# 2K-1 General Information for Proprietary Mechanical Systems

## A. Introduction

A variety of manufactured structural control systems are available from commercial vendors designed to treat stormwater runoff and/or provide water quantity control. These systems include:
- Hydrodynamic systems such as gravity and vortex separators
- Filtration systems
- Catch basin media inserts
- Chemical treatment systems
- Package treatment plants
- Prefabricated detention structures

Many proprietary systems are useful on small sites and space-limited areas where there is not enough land or room for other structural control alternatives. Proprietary systems can often be used in pretreatment applications in a treatment train. An example would be special systems for capture and removal of oils and petroleum products from storm runoff at industrial sites and fueling areas such as truck plazas. However, proprietary systems are often more costly than other alternatives and may have high maintenance requirements. Perhaps the largest difficulty in using a proprietary system is the lack of adequate independent performance data. Below are general guidelines that should be followed before considering the use of a proprietary commercial system.

***Note: It is the policy of this Manual not to recommend any specific commercial vendors for proprietary systems. However, this subsection is being included in order to provide communities with a rationale for approving the use of a proprietary system or practice in their jurisdictions.***

## B. Guidelines for using proprietary systems

In order for use as a limited application stormwater quality BMP, a proprietary system must have a demonstrated capability of meeting the stormwater management goals for which it is being intended. This means that the system must provide:

1. Independent third-party scientific verification of the ability of the proprietary system to meet water quality treatment objectives and/or to provide water quantity control (channel or flood protection).

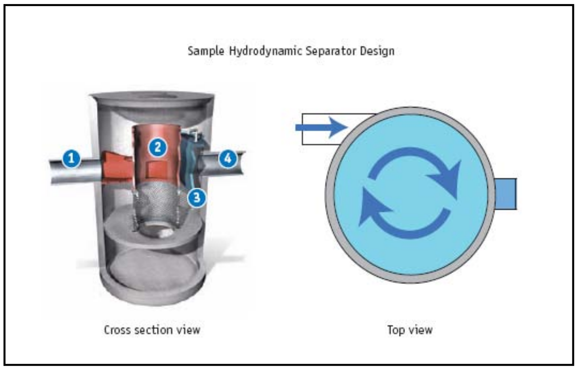
2. Proven record of longevity in the field.

3. Proven ability to function in Iowa conditions (e.g., climate, rainfall patterns, soil types, etc.). For a propriety system to meet (1) above for water quality goals, the following monitoring criteria should be met for supporting studies:
   - At least 15 storm events must be sampled.
   - The study must be independent or independently verified (i.e., may not be conducted by the vendor or designer without third-party verification).
   - The study must be conducted in the field, as opposed to laboratory testing.

- Field monitoring must be conducted using standard protocols that require proportional sampling both upstream and downstream of the device.
- Concentrations reported in the study must be flow-weighted.
- The proprietary system or device must have been in place for at least one year at the time of monitoring. Although local data is preferred, data from other regions can be accepted as long as the design accounts for the local conditions.

Local jurisdictions may submit a proprietary system to further scrutiny based on the performance of similar practices. A poor performance record or high failure rate is valid justification for not allowing the use of a proprietary system or device. Consult your local review authority for more information in regards to the use of proprietary structural stormwater controls.

# 2K-2 Hydrodynamic Devices




Source: University of New Hampshire SW Center

| Pollutant Removal<br>**Low = <30% Medium = 30-65% High = 65-100%** | Low | Med | High |
|---|---|---|---|
| **Suspended Solids** | ■ | | |
| **Nitrogen** | ■ | | |
| **Phosphorous** | ■ | | |
| **Metals** | | ■ | |
| **Bacteriological** | ■ | | |
| **Hydrocarbons** | | ■ | |

**Description:** Hydrodynamic separators (HDS) are flow-through structures with a settling or separation unit to remove sediments and other pollutants that are widely used in storm water treatment. Hydrodynamic devices are designed to remove solids, oil/grease, floatables and other debris from stormwater runoff through gravitational trapping of pollutants. These are typically used in combination with other structural BMPs, such as a pretreatment device.

**Typical Uses:** Used in ultra high density and industrial, commercial site for targeted removal of pollutants in stormwater runoff from small catchments (< 10 acres). Manufactured HDS devices are widely used throughout the United States; there are many options on the market. The small footprint makes them particularly suitable for urban areas or as retrofits to existing storm drain networks. Relatively simple to maintain, making them ideal for use as pretreatment components in treatment trains that also include filtration or infiltration systems.

**Advantages:**

- Units are typically underground or within existing structures and do not consume much site space
- Filtration devices can be customized to reduce a specific pollutant of concern
- Can often be easily incorporated into fully developed sites
- Can be used for pre-treatment prior to infiltration practices
- Relevant for use on industrial sites because filters can remove pollutants such as metals and oils

**Limitations:**

- Efficiency has not been widely tested; independent evaluation indicates poor performance for TSS removal and low to medium removal of metals and hydrocarbons
- Each type of unit has specific design constraints and limitations for use
- Can be more costly that other treatment methods; high capital and operations and maintenance costs
- Treatment may be greatly reduced if frequent maintenance is not conducted
- Subject to freezing in cold climates; poor cold weather performance

**Maintenance Requirements:**

- High degree of maintenance and weekly management required
- Service chemical feed equipment daily and/or weekly

## A. Description

Hydrodynamic separators (HDS) are flow-through structures with a settling or separation unit to remove sediments and other pollutants that are widely used in storm water treatment. No outside power source is required, because the energy of the flowing water allows the sediments to efficiently separate. Depending on the type of unit, this separation may be by means of swirl action or indirect filtration.

