Chapter 11 Oil Water Separators

11.1 Purpose

Oil water separators remove oil and other water-insoluble hydrocarbons and settleable solids from stormwater runoff. This chapter provides a discussion of their application and design criteria. BMPs are described for baffle type and coalescing plate separators.

11.2 Description

Oil water separators are typically the American Petroleum Institute (API) (also called baffle type) (American Petroleum Institute, 1990) or the coalescing plate (CP) type using a gravity mechanism for separation. See Figure 5 - 33 and Figure 5 - 34. Oil water separators typically consist of three bays; forebay, separator section, and the afterbay. The CP separators need considerably less space for separation of the floating oil due to the shorter travel distances between parallel plates. A spill control (SC) separator (Figure 5 - 35) is a simple catch basin with a T-inlet for temporarily trapping small volumes of oil. The spill control separator is included here for comparison only and is not designed for, or to be used for, treatment purposes.

11.3 Applications/Limitations

This BMP is specific for discharges to the stormwater system. Oil water separators that will discharge to the sanitary sewer system shall follow the “City of Tacoma Environmental Services Source Control Oil Water Separator Policy” available at www.cityoftacoma.org/stormwater.

For low concentrations of oil, other treatments may be more applicable. These include sand filters and emerging technologies.

Without intense maintenance oil/water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels.

Pretreatment should be considered if the level of total suspended solids (TSS) in the inlet flow would cause clogging or otherwise impair the long-term efficiency of the separator.

For inflows from small drainage areas (fueling stations, maintenance shops, etc.) a coalescing plate (CP) type separator is typically considered, due to space limitations. However, if plugging of the plates is likely, then a new design basis for the baffle type API separator may be considered on an experimental basis (see Section 11.6).

