligned at right angle to the outlet pipe. According to the Drainage Masterplan for Putrajaya, the discharge standard for the minor drainage system for residential area is the 5 year ARI event. The pipe diameter is 0.75 m.

The operation of the trap involves the diversion of all low flow into the oil and grease baffle chamber using a diversion weir. Flow in the oil and grease chamber passes under and over a number of baffles and weirs to facilitate the trapping of floating oil and grease as well as oil associated with grit. The oil and grease chamber is to be designed to accommodate a peak discharge of 20% of the 1 year ARI discharge.

The design discharges for the 1 year and 5 year ARI events are as follows:-

$$Q_1 = 0.5\ m^3/s$$
$$Q_5 = 0.8\ m^3/s$$

The proposed layout and sections of the oil, grease and grit trap is given in the diagrams attached. The computations presented make reference to the diagrams attached.

7.4.2 Diversion Weir

7.4.2.1 The water level in the junction pit under the 5 year ARI peak discharge condition should not result in higher tailwater conditions to the drainage system. It has been assumed when computing the discharge capacity of the 0.75 m diameter pipe in design condition A that the tailwater level at this junction pit is the soffit level of the pipe.

The height of the diversion weir should be higher than the water level in the inlet pipe corresponding to the discharge of 20% of the peak 1 year ARI discharge, ie. $Q = 0.10\ m^3/s$.

Flow depth in the 0.75 m diameter pipe at 0.75% slope is estimated to be 0.19 m.

Set height of diversion weir to be 0.2 m above the invert of the pipe

7.4.2.2 The available head over the diversion weir for the discharge of the 5 year ARI peak discharge is the difference between the assumed tailwater level (ie. soffit of the inlet pipe) and the crest of the diversion weir, ie.

$$\Delta H = 0.75 - 0.2 = 0.55 \text{ m}.$$

The required width of the diversion weir to convey the 5 year ARI discharge is computed as follows:-

$$W = \frac{Q}{C_w \cdot (\Delta H)^{1.5}}$$

where C_w is the weir coefficient.

Adopting a weir coefficient of 1.7 gives the diversion weir width as follows:-

$$W = \frac{0.8}{1.7 \cdot (0.55)^{1.5}} = 1.15\text{m}$$

Adopt width of diversion weir of 1.2 m
Dimension D3 = 1.0 m
Dimension D6 = 1.0 m

7.4.3 Containment Chamber

7.4.3.1 Flow velocity within the oil and grease trap should be such that flow conditions is not that of turbulent flow. The Reynolds Number should therefore be kept to 10,000; ie.

$$\frac{vR}{\nu} \leq 10000$$

where R is the hydraulic radius and ν is the kinematic viscosity of water (ie. 1 x 10^{-6} m^2/s)

For a rectangular flow area, the following applies:-

$$Q = 0.01P$$

where P is the wetted perimeter of the flow section.

∴ select a 3 m (h) by 4 m (w) oil and grease trap flow area

Dimension D5 = 4 m
Floor level (RL C) in the oil and grease chamber is to be 3 m below RL A

7.4.3.2 No necessary to check for compliance with equation 7.1 by ensuring that the the toe of the oil baffle (ie. RL D) is greater than 0.25 m from the surface of the water (ie. RL A).

7.4.4 Inlet and Outlet Design

7.4.4.1 The size of the inlet to the oil and grease trap can be computed as follows:-

Available head ΔH = 0.2 m. Adopting a head loss coefficient of 1.5, the prescribed inlet velocity at the pipe elbow entry to the oil and grease trap can be computed as follows:-

$$v_{in} = \left(\frac{\Delta H \cdot 2g}{1.5}\right)^{0.5} = 1.62 \text{ m/s}$$

The area of the inlet pipe elbow is computed as the discharge (ie. 0.125 m3/s) divided by the inlet velocity v_{in}, ie.

$$A_{in} = 0.10/1.62 = 0.062 \text{ m}^2$$

The diameter of the inlet pipe elbow is 0.28 m.

Select diameter of inlet pipe elbow (ie dimension X) to be 0.3 m diameter

7.4.4.2 Invert of the outlet pipe is to be located such that the elevation of the water level for the design discharge is at RL A. Adopting a 0.3 m diameter pipe, the computed head loss is approximately 0.2 m and the soffit of the outlet pipe is at elevation RL A - 0.2m. The invert of the outlet pipe is at RL A - 0.5 m.