HDS are most effective where the materials to be removed from runoff are heavy particulates (which can be settled) or floatables (which can be captured), rather than solids with poor settleability or dissolved pollutants. In addition to the standard units, some vendors offer supplemental features to reduce the velocity of the flow entering the system. This increases the efficiency of the unit by allowing more sediment to settle out.

The design of HDS devices varies, and is completed by the manufacturer in accordance with local watershed conditions and target water quality treatment objectives. Often, these systems are designed to replace or retrofit existing catch-basins. Typically, HDS devices consist of a chamber that is configured for tangential-flow, meaning that stormwater enters the device through an angled inlet that creates a swirl action to enhance particle settling. Many also contain a flow partition to minimize sediment re-suspension during times when flow rates exceed the design target. Typically, HDS devices are equipped with a baffled outlet to remove floating debris, oil, and grease in stormwater runoff. To prevent the re-suspension of captured solids during times of high flow volume, some manufacturers have adapted HDS designs to include internal, online bypasses. When appropriate, these systems also can be outfitted with external, offline bypasses so that high flows can bypass the system completely.

## B. Applicability

This technology may be used by itself or in conjunction with other storm water BMPs as part of an overall storm water control strategy. Hydrodynamic separators come in a wide size range and some are small enough to fit in conventional manholes. This makes hydrodynamic separators ideal for areas where land availability is limited. Also, because they can be placed in almost any specific location in a system, hydrodynamic separators are ideal for use in potential storm water “hotspots”--areas such as near gas stations, where higher concentrations of pollutants are more likely to occur. The use of hydrodynamic separators is growing as a result of decreasing land availability for the installation of storm water BMPs. Hydrodynamic separator systems from four vendors are summarized below. Although there are many hydrodynamic separation systems available, the following four products address the major types:

- Continuous Deflective Separation (CDS)
- Downstream Defender™
- Stormceptor®
- Vortechs™

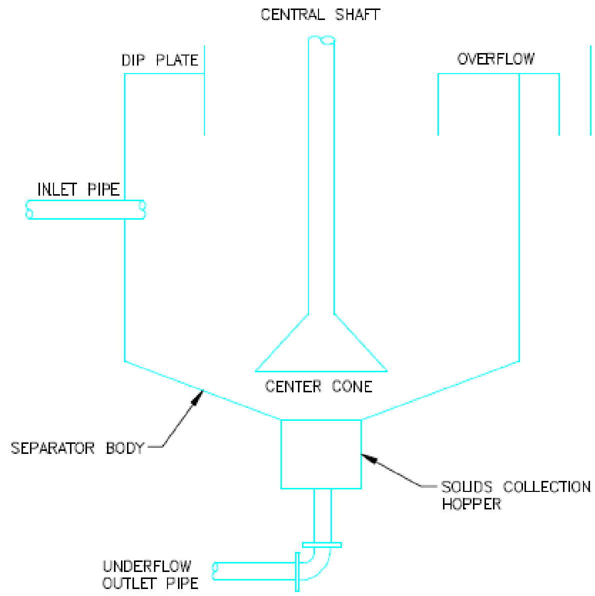
## C. Continuous deflective separation (CDS)

CDS' hydrodynamic separator technology is suitable for gross pollutant removal. The system utilizes the natural motion of water to separate and trap sediments by indirect filtration. As the storm water flows through the system, a very fine screen deflects the pollutants, which are captured in a litter sump in the center of the system. Floatables are retained separately. This non-blocking separation technique is the only technology presented here that does not rely on secondary flow currents induced by vortex action. The processing capacities of CDS units vary from 3 to 300 cubic feet per second (cfs), depending on the application. Precast modules are available for flows up to 62 cfs, while higher flow processing requires cast-in-place construction. Every unit requires a detailed hydraulic analysis before it is installed to ensure that it achieves optimum solids separation. The cost per unit (including installation) ranges from $2,300 to $7,200 per cfs capacity, depending on site-specific conditions and does not include any required maintenance. Maintenance of the CDS technology is site-specific but the manufacturer recommends that the unit be checked after every runoff event for the first 30 days after installation. During this initial installation period the unit should be visually inspected and the amount of deposition should be measured, to give the operator an idea of the expected rate of sediment deposition. Deposition can be measured with a calibrated "dip stick". After this initial operation period, CDS Technologies recommends that the unit be inspected at least once every 30 days during the wet season. During these inspections, the floatables should be removed and the sump cleaned out (if it is more than 85% full). It is also recommended that the unit be pumped out and the screen inspected for damage at least once per year.