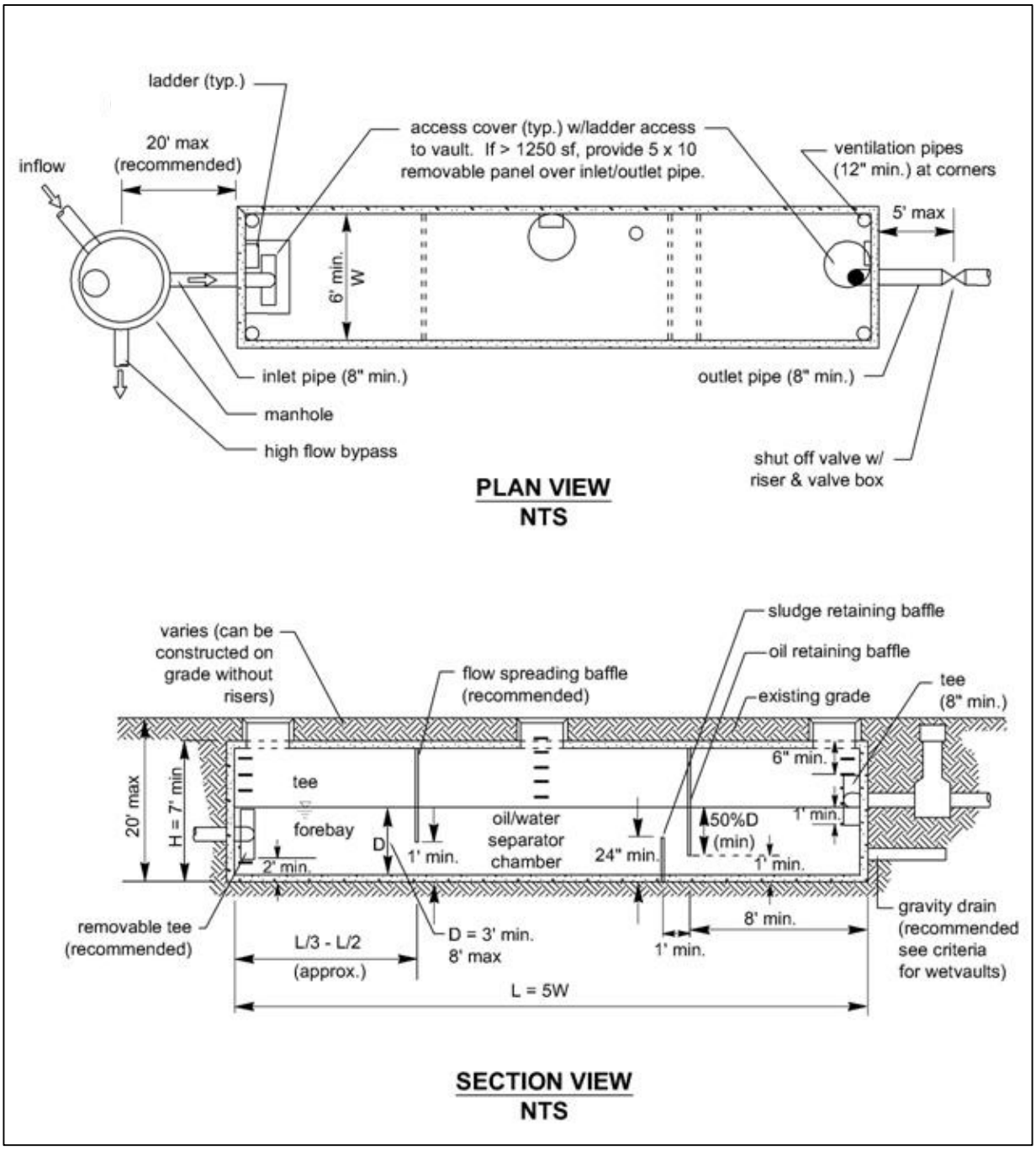

Figure 5 - 33. API (Baffle Type) Separator

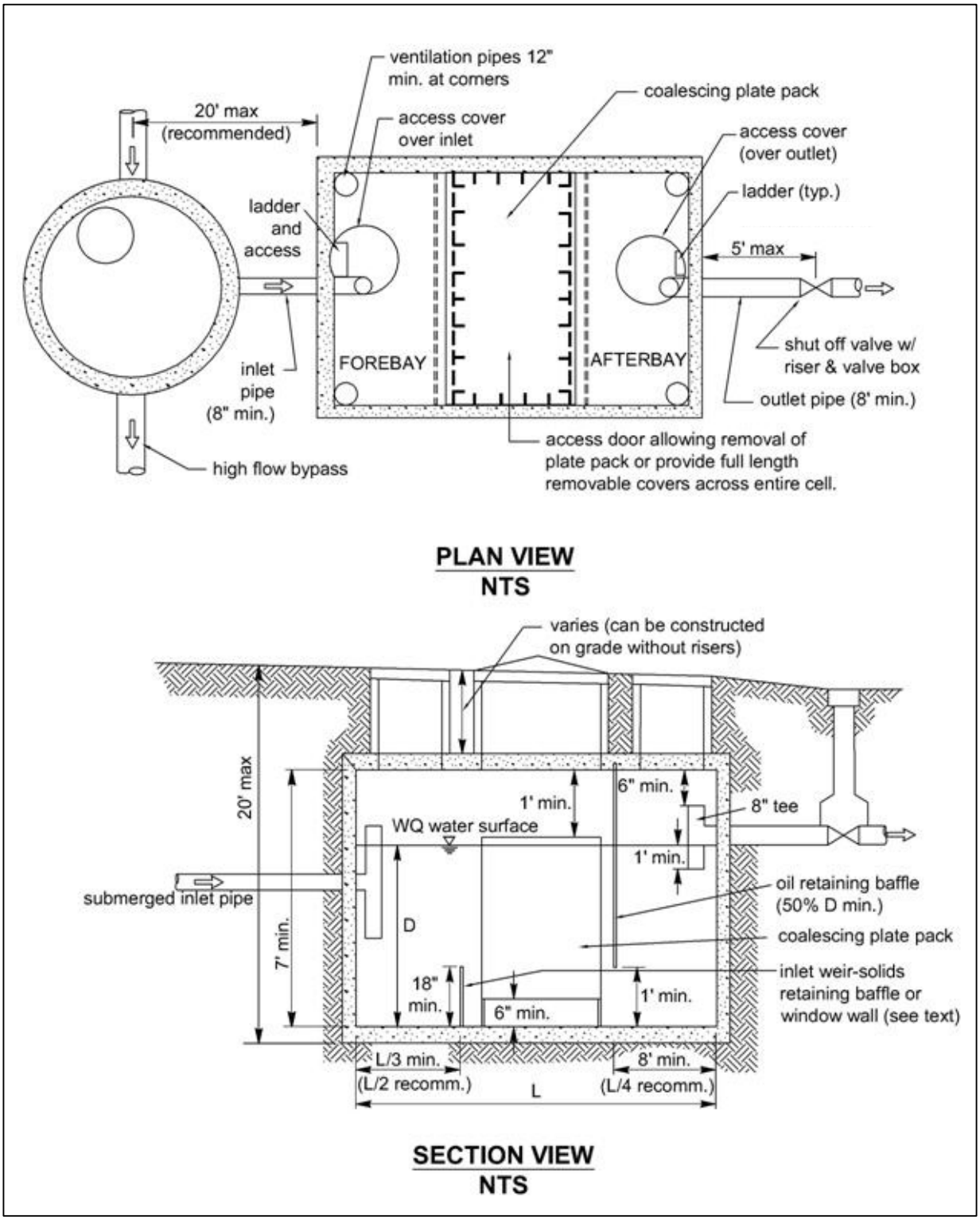

Figure 5 - 34. Coalescing Plate Separator

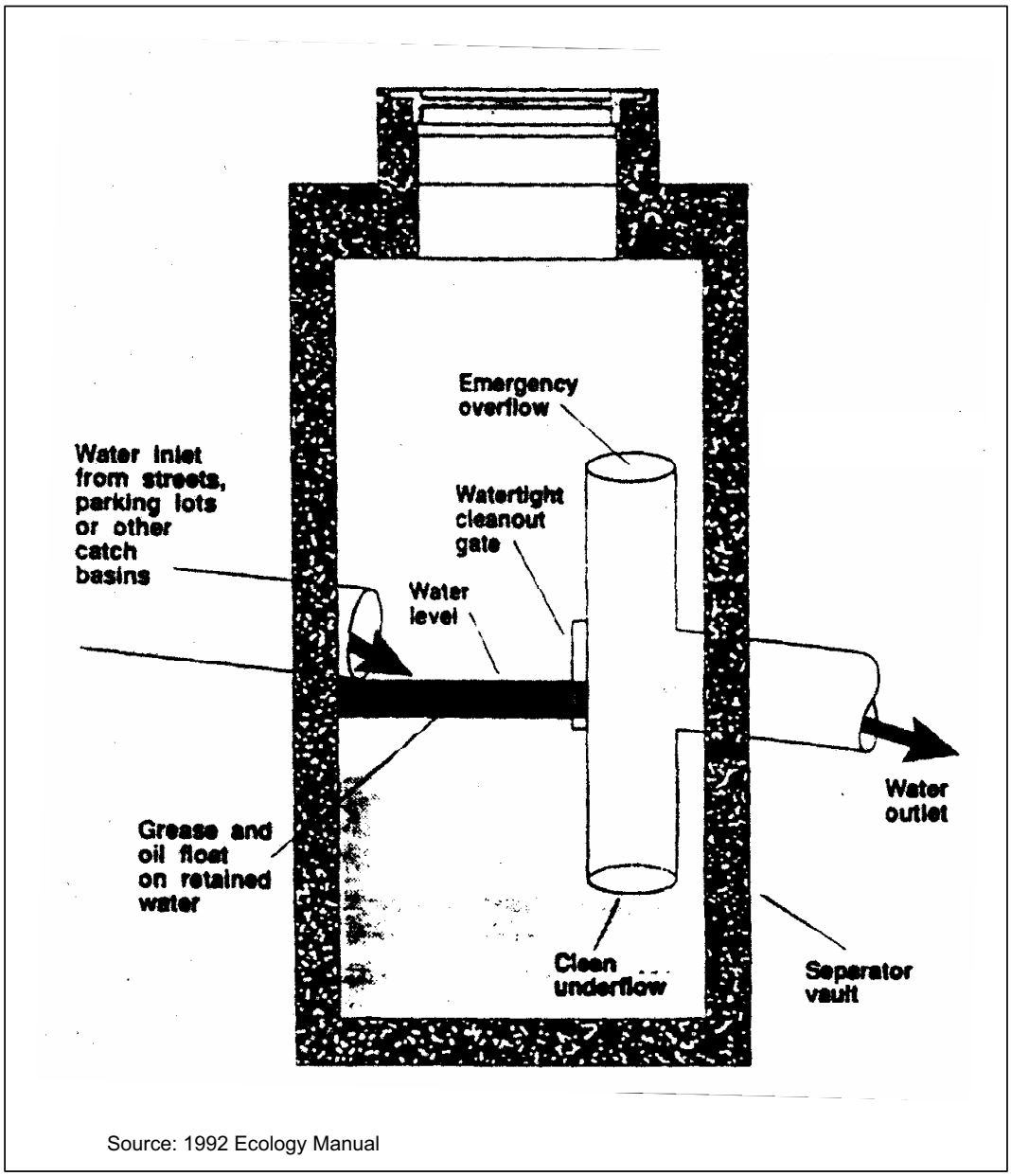

Figure 5 - 35. Spill Control Separator (not for oil treatment)

11.4 Site Suitability

Consider the following site characteristics:

- Sufficient land area
- Adequate TSS control or pretreatment capability
- Compliance with environmental objectives
- Adequate influent flow attenuation and/or bypass capability
- Sufficient access for operation and maintenance (O & M)

11.5 Design Criteria

11.5.1 General Considerations

The following are design criteria applicable to API and CP oil/water separators:

- If practicable, determine oil/grease (or TPH) and TSS concentrations, lowest temperature, pH, empirical oil rise rates in the runoff, and the viscosity and specific gravity of the oil. Also determine whether the oil is emulsified or dissolved. (*Washington State Department of Ecology*, 2005) Do not use oil/water separators for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.