Select 0.3 m outlet pipe
Invert of outlet pipe to be at RL A - 0.5 m

7.4.5 Summary

Dimensions	Magnitude
Pipe Diameter X	0.30 m
Pipe Diameter Y	0.75 m
Dimension D1	5.0 m
Dimension D2	5.0 m
Dimension D3	1.0 m
Dimension D4	4.0 m
Dimension D5	4.0 m
Dimension D6	1.0 m
Elevations	**Magnitude**
RL A	As required
RL B	RL A + 0.2m
RL C	RL A - 3.0 m
RL D	RL A - 1.0 m
RL E	RL C - 0.5 m
RL F	RL A - 0.5 m

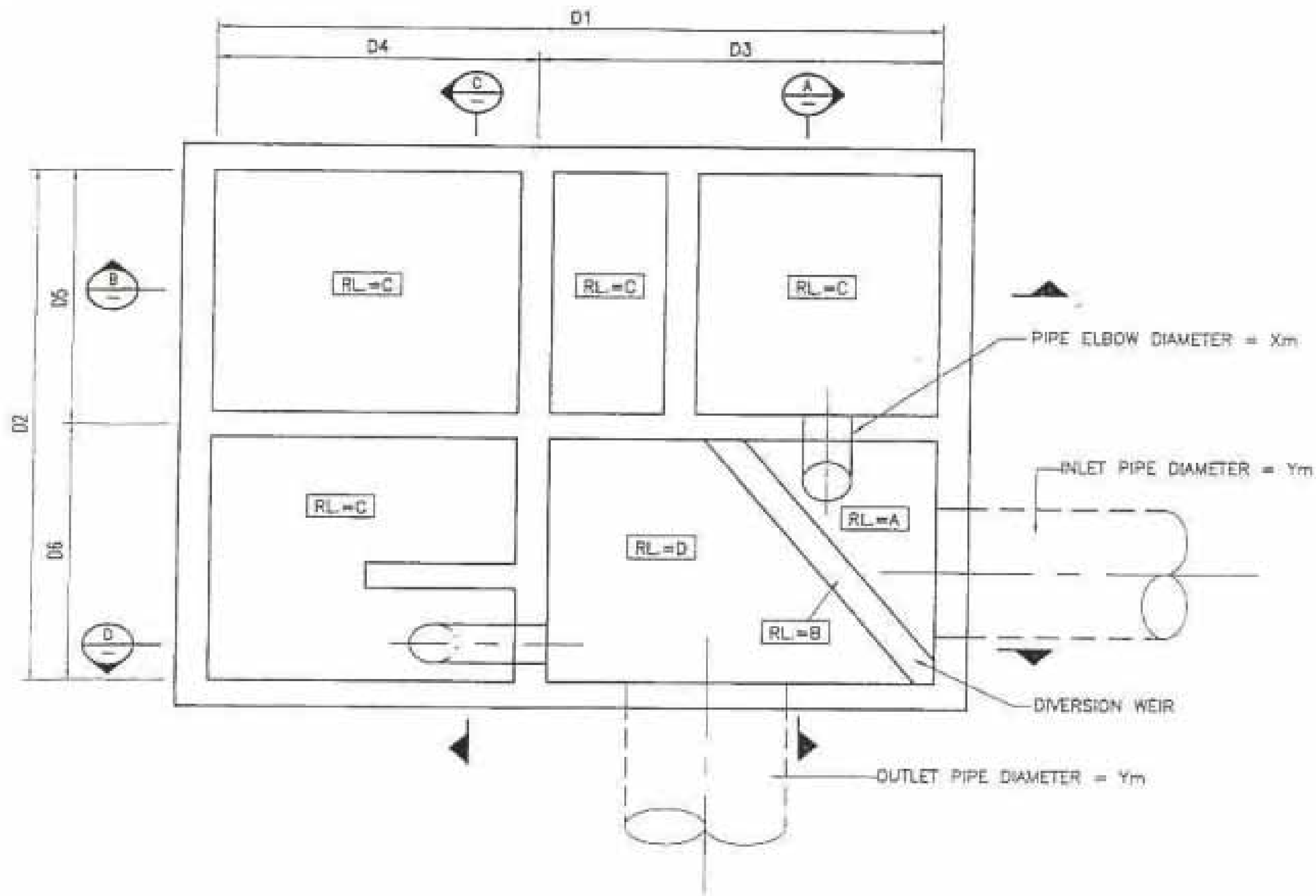

Figure 7.10 Oil And Grease Trap (Plan)