## D. Downstream Defender

The Downstream Defender, manufactured by H.I.L.Technology, Inc., regulates both the quality and quantity of storm water runoff. The Downstream Defender is designed to capture settleable solids, floatables, and oil and grease. It utilizes a sloping base, a dip plate and internal components to aid in pollutant removal. As water flows through the unit, hydrodynamic forces cause solids to begin settling out. A unique feature of this unit is its sloping base (see Figure 1), which is joined to a benching skirt at a 30 degree angle. This feature helps solids to settle out of the water column. The unit's dip plate encourages solids separation and aids in the capture of floatables and oil and grease. All settled solids are stored in a collection facility, while flow is discharged through an outlet pipe. H.I.L. Technology reports that this resulting discharge is 90 percent free of the particles greater than 150 microns that originally entered the system. The Downstream Defender comes in pre-designed standard manhole size, typically ranging from 4 to 10 feet in diameter. These units have achieved 90 percent removal for flows from 0.75 cfs to 13 cfs. To meet specific performance criteria, or for larger flow applications, units may be custom designed up to 40 feet in diameter. (These are not able to fit in conventional manholes.) The approximate capital and installation costs, range from $10,000 to $35,000 per pre-cast unit. Inspecting the Downstream Defender periodically (once a month) over the first year of operation will aid in determining the rate of sediment and floatables accumulation. A probe (or dipstick) may be used to help determine the sediment depth in the collection facility. (With this inspection information a maintenance schedule may be established.) A sump vac (commercial or municipally-owned) may be used to remove captured floatables and solids. With proper upkeep, H.I.L. Technology reports the Downstream Defender will remove sediment from stormwater for more than 30 years.

**Figure 1:** Generalized hydrodynamic separator




Source: Fenner and Tyack, 1997

## E. Stormceptor

Stormceptor Corporation is based in Canada and has licensed manufacturers throughout Canada and the United States. Stormceptor is designed to trap and retain a variety of non-point source pollutants, using a by-pass chamber and treatment chamber. Stormceptor reports that it is capable of removing 50% to 80% of the total sediment load when used properly. Stormceptor units are available in prefabricated sizes up to 12 feet in diameter by 6 to 8 feet deep. Customized units are also available for limited spaces. Stormceptor recommends its units for the following areas:

- Redevelopment projects of more than 2,500 square feet where there was no previous storm water management (even if the existing impervious area is merely being replaced).
- Projects that result in doubling the impervious area.
- Projects that disturb at least half of the existing site.

The cost of the Stormceptor unit is based on the costs of two important system elements:

- A treatment chamber and by-pass insert.
- Access way and fittings.

Typically, the cost for installation of a unit for a one acre drainage area is $9,000. This cost will vary depending on site-specific conditions. Stormceptor units range from 900 to 7,200 gallons and cost between $7,600 and $33,560. Cleaning costs depend on several factors, including the size of the installed unit and travel costs for the cleaning crew. Cleaning usually takes place once per year and costs approximately $1,000 per structure. Vacuum trucks are used to clean out the Stormceptor unit. Although annual maintenance is recommended, maintenance frequency will be based on site-specific conditions. The need for maintenance is indicated by sediment depth; typically, when the unit is filled to within one foot of capacity, it should be cleaned. Visual inspections may also be performed and are especially recommended for units that may capture petroleum based pollutants. The visual inspection is accomplished by removing the manhole cover and using a dipstick to determine the petroleum or oil accumulation in the unit. If the Stormceptor unit is not maintained properly, approximately 15% of its total sediment capacity will be reduced each year, assuming an average sediment load.

## F. Vortechs

The Vortechs™ storm water treatment system, manufactured by Vortechnics™ of Portland, Maine, has been available since 1988. Like the other hydrodynamic separators, Vortechs removes floating pollutants and settleable solids from surface runoff. This system combines swirl-concentrator and flow-control technologies to separate solids from the flow. Constructed of precast concrete, Vortechs uses four structures to optimize storm water treatment through its system. These are:

1. **Baffle wall:** Situated permanently below the water line, this structure helps to contain floating pollutants during high flows and during cleaning.

2. **Circular grit chamber:** This structure aids in directing the influent into a vortex path. The vortex action encourages sediment to be caught in the swirling flow path and to settle out later, when the storm event is complete.

3. **Flow control chamber:** This device helps keep pollutants trapped by reducing the forces that encourage resuspension and washout. This chamber also helps to eliminate turbulence within the system.

4. **Oil chamber:** This structure helps to contain floatables.

Vortechnics manufactures nine standard-sized units. These range from 9 feet by 3 feet to 18 feet by 12 feet. The unit sizes depend on the estimated runoff volume to be treated. For specific applications, dimensions of the runoff area are used to customize the unit. Vortechnics reports that Vortechs systems are able to treat runoff flows ranging from 1.6 cfs to 25 cfs. The cost for these units ranges from $10,000 to $40,000, not including shipment or installation. As with other hydrodynamic separator systems, maintenance of the Vortechs system is site-specific. Frequent inspections (once a month) are recommended during the first year and whenever there may be heavy contaminant loadings: after winter sandings, soil disturbances, fuel spills, or sometimes, intense rain or wind. The Vortechs unit requires cleaning only when the system has nearly reached capacity. This occurs when the sediment reaches within one foot of the inlet pipe. The depth may be gauged by measuring the sediment in the grit chamber with a rod or dipstick. To clean the system, the manhole cover above the grit chamber is lifted and the sediment is removed using a vacuum truck. Following sediment removal, the manhole cover is replaced securely to ensure that runoff does not leak into the unit.

