Chapter 16 – Hydrodynamic Separators

TABLE OF CONTENTS

16.1 Overview of Practice ......................................................................................................... 1
16.2 Design Considerations ..................................................................................................... 2
16.3 Manufactured Products .................................................................................................... 3
  16.3.1 Stormceptor .................................................................................................................. 3
  16.3.2 Vortechs Stormwater Treatment System ................................................................. 6
  16.3.3 Downstream Defender ................................................................................................. 8
  16.3.4 BaySaver .................................................................................................................... 11
LIST OF TABLES

Table 16.1.  Typical Maintenance Activities for Gravity Separators Error! Bookmark not defined.
Table 16.2.  Hydrodynamic Separators Information Matrix (VTRC, 2004)................................. 16

LIST OF FIGURES

Figure 16.1.  Stormceptor During Normal Flow Conditions ......................................................... 4
Figure 16.2.  Stormceptor During High Flow Conditions .............................................................. 5
Figure 16.3.  Vortechs Stormwater Treatment System ................................................................. 7
Figure 16.4.  Section View of Downstream Defender System ...................................................... 9
Figure 16.5.  Plan View of Downstream Defender System ......................................................... 10
Figure 16.6.  BaySaver Primary Separation Manhole ................................................................. 12
Figure 16.7.  Plan View of BaySaver System ............................................................................. 13
Figure 16.8.  Section through BaySaver Storage Manhole ......................................................... 14
Figure 16.9.  BaySaver Separation Unit ......................................................................................... 15
16.1 Overview of Practice

The following design example provides guidance for the implementation of manufactured oil / water hydrodynamic separation devices for purposes of runoff quality management on VDOT facilities projects.

Hydrodynamic separation devices are designed to remove settleable solids, oil and grease, debris, and floatables from stormwater runoff through gravitational settling. Oil / water separation devices are not intended to mitigate the peak rate of runoff from their contributing watershed. Their implementation is solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible. These manufactured systems are designed as flow-through structures. In contrast to conventional BMP measures capable of storing a designated water quality volume, flow into a manufactured hydrodynamic separator is regulated by its inflow pipe or other structural hydraulic devices. When the maximum design inflow is exceeded, the inflow may be regulated by a pipe restrictor, causing stormwater to back up into the upstream conveyance system or associated storage facility. When structural devices are employed to regulate flow into the hydrodynamic separator, flows in excess of the desired treatment volume either bypass the structure completely or bypass the separator’s treatment chamber (VADCR, 2000).

Hydrodynamic separators are often employed as pretreatment measures for high-density or ultra urban sites, or for use in hydrocarbon hotspots, such as gas stations and areas with high vehicular traffic. Hydrodynamic separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols and alcohol (Georgia Stormwater Manual 2001). Hydrodynamic separators are limited in application by the following:

- Hydrodynamic separators are not capable of removing more than 80 percent of total suspended solids TSS.
- Dissolved pollutants are not effectively removed by these BMPs.
- Frequent maintenance is required to maintain desired pollutant removal performance levels.
- Hydrodynamic separators do not reduce peak rates of runoff to pre-developed levels.

Hydrodynamic separation devices are generally categorized as Chambered Separation Structures or Swirl Concentration Structures.

Chambered separation devices rely on gravitational settling of particles and, to a lesser degree, centrifugal forces to remove pollutants from stormwater. Chambered systems exhibit an upper bypass chamber and a lower storage / separation chamber. Runoff enters the structure in the upper bypass chamber and is channeled through a downpipe into the lower storage / separation, or treatment chamber. The system is designed such that when inflow exceeds the operating capacity, flow “jumps” the downpipe and completely bypasses the lower treatment chamber (VADCR, 1999).
Swirl separation structures are characterized by an internal mechanism that creates a swirling motion. This motion results in the settling of solids to the bottom of the chamber. Additional chambers serve to trap oil and other floating pollutants. Swirl separators do not exhibit a means for bypassing large runoff producing events. Larger flows simply pass through the structure untreated; however, due to the swirling motion within the structure, large flow events do not re-suspend previously trapped particulates. (VADCR, 1999)

16.2 Design Considerations

The design process for a specific installation of a hydrodynamic separator usually begins with a review of various vendor publications and use of preliminary sizing guidelines provided by the vendor. The specific design criteria for the hydrodynamic separator being considered should be obtained from the manufacturer or vendor to ensure that the latest design and sizing criteria are used. At the very least, the design for a particular site should be reviewed by the manufacturer to ensure that the system is adequately sized and located. The following criteria are intended to serve only as general guidelines.