- Locate the separator offline and bypass the incremental portion of flows that exceed the offline 15-minute water quality design flow rate multiplied by 3.5. If it is necessary to locate the separator online, try to minimize the size of the area needing oil control, and use the online water quality design flow rate multiplied by 2.0.
- The separator shall be installed upstream of any other stormwater treatment facility.
- The separator shall be installed upstream of any pumps to prevent oil from emulsifying.
- Separators may be installed upstream or downstream of flow control facilities.
- Separator vaults shall be watertight. Pipes entering and exiting a vault below the water quality design water surface shall be sealed using a non-porous, non-shrinking vault.
- Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shutoff capability in the event of a spill.
- Include a submerged inlet pipe with a down-turned elbow in the first bay at least two feet from the bottom. The outlet pipe shall be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.
- Use absorbents in the afterbay as needed.
- Use only storm drain pipes or impervious conveyances for routing oil contaminated stormwater to the oil and water separator.
- Specify appropriate performance tests after installation and shakedown, and/or certification by a professional engineer that the separator is functioning in accordance with design objectives. Expeditious corrective actions must be taken if it is determined that the separator is not achieving acceptable performance levels.
- Add pretreatment for TSS that could clog the separator, or otherwise impair the long-term effectiveness of the separator.

11.5.2 Criteria for Baffles

- Oil retaining baffles (top baffles) shall be located at least 1/4 of the total separator length from the outlet and shall extend down at least 50% of the water depth and at least 1 foot from the separator bottom.
- Baffle height to water depth ratios shall be 0.85 for top baffles and 0.15 for bottom baffles.

11.5.3 Maintenance

Per Minimum Requirement #10, an operation and maintenance plan shall be prepared for all stormwater management facilities. See Volume 1, Appendix C, Maintenance Checklist #17 and #18 for specific maintenance requirements for oil water separators. Maintenance shall be a basic consideration in design and cost-determination of the stormwater management facility.