Hydrodynamic separators are most effective where the separation of heavy particulates or floatables from stormwater runoff is required. The typical concentrations of heavy particulate and floatable pollutants found in storm water are shown in Table 1. Hydrodynamic separators are designed to remove settleable solids and capture floatables; *however, suspended solids are not effectively removed*. Most units are small (depending on the flow entering needing to be treated) and may be able to fit into pre-existing manholes. For this reason, this technology is particularly well suited to locations where there is limited land available.

**Table 1:** Concentration of pollutants in stormwater

| Pollutant | Concentration |
|---|---|
| TSS | 100 mg/L |
| Total P | 0.33 mg/L |
| Total Kjeldahl Nitrogen | 1,50 mg/L |
| Total Cu | 34 mg/L |
| Total Pb | 144 mg/L |
| Total Zn | 160 mg/L |

Source: U.S. EPA, 1995

The units designed for hydrodynamic separators are generally prefabricated in set sizes up to 12 feet in diameter, but they may be customized for a specific site if needed. Some structures are available in concrete or fiberglass. (Fiberglass is recommended for areas of potential hazardous material spills.) These materials are both suitable for retrofit applications. Hydrodynamic separators are also good for potential storm water "hotspots" or sites that fall under industrial NPDES stormwater requirements. "Hotspots" are areas such as gas stations, where a higher concentration of pollutants is more likely to be found.

## G. Advantages and disadvantages

The use of hydrodynamic separators as wet weather treatment options may be limited by the variability of net solids removal. While some data suggest excellent removal rates, these rates often depend on site-specific conditions, as well as other contributing factors. Pollutants such as nutrients, which adhere to fine particulates or are dissolved, will not be significantly removed by the unit. Site constraints, including the availability of suitable land, appropriate soil depth, and stable soil to support the unit structurally, may also limit the applicability of the hydrodynamic separator. The slope of the site or collection system may necessitate the use of an underground unit, which can result in an extensive excavation. Observable improvements in waterways are often attributable to the use of hydrodynamic separators. This is due to the reduction of sediments, floatables, and oil and grease in the flow out of the unit. These positive impacts are only achievable when proper design and O&M of the unit are implemented.

## H. Performance

Hydrodynamic separators are designed primarily for removing floatable and gritty materials; they may have difficulty removing the less-settleable solids generally found in storm water. The reported removal rates of sediments, floatables, and oil and grease differ depending on the vendor.

The following observations are based on median values that reflect the performance of four systems evaluated at the University of New Hampshire Stormwater Center (UNHSC) in 2004 to 2006: the VortSentry, the CDS, the V2B1, and the Aqua-Swirl. Water quality performance was moderate to poor across the range of pollutants commonly associated with stormwater treatment performance assessment. The median annual average for removal of total suspended solids in these systems was well below the EPA's recommended level for removal—they performed in the 30 percent range during the warmer months and 20 percent range in the winter. Likewise, they did not meet regional ambient water quality criteria for removal of petroleum hydrocarbons and zinc. No removal was recorded for nutrients, dissolved inorganic nitrogen, or total phosphorus.

## I. Water quantity control

Typically, HDS devices are flow-through systems. Therefore, they exhibit no peak flow reduction, volume detention, or lag time.

## J. Cold climate

As a class, the ability of HDS devices to remove sediments is significantly impacted during cold winter months. This is due to the increased viscosity of stormwater runoff and high concentrations of chloride, both of which combine to reduce particle settling velocity. Calculations of particle settling velocities at temperatures and chloride concentrations typically found in winter runoff demonstrated that HDS devices need about twice the time necessary to settle the same size particles in cold weather. When designed for installation in prolonged cold climate conditions, HDS devices that rely on particle settling for sediment removal need to be oversized to account for these changes in system performance.

## K. Operation and maintenance

Hydrodynamic separators do not have any moving parts, and are consequently not maintenance intensive. However, maintaining the system properly is very important in ensuring that it is operating as efficiently as possible. Proper maintenance involves frequent inspections throughout the first year of installation. The unit is full when the sediment level comes within one foot of the unit's top. This is recognized through experience or the use of a "dip stick" or rod for measuring the sediment depth. When the unit has reached capacity, it must be cleaned out. This may be performed with a sump vac or vacuum truck, depending on which unit is used. In general, hydrodynamic separators require a minimal amount of maintenance, but lack of attention will lower their overall efficiency. Systems in which the catch-basin is designed to be open and accessible allow for more thorough removal of sediment and are less costly to maintain.

## L. Costs

The capital costs for hydrodynamic separators depend on site-specific conditions. These costs are based on several factors including the amount of runoff (in cfs) required to be treated, the amount of land available, and any other treatment technologies that are presently being used. Capitol costs can range from $2,300 to $40,000 per pre-cast unit. Units which are site-specifically designed, typically cost more and the price is based on the individual site. Total costs for hydrodynamic separators often include pre-design costs, capital costs, and operation and maintenance (O&M) costs. Again, these costs are site-specific. The pre-design costs depend upon the complexity of the intended site. O&M costs vary based on the company contracted to clean out the unit, and may depend on travel distances and cleaning frequency. These costs generally are low (maximum of $1,000 a year) and vary from year to year. The individual unit prices are discussed in the current status section previously mentioned. This covers a more in depth price range of the various systems.