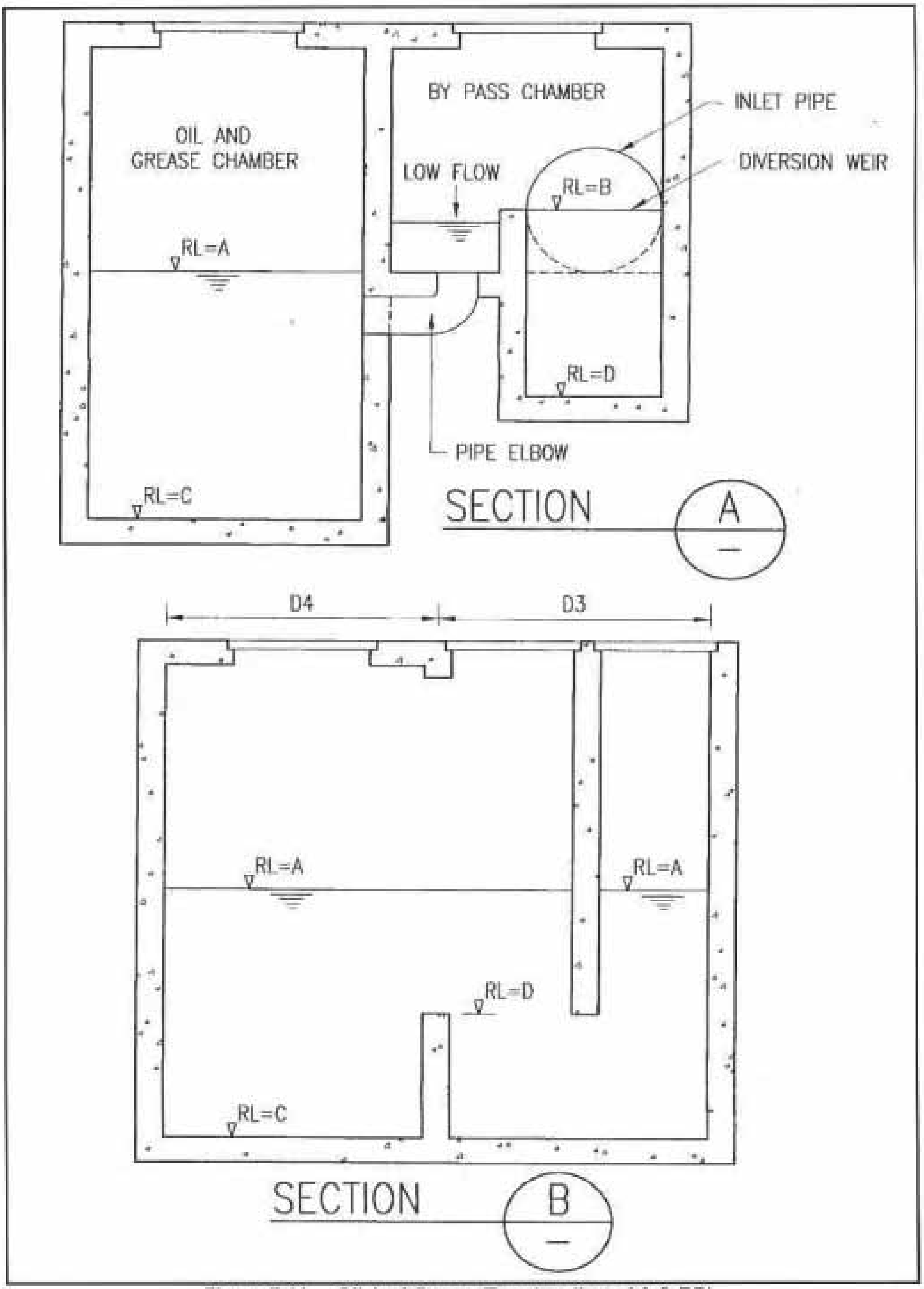

Figure 7.11 Oil And Grease Trap (sections AA & BB)