Any standing water removed during maintenance operation must be disposed of in a City approved manner. See the dewatering requirements in Volume 4 of this manual. Pretreatment may be necessary. Solids must be disposed of in accordance with state and local waste regulations.

Facilities shall be constructed such that the facility can be easily inspected by one person. This may require construction of additional inspection ports or access manholes to allow inspection acces to be opened by one person.

11.6 Oil Water Separator BMPs

Two BMPs are described in this section:

- BMP T1110 for baffle type separators
- BMP T1111 for coalescing plate separators

11.6.1 BMP T1110 API (Baffle type) Separators

11.6.1.1 Design Criteria

- API separators shall be divided into three compartments: a forebay, an oil separation cell and an afterbay.
  - The forebay is designed primarily to trap and collect sediment, support plug flow conditions and reduce turbulence.
  - The oil separation cell traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area.
  - The afterbay provides a relatively oil-free cell before the outlet and provides a secondary oil separation area.
- The length of the forebay shall be approximately 1/3 to 1/2 the length of the vault. In addition, the surface area of the forebay must be at least 20 square feet per 10,000 square feet of impervious area draining to the separator.
- A removable flow-spreading baffle, extending from the surface to a depth of up to 1/2 the vault depth (D) is recommended to spread flows. Design guidelines for level spreaders are provided in Section 5.2 of this volume.
- A removable baffle (sediment-retaining baffle) shall be a minimum of 24 inches and located at least 1 foot from the oil-retaining baffle. A “window-wall” baffle may be used, but the area of the window opening must be at least three times greater than the area of the inflow pipe.
- A removable oil retaining baffle shall be provided and located approximately 1/4 L from the outlet wall, or a minimum of 8 feet, whichever is greater (the 8-foot minimum is for maintenance purposes). The oil-retaining baffle shall extend from the elevation of the water surface to a depth of at least 50 percent of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.
- Baffles may be fixed rather than removable if additional entry ports and ladders are provided so that both sides of the baffle are accessible to maintenance crews.
- Baffle separator vaults shall have a minimum length-to-width ratio of 5:1.
- The design water depth (D) shall be no deeper than 8 feet unless approved by Environmental Services.

- Baffle separator vaults shall have a design water depth-to-width ratio of between 0.3 and 0.5.

11.6.1.2 Sizing Criteria

- Determine the oil rise rate, V_t, in cm/sec, using Stokes' Law, or empirical determination, or 0.033 ft./min. for 60μ (micron) oil droplet size. The application of Stokes' Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min. rise rate.

  Stokes Law equation for rise rate, V_t (cm/sec):

  $$Vt = [(g)(\rho_w - \rho_o)(d^2)] / [(18*\mu_w)]$$

  Where:

  Vt = the rise rate of the oil droplet (cm/s or ft/sec)
  g = acceleration due to gravity (cm/s² or ft/s²)
  ρ_w = density of water at the design temperature (g/cm³ or lbm/ft³)
  ρ_o = density of oil at the design temperature (g/cm³ or lbm/ft³)
  d = oil droplet diameter (cm or ft)
  μ_w = absolute viscosity of the water (g/cm·s or lbm/ft·s)

  Use:

  oil droplet diameter, D=60 microns (0.006 cm)
  ρ_w =0.999 gm/cc. at 32° F
  ρ_o: Select conservatively high oil density,
  For example, if diesel oil @ ρ_o =0.85 gm/cc and motor oil @ ρ_o = 0.90 can be present then use ρ_o =0.90 gm/cc
  η_w = 0.017921 poise, gm/cm-sec. at T_w=32 °F

  Use the following separator dimension criteria:

  - Separator water depth, d ≥3≤8 feet (to minimize turbulence)
  - Separator width, 6-20 feet
  - Depth/width (d/w) of 0.3-0.5

For Stormwater Inflow from Drainages under 2 Acres

Ecology modified the API criteria for treating stormwater runoff from small drainage areas (fueling stations, commercial parking lots, etc.) by using the design hydraulic horizontal velocity, V_h, for the design V_h/V_t ratio rather than the API minimum of V_h/V_t = 15. The API criteria appear applicable for greater than two acres of impervious drainage area.