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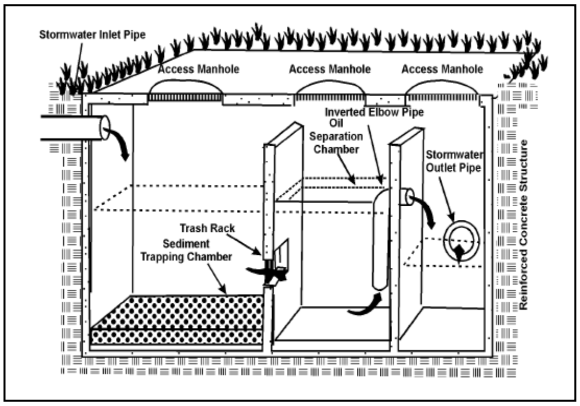
# 2K-3 Gravity Separator Systems




Source: U.S. EPA, 199

| Pollutant Removal<br>**Low = <30%  Medium = 30-65%  High = 65-100%** | | | |
|---|---|---|---|
| | Low | Med | High |
| **Suspended Solids** | ■ | | |
| **Nitrogen** | ■ | | |
| **Phosphorous** | ■ | | |
| **Metals** | | ■ | |
| **Bacteriological** | ■ | | |
| **Hydrocarbons** | | ■ | |

**Description:** Gravity oil/particle separators, also called oil/grit separators, water quality inlets**,** and oil/water separators, consist of one or more chambers designed to remove trash and debris and to promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater runoff. Oil/particle separators are typically designed as off-line systems for pretreatment of runoff from small impervious areas, and therefore provide minimal attenuation of flow. Due to their limited storage capacity and volume, these systems have only limited water quality treatment capabilities. While oil/particle separators can effectively trap floatables, oil, and grease, they are ineffective at removing nutrients and metals and only capture coarse sediment.

**Typical Uses:** Used in ultra high density and industrial, commercial site for targeted removal of pollutants in stormwater runoff from small catchments (< 10 acres). For limited removal of trash, debris, oil and grease, and sediment from stormwater runoff from relatively small impervious areas with high traffic volumes or high potential for spills such as parking lots and commercial/industrial manufacturing facilities, truck loading areas, gas stations, refueling areas, automotive repair facilities, fleet maintenance yards, and commercial vehicle washing facilities

**Advantages:**

- Units are typically underground or within existing structures and do not consume much site space
- Filtration devices can be customized to reduce a specific pollutant of concern
- Can often be easily incorporated into fully developed sites
- Can be used for pre-treatment prior to infiltration practices
- Relevant for use on industrial sites because filters can remove pollutants such as metals and oils

**Limitations:**

- Limited pollutant removal; cannot effectively remove soluble pollutants or fine particles
- Can become a source of pollutants due to re-suspension of sediment unless maintained frequently
- Maintenance often neglected ("out of sight and out of mind")
- Limited to relatively small contributing drainage areas
- Subject to freezing in cold climates; poor cold-weather performance

**Maintenance Requirements:**

- High degree of maintenance and weekly management required
- Service chemical feed equipment daily and/or weekly

# A. General description

Gravity separators (also known as oil-grit separators) are hydrodynamic separation devices that are designed to remove grit and heavy sediments, oil and grease, debris and floatable matter from stormwater runoff through gravitational settling and trapping. Gravity separator units contain a permanent pool of water and typically consist of an inlet chamber, separation/storage chamber, a bypass chamber, and an access port for maintenance purposes. Runoff enters the inlet chamber where heavy sediments and solids drop out. The flow moves into the main gravity separation chamber, where further settling of suspended solids takes place. Oil and grease are skimmed and stored in a waste oil storage compartment for future removal. After moving into the outlet chamber, the clarified runoff is then discharged.

The performance of these systems is based primarily on the relatively low solubility of petroleum products in water and the difference between the specific gravity of water and the specific gravities of petroleum compounds. Gravity separators are not designed to separate other products such as solvents, detergents, or dissolved pollutants. The typical gravity separator unit may be enhanced with a pretreatment swirl concentrator chamber, oil draw-off devices that continuously remove the accumulated light liquids, and flow control valves regulating the flow rate into the unit.

Gravity separators are best used in commercial, industrial and transportation land uses and are intended primarily as a pretreatment measure for high-density or ultra urban sites, or for use in hydrocarbon hotspots, such as gas stations and areas with high vehicular traffic. However, gravity separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols and alcohols. Since re-suspension of accumulated sediments is possible during heavy storm events, gravity separator units are typically installed off-line. Gravity separators are available as prefabricated proprietary systems from a number of different commercial vendors.

# B. Pollutant removal capabilities

Testing of gravity separators has shown that they can remove between 40% and 50% of the TSS loading when used in an off-line configuration (Curran, 1996 and Henry, 1999). Gravity separators also provide removal of debris, hydrocarbons, trash and other floatables. They provide only minimal removal of nutrients and organic matter. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and independent performance evaluations.

- Total Suspended Solids – 40%
- Total Phosphorus – 5%
- Total Nitrogen – 5%
- Fecal Coliform – insufficient data
- Heavy Metals – insufficient data

Actual field testing data and pollutant removal rates from an independent source should be obtained before using a proprietary gravity separator system.

## C. Design criteria and specifications

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

2. Gravity separators are typically used for areas less than 1 acre. The contributing area to any individual gravity separator can be limited to 1 acre or less of impervious cover.

3. Gravity separator systems can be installed in almost any soil or terrain. Since these devices are underground, appearance is not an issue and public safety risks are low.