- The use of oil-grit hydrodynamic separators should be limited to the following applications:
  - Pretreatment for other structural controls.
  - High-density, ultra urban or other space-limited development sites.
  - Hotspot areas where the control of grit, floatables, and/or oil and grease is required.

- Hydrodynamic separators are typically limited in use to drainage areas less than five acres. It is recommended that the contributing drainage area to any single separator be limited to one acre or less of impervious cover.

- Manufactured separation systems can be used in almost any soil or terrain. Additionally, since located underground, aesthetic and public safety issues are rarely encountered.

- Separation devices are sized based on rate of runoff. This design criteria contrasts with most BMPs, which are sized for a designated runoff volume.

- Hydrodynamic separators are typically designed to bypass runoff flows in excess of the design flow rate. This bypass may be accomplished by a built in bypass mechanism or a diversion weir or flow splitter located upstream of the separator in the runoff conveyance system. As with all runoff control structures, an adequately stabilized outfall must be provided at the separator’s discharge point.

- The separator units should be watertight to prevent possible groundwater contamination.

- The separation chamber must provide three distinct storage volumes:
  - Volume for separated oil storage at the chamber top
  - Volume for settleable solids at the chamber bottom
16.3 - Manufactured Products

- Volume to provide adequate flow-through detention time (volume to ensure maximum horizontal velocity of 3 ft/min through the chamber)
  - The total wet storage of the gravity separator unit should be at least 400 cubic feet per contributing impervious acre.

- The minimum depth of the permanent pools should be four feet.

- Hydrodynamic separators require a much more intensive maintenance schedule than other BMP measures. A typical maintenance schedule is shown as follows:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspect the gravity separator unit.</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Clean out sediment, oil and grease, and floatables, using catch basin cleaning equipment (vacuum pumps). Manual removal of pollutants may be necessary.</td>
<td>As needed</td>
</tr>
</tbody>
</table>

Table 16.1. Typical Maintenance Activities for Gravity Separators

- All specific design criteria should be obtained from the manufacturer.

Source: Georgia Stormwater Management Manual, published by the Atlanta Regional Commission, Atlanta, Georgia, 2001

16.3 Manufactured Products

The following discussion of manufactured hydrodynamic separators is intended only to serve as a description of the most widely used proprietary systems. The products discussed in this design example do not constitute an exhaustive list of all hydrodynamic separation devices available. Presentation of the following products does not preclude the use of other available systems, nor does it constitute an endorsement of any one system.

16.3.1 Stormceptor

Stormceptor is a precast, modular, vertical cylindrical tank divided into an upper bypass and lower storage chamber. The Stormceptor functions by diverting flow through a downpipe into the lower storage / separation chamber. Flow is then routed horizontally around the circular walls of the separation chamber. The circular flow motion, along with gravitational settling, traps sediments and other particulate pollutants. Flow then exits the Stormceptor through an outlet riser pipe. The outlet pipe is submerged, thus preventing trapped floatables from exiting the structure. The configuration also prevents turbulent flow in the storage / separation chamber, thus preventing resuspension of trapped particulates. The Stormceptor has no moving parts, and requires no external power source. (VADCR, 1999)

During large runoff producing events, flow entering the Stormceptor floods over the diversion weir and through the bypass chamber into the downstream conveyance system. The overflow of the system is controlled by the incoming stormwater velocity
and the hydraulics of the diversion weir. The bypass configuration does result in a backwater condition in the upstream conveyance system. (VADCR, 1999)

It is generally recommended that Stormceptor systems be fully pumped a minimum of once per year. This frequency must be increased if high levels of sediment loading are observed. Schematic details of the Stormceptor system are presented as follows.