Performance verification of this design basis must be obtained during at least one wet season using the test protocol referenced in Chapter 10 for new technologies.

The following is the sizing procedure using modified API criteria:

1. Determine V_t and select depth and width of the separator section based on above criteria.

2. Calculate the minimum residence time (t_m) of the separator at depth d:

   $t_m = d/V_t$

3. Calculate the horizontal velocity of the bulk fluid, V_h, vertical cross-sectional area, A_v, and actual design V_h/V_t.

   $V_h = Q/dw = Q/A_v$ (V_h maximum at < 2.0 ft/min.)

   Q = (3.5) (offline 15 minute water quality design flow rate in ft³/min determined by WWHM, at minimum residence time, t_m)

   At V_h/V_t determine F, turbulence and short-circuiting factor API F factors range from 1.28-1.74 (see Appendix D).

4. Calculate the minimum length of the separator section, l(s), using:

   $l(s) = FQt_m/wd = F(V_h/V_t)d$
   $l(t) = l(f) + l(s) + l(a)$
   $l(t) = l(t)/3 + l(s) + l(t)/4$

   Where:

   l(t) = total length of 3 bays
   l(f) = length of forebay
   l(a) = length of afterbay

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

   V = minimum hydraulic design volume
   A_h = minimum horizontal area of the separator

For Stormwater Inflow from Drainages > 2 Acres:

Use $V_h = 15\ V_t$ and $d = (Q/2V_h)^{1/2}$ (with d/w = 0.5) and repeat above calculations 3- 5.

11.6.2 BMP T1111 Coalescing Plate (CP) Separators

11.6.2.1 Design Criteria

- Coalescing plate separators shall be divided by baffles or berms into three compartments: a forebay, an oil separation cell which houses the plate pack, and an afterbay. The forebay controls turbulence and traps and collects debris. The oil separation call captures and holds oil. The afterbay provides a relatively oil-free exit cell before the outlet.
- The length of the forebay shall be a minimum of 1/3 the length of the vault, L (though ½ L is recommended). In addition, it is recommended that the surface area of the forebay be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator. In lieu of an attached forebay, a separate grit chamber, sized to be a least 20 square feet per 10,000 square feet of tributary impervious area, may precede the oil/ water separator.
- An oil-retaining baffle shall be provided. For large units, a baffle position of 0.25 L from the outlet wall is recommended. The oil-retaining baffle shall extend from the water surface to a depth of at least 50 percent of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.
- A bottom sediment-retaining baffle shall be provided upstream of the plate pack. The minimum height of the sediment-retaining baffle shall be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.
- It is recommended that entire space between the sides of the plate pack and the vault wall be filled with a solid but lightweight removable material such as a plastic or polyethylene foam to reduce short-circuiting around the plate pack. Rubber flaps are not effective for this purpose.
- The Reynolds Number through the separator bay shall be <500 (laminar flow).
- The separator plates shall meet the following criteria:
    - Plates shall be inclined at 45º to 60º from the horizontal. This range of angles exceeds the angle of repose of many solids and therefore provides more effective droplet separation while minimizing the accumulation of solids on the individual plates.
    - Plates shall have a minimum plate spacing of ½ inch (perpendicular distance between plates) and have corrugations.
    - Locate plate pack at least 6 inches from the bottom of the separator for sediment storage.
    - Locate plate pack such that there is 12 inches minimum from the top of the plate pack and the bottom of the vault cover.
    - Design plates for ease of removal and cleaning with high-pressure rinse or equivalent.

11.6.2.2 Sizing Criteria

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$A_h = Q/Vt = [Q] / [(.00386) * ((S_w - S_o)/(\mu_w))]$

Where

A_h = horizontal surface area of the plates (ft^2)
Vt = rise rate of the oil droplet (ft/min)
Q = design flowrate (ft^3/min) The design flowrate is the offline 15-minute water quality design flowrate predicted by WWHM multiplied by 3.5.
S_w = specific gravity of water at the design temperature
S_o = specific gravity of oil at the design temperature
μ_w = absolute viscosity of the water (poise)