4. Gravity separators are rate-based devices. This contrasts with most other stormwater structural controls, which are sized based on capturing and treating a specific volume.

5. Gravity separator units are typically designed to bypass runoff flows in excess of the design flow rate. Some designs have built-in high flow bypass mechanisms. Other designs require a diversion structure or flow splitter ahead of the device in the drainage system. An adequate outfall must be provided.

6. The separation chamber should provide for three separate storage volumes:
   - A volume for separated oil storage at the top of the chamber
   - A volume for settleable solids accumulation at the bottom of the chamber
   - A volume required to give adequate flow-through detention time for separation of oil and sediment from the stormwater flow

7. The total wet storage of the gravity separator unit should be at least 400 cubic feet per contributing impervious acre.

8. The minimum depth of the permanent pools should be 4 feet.

9. Horizontal velocity through the separation chamber should be 1 to 3 feet per minute or less. No velocities in the device should exceed the entrance velocity.

10. A trash rack should be included in the design to capture floating debris, preferably near the inlet chamber to prevent debris from becoming oil impregnated.

11. Ideally, a gravity separator design will provide an oil draw-off mechanism to a separate chamber or storage area.

12. Adequate maintenance access to each chamber must be provided for inspection and cleanout of a gravity separator unit.

13. Gravity separator units should be watertight to prevent possible groundwater contamination.

14. The design criteria and specifications of a proprietary gravity separator unit should be obtained from the manufacturer.

## D. Inspection and maintenance requirements

**Table 1:** Typical maintenance activities for gravity separators

| Activity | Schedule |
|---|---|
| Inspect the gravity separator unit | Regularly (quarterly) |
| Clean sediment, oil and grease, and floatables, using catch basin cleaning equipment (vacuum pumps). Manual removal of pollutants may be necessary. | As needed |

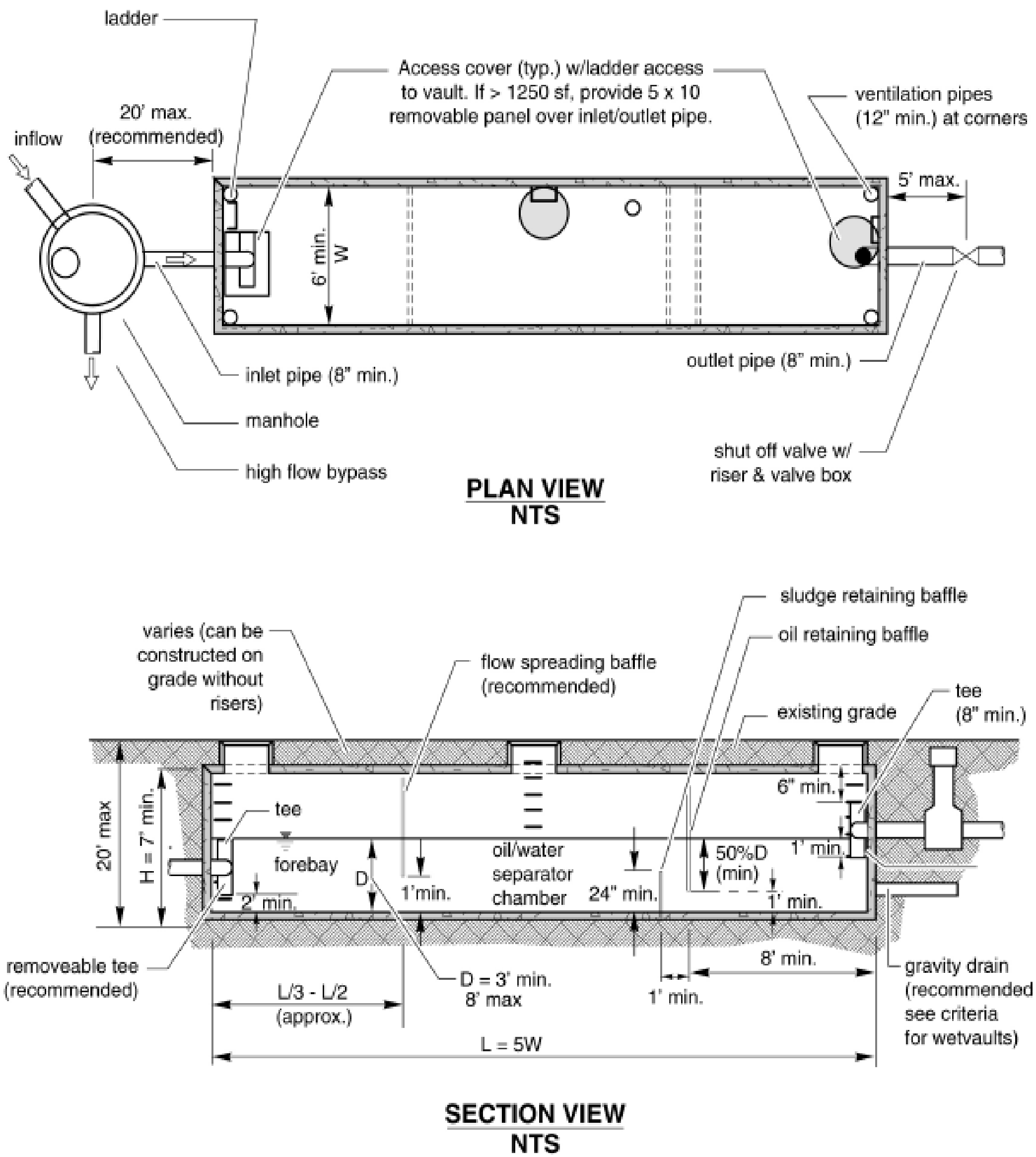
## E. Additional maintenance considerations and requirements

1. Additional maintenance requirements for a proprietary system should be obtained from the manufacturer.

2. Failure to provide adequate inspection and maintenance can result in the re-suspension of accumulated solids. Frequency of inspection and maintenance is dependent on land use, climate conditions, and the design of gravity separator.