---

**Figure 16.1. Stormceptor During Normal Flow Conditions**

Figure 16.2. Stormceptor During High Flow Conditions


Current Stormceptor product information and vendor contacts can be obtained at: http://www.stormceptor.com
16.3.2 Vortechs Stormwater Treatment System

The Vortechs Stormwater Treatment System is a precast rectangular unit composed of three chambers. The first chamber serves as a grit chamber, and creates a swirling motion that directs settleable solids toward the center where they become trapped. The Vortechs system is an all-inclusive proprietary system, with the swirl-inducing mechanism self contained within the unit. Flow is then slowly released from this chamber into the oil chamber. The oil chamber contains a barrier which traps oil and grease and other floatable pollutants. The final chamber is the flow control chamber, which forces water to back up, thus reducing velocities and turbulence. The Vortechs Stormwater Treatment System contains no moving parts and requires no external power source. (VADCR, 1999)

During large runoff producing events, the flow control chamber of the Vortechs system forces runoff to fill the structure. As this occurs, the swirling action in the grit chamber increases, keeping sediment concentrated at the center of the chamber. Because the swirling action of the system increases as the volume of runoff entering the structure increases, the resuspension of previously deposited material is eliminated. The Vortechs system is capable of providing limited flow attenuation within its storage capacity. When the volume of runoff entering the structure exceeds the capacity of the three chambers, the conveyance system leading to the Vortechs system will experience a backwater condition.

To ensure proper performance, the Vortechs system must be cleaned when it becomes full of pollutant material. During the first year of operation, the manufacturer recommends monthly inspections since contaminant loading rates vary greatly. Cleaning of the system is most readily accomplished by use of a vacuum truck.

Schematic details of the Vortechs system are presented as follows.
Figure 16.3. Vortechs Stormwater Treatment System


Current Vortechs product information and vendor contacts can be obtained at: www.vortechnics.com
16.3.3 Downstream Defender

The Downstream Defender system is adaptable to all types of land uses. Additionally, the Downstream Defender can be installed in existing pipe systems as a retrofit.

The Downstream Defender is characterized by a concrete cylindrical structure with stainless steel components, and an internal $30^\circ$ sloping base. Runoff entering the structure passes through a tangential inlet pipe, resulting in a swirling motion. The flow then spirals downward along the perimeter of the structure. During this downward path, heavier particles settle out by gravity and by drag forces exerted along the wall and base of the structure. As flow rotates about the vertical axis, these solids are directed toward the base of the structure, where they are stored. The system’s internal components direct the main flow away from the structure's perimeter and back up the middle of the vessel as a narrower spiraling column rotating at a slower velocity than the outer downward flow. When this upward flow reaches the top of the structure, it is virtually free of solids, and is then discharged through the outlet pipe. The Downstream Defender has no moving parts and requires no external power source.

During the first 12 months of operation, inspections should be conducted frequently following runoff-producing events in order to determine the sediment loading rate. After this time, a probe may be used after storm events to determine a maintenance schedule. H.I.L. Technology, Inc. recommends inspection and clean-out of the Downstream Defender system a minimum of twice per year.

Schematic details of the Downstream Defender system are presented as follows:
Figure 16.4. Section View of Downstream Defender System

16.3 - Manufactured Products

Figure 16.5. Plan View of Downstream Defender System


Current Downstream Defender product information and vendor contacts can be obtained at:
www.hil-tech.com
16.3.4 BaySaver

The BaySaver system is composed of three main components: the primary separation manhole, the secondary storage manhole, and the BaySaver Separator Unit. Runoff enters the system through the primary separation manhole. The larger sediments contained in the runoff settle into the primary separation manhole whose flow exits through a trapezoidal weir. The runoff leaving the primary separation manhole carries with it floating contaminants, debris, and fine sediment which are then treated in the secondary storage manhole. The BaySaver system employs three potential flowpaths for runoff entering the system. First flush and low flows are diverted into the second manhole for the most efficient treatment. As the water level rises in the primary separation manhole, more water flows over the skimming weir and into the secondary manhole. The majority of oils and fine sediments are removed by this flow path. During more intense storms, water can flow through 90-degree elbow pipes located in the primary separation manhole. Because the elbows are situated below the surface, the water entering the secondary storage manhole is free from floating contaminants. During large, infrequent storm events, the BaySaver system bypasses the treatment stages, conveying water directly from inlet to outlet. Bypassed flows are prevented from entering the sedimentation manholes, and thus resuspension of contaminants does not occur. The BaySaver system contains no moving parts and requires no external power source. (VADCR, 1999)

It is generally recommended that BaySaver systems be fully pumped a minimum of once per year. This frequency may be increased if high levels of sediment loading are observed.