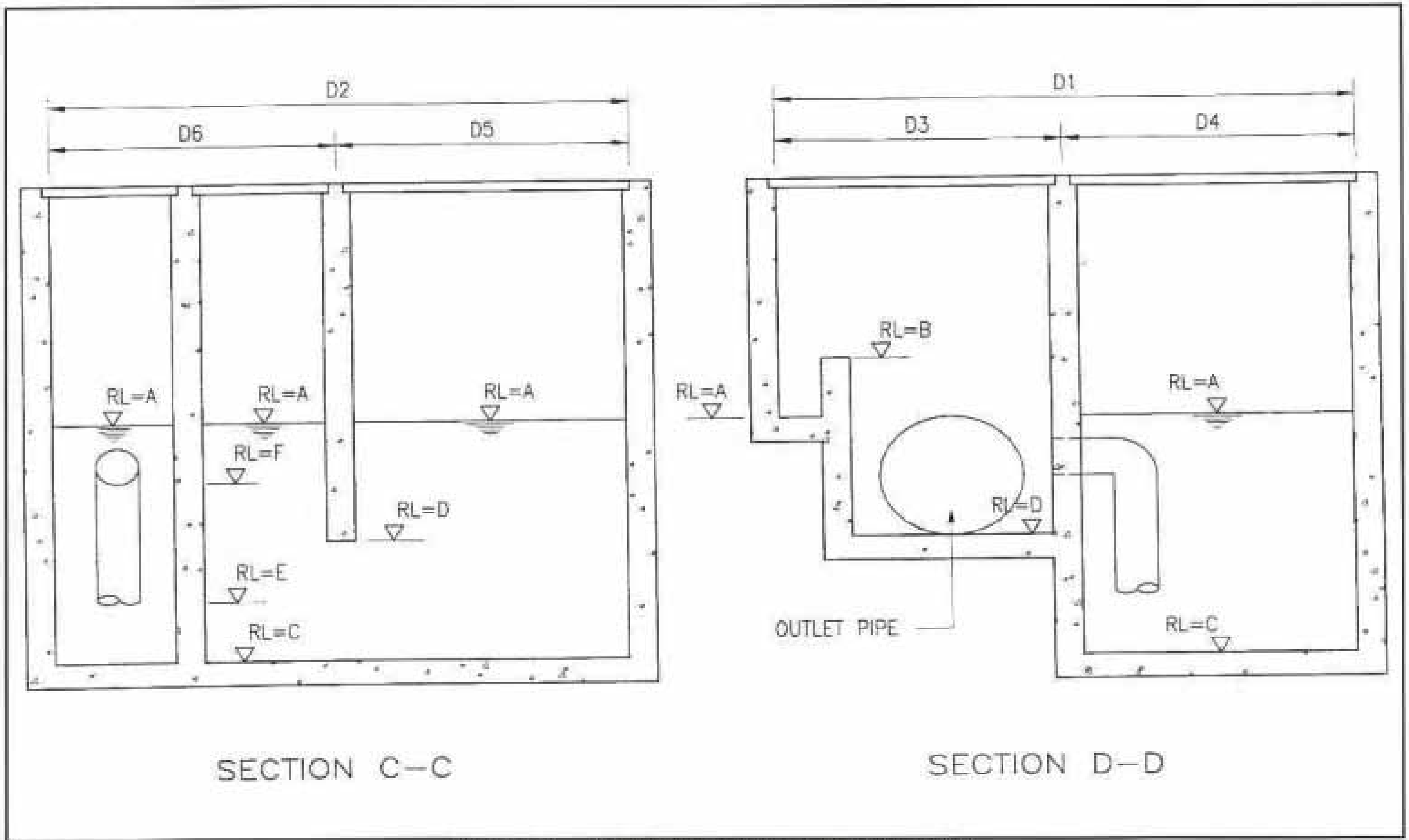

Figure 7.12 Oil And Grease Trap (sections CC & DD)