3. Proper disposal of oil, solids, and floatables removed from the gravity separator must be ensured.

**Figure 1:** Typical API-type (Baffle) grit chamber




Source: Washington Department of Ecology, 2000

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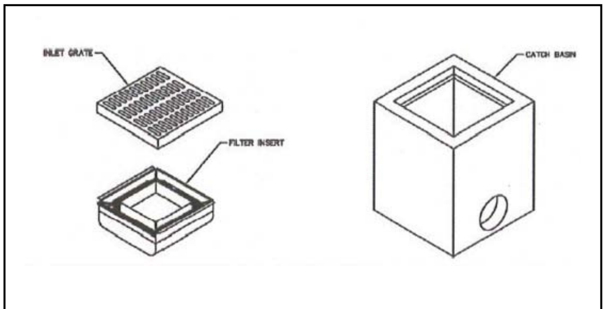
# 2K-4 Catch Basins with Sumps and Catch Basin Inserts




Schematic: Catch basin insert (PADEP)

| Pollutant Removal<br>**Low = <30% Medium = 30-65% High = 65-100%** | | | |
|---|---|---|---|
| | Low | Med | High |
| **Suspended Solids** | | | ■ |
| **Nitrogen** | | | |
| **Phosphorous** | | | |
| **Metals** | | | ■ |
| **Bacteriological** | | | |
| **Hydrocarbons** | | ■ | |

**Description:** A catch basin (also known as a storm drain inlet, curb inlet) is an inlet to the storm drain system that typically includes a grate or curb inlet where stormwater enters the catch basin. Catch basins may include a sump to capture sediment, debris, and associated pollutants. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump), and routine maintenance to retain the storage available in the sump to capture sediment. Catch basin inserts are filtration devices. The inserts allow stormwater to pass through filter media which are designed to reduce specific stormwater pollutants, primarily solids and oils. Pollutants are captured physically or through sorption onto the filter media. Filters may either be inserts that are retrofitted into existing catch basins or manholes, or stand alone units supplied by a manufacturer.

**Typical Uses:** Used in ultra high density and industrial, commercial sites for targeted removal of pollutants in stormwater runoff from small catchments (< 10 acres).

**Advantages:**

- Units are typically underground or within existing structures and do not consume much site space
- Filtration devices can be customized to reduce a specific pollutant of concern
- Can often be easily incorporated into fully developed sites
- Can be used for pre-treatment prior to infiltration practices
- Relevant for use on industrial sites because filters can remove pollutants such as metals and oils

**Limitations:**

- Efficiency has not been widely tested
- Each type of unit has specific design constraints and limitations for use
- Can be more costly that other treatment methods; high capital and operations and maintenance costs
- Treatment may be greatly reduced if frequent maintenance is not conducted
- Subject to freezing in cold climates

**Maintenance Requirements:**

- High degree of maintenance and weekly management required
- Service chemical feed equipment daily and/or weekly

## A. Introduction

Filtration devices, depending on the design, can treat stormwater to reduce nutrients, sediment, floatables, metals, oil, and/or organic compounds. Different filtration media are used depending on the type of pollutant to be removed. Filter media may be a screen, fabric, activated carbon, perlite, zeolite, or another material. Often a combination of filter media can be used to target the specific pollutants of interest. Catch basin inserts represent a special type of filtration practice that can be used for treatment in small catchments for specific targeted pollutant removal.

## B. Description

Catch basins, also known as storm drain inlets and curb inlets, are inlets to the storm drain system. They typically include a grate or curb inlet and could include a sump to capture sediment, debris, and pollutants. Catch basins may be used in combined sewer overflow (CSO) watersheds to capture floatables and settle some solids; they act as pretreatment for other treatment practices by capturing large sediments. The effectiveness of catch basins with sumps, their ability to remove sediments and other pollutants, depends on its design (e.g., the size of the sump) and on maintenance procedures to regularly remove accumulated sediments from its sump. Inserts designed to remove oil and grease, trash, debris, and sediment can improve the efficiency of catch basins. Some inserts are designed to drop directly into existing catch basins, while others may require retrofit construction.

These devices differ from structural stormwater filters in two aspects. First, these devices are proprietary and are designed to fit as an insert into the hydraulic infrastructure (e.g. catch basin). Second, the media material may have unique characteristics that are different from the soil/sand media recommended for general stormwater filtration. Filtration devices have been developed for use in locations such as underground chambers, catch basins, trench drains, and roof drains. The manufacturer specifications should indicate key design parameters such as size, allowable flow rate, allowable pollutant concentrations, and removal efficiency. A bypass should be part of the system to allow high flows to circumvent the filtration device. Performance data is often provided by the manufacturer. Users should review this information to ensure it was provided by an independent source.