Schematic details of the BaySaver system are presented as follows.
Figure 16.6. BaySaver Primary Separation Manhole

Figure 16.7. Plan View of BaySaver System

Figure 16.8. Section through BaySaver Storage Manhole

Figure 16.9. BaySaver Separation Unit


Current Baysaver product information and vendor contacts can be obtained at: http://www.baysaver.com/

The Virginia Transportation Research Council, via contract with University of Virginia, has constructed the following information matrices for the most widely used hydrodynamic separators, as of 2004. The user is referred to the following for the originally published matrices:

<table>
<thead>
<tr>
<th>System Type</th>
<th>Manufacturer</th>
<th>Operation</th>
<th>Sizing and/or Area Located</th>
<th>Maintenance</th>
<th>Cost</th>
<th>General Performance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrodynamic Separators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2B1</td>
<td>Rasaro, Inc.</td>
<td>Solid concentrate in 2 chambers. Second chamber collects deionized and out. May be in wet pool or only first flush.</td>
<td>3 – 5 cfs treatment capability. Hand for solid or inorganic system. Flows greater than first flush directed directly to outlet.</td>
<td>Required only in first chamber if register maintenance. Residuals removed by vacuum man.</td>
<td>ND</td>
<td>60% TSS removal for first flush.</td>
<td>Floating polynaphthalene coated from peak storm flows.</td>
</tr>
<tr>
<td>Boy Serve®</td>
<td>Boy Serve, Inc.</td>
<td>Gravity sedimentation in 2 sediment chambers connected by KG® separator. Primary treatment chamber a single column.</td>
<td>Embryonic or decompose if excess water. Flow to outlet.</td>
<td>Required as a single chamber when decompose.</td>
<td>$7,000 – $18,000 (material only)</td>
<td>Designed to remove TSS, O&amp;G, and debris.</td>
<td></td>
</tr>
<tr>
<td>Stormsep®</td>
<td>CSR Americas</td>
<td>Multi-shaped device. First flash or low flows directed beneath high slurry platforms to settling chamber. Outlet from center of settling column to smaller flow chambers.</td>
<td>Maximum of 200 – 7,000 gpd, 0.5 – 8.7 m3 per storm area.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stormvac®</td>
<td>Jenson Process</td>
<td>Rectangular footprint.</td>
<td>Variable sizes available.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertex®</td>
<td>Vertex, Inc.</td>
<td>Rectangular footprint consists of 3 chambers. Swirl concentrator, O&amp;G removal, sand filters to energy dissipation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 16.2. Hydrodynamic Separators Information Matrix (VTRC, 2004)
<table>
<thead>
<tr>
<th>System Type</th>
<th>Manufacturer</th>
<th>Operation</th>
<th>Siting and/or Area Treated</th>
<th>Maintenance</th>
<th>Cost</th>
<th>General Performance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelletstream settle to ramp or weir in channel. Radial flow clarifier. Minimum area per pool.</td>
<td>available up to 62 cfs. Clinching effect can treat up to 300 cfs. Screen sizes and unit dimensions determined for specific applications.</td>
<td>installation</td>
<td>$10,000 - $35,000 per unit (excluding installation)</td>
<td>BD trimmed sediment 0.050 - 0.01 mm (over 95% measured less than 0.75 mm). Estimate total solids removed was 90% for theoretical design flows. Oil-waste capacity 10 - 1650 gal; sediment storage capacity of 0.1 - 2.3 gal.</td>
<td>ND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream Defender™</td>
<td>H.T. Technology, Inc.</td>
<td>Centrifugation creates a 3D flow path. Sediment settles to bottom of storage area. GFS also stores outside treatment path to prevent re-entrainment. Minimum area per pool.</td>
<td>Clean-out after 1 - 2.5 ft of sediment accumulates - or annually.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 16.2 Cont’d. – Hydrodynamic Separators Information Matrix (VTRC, 2004)