## C. Selection of catch basin insert filtration devices

When selecting or specifying a catch basin insert filtration device, designers should research the following:

1. What are the minimum or maximum drainage areas recommended for the device or method?

2. What flow rates or volumes can the device accommodate? Will accessory structures be necessary to divert high flow around the filtration device?

3. What are the characteristics of the pollutants in the water used for testing? What particle size distribution was tested? Research protocols used for testing.

4. Are pollutant removal tests verified by independent organizations such as the Technology Verification ETV program.

5. Does the device contain a by-pass for high flows? If so, what is the percentage of flow prior to by-pass.

6. What are the construction costs? Does the cost include all materials, installation, and delivery?

7. What are the maintenance requirements? What are the costs of the required maintenance? Is there a standard operation and maintenance plan? What is the typical life of the filtration unit?

8. Does the local regulatory authority approve the use of filtration devices?

9. Will the manufacturer provide design computations and CADD details?

## D. Applicability

Though they are used in drainage systems throughout the United States, many catch basins are not ideally designed for sediment and pollutant capture. Catch basins with sumps are ideally used as pretreatment to another stormwater management practice. Retrofitting existing catch basins may substantially improve their performance. A simple retrofit option is to ensure that all catch basins have a hooded outlet to prevent floatable materials, such as trash and debris, from entering the storm drain system. Catch basin inserts for both new development and retrofits at existing sites may be preferred when available land is limited, as in urbanized areas.

## E. Limitations

Catch basins have three major limitations:

- Even ideally designed catch basins cannot remove pollutants as well as structural stormwater management practices, such as wet ponds, sand filters, and stormwater wetlands.
- Unless frequently maintained, catch basins can become a source of pollutants through re-suspension.
- Catch basins cannot effectively remove soluble pollutants or fine particles.

## F. Siting and design considerations

The performance of catch basins with sumps is related to the volume in the sump (i.e., the storage in the catch basin below the outlet). Lager et al. (1997) described an "optimal" catch basin sizing criterion, which relates all catch basin dimensions to the diameter of the outlet pipe (D):

- The diameter of the catch basin should be equal to 4D.
- The sump depth should be at least 4D. This depth should be increased if cleaning is infrequent or if the area draining to the catch basin has high sediment loads.
- The top of the outlet pipe should be 1.5 D from the bottom of the inlet to the catch basin.

Catch basins sumps should also be sized to accommodate the volume of sediment that enters the system. Pitt et al. (1997) proposed a sizing criterion based on the concentration of sediment in stormwater runoff. The catch basin is sized, with a factor of safety, to accommodate the annual sediment load in the catch basin sump. This method is preferable where high sediment loads are anticipated, and where the optimal design described above is suspected to provide little treatment.

The basic design should also incorporate a hooded outlet to prevent floatable materials and trash from entering the storm drain system. Adding a screen to the top of the catch basin would not likely improve the performance of catch basins for pollutant removal, but it would help capture trash entering the catch basin (Pitt et al., 1997).

Several varieties of catch basin inserts exist for filtering runoff. There are two basic catch basin insert varieties. One insert option consists of a series of trays, with the top tray serving as an initial sediment trap, and the underlying trays composed of media filters. Another option uses filter fabric to remove pollutants from stormwater runoff. Yet another option is a plastic box that fits directly into the catch basin. The box construction is the filtering medium. Hydrocarbons are removed as the stormwater passes through the box while trash, rubbish, and sediment remain in the box as stormwater exits. These devices have a very small volume, compared to the volume of the catch basin sump, and would typically require very frequent sediment removal. Bench test studies found that a variety of options showed little removal of total suspended solids, partially due to scouring from relatively small (6 month) storm events (ICBIC, 1995).

One design adaptation of the standard catch basin is to incorporate infiltration through the catch basin bottom. Two challenges are associated with this design. The first is potential ground water impacts, and the second is potential clogging, preventing infiltration. Infiltrating catch basins should not be used in commercial or industrial areas, because of possible ground water contamination. While it is difficult to prevent clogging at the bottom of the catch basin, it might be possible to incorporate some pretreatment into the design.

## G. Maintenance considerations

Typical maintenance of catch basins includes trash removal if a screen or other debris capturing device is used, and removal of sediment using a vactor truck. Operators need to be properly trained in catch basin maintenance. Maintenance should include keeping a log of the amount of sediment collected and the date of removal. Some cities have incorporated the use of GIS systems to track sediment collection and to optimize future catch basin cleaning efforts.

One study (Pitt, 1985) concluded that catch basins can capture sediments up to approximately 60 percent of the sump volume. When sediment fills greater than 60% of their volume, catch basins reach steady state. Storm flows can then re-suspend sediments trapped in the catch basin, and will bypass treatment. Frequent cleaning can retain the volume in the catch basin sump available for treatment of stormwater flows.

At a minimum, catch basins should be cleaned once or twice per year (Aronson et al., 1993). Two studies suggest that increasing the frequency of maintenance can improve the performance of catch basins, particularly in industrial or commercial areas. One study of 60 catch basins in Alameda County, California, found that increasing the maintenance frequency from once per year to twice per year could increase the total sediment removed by catch basins on an annual basis (Mineart and Singh, 1994). Annual sediment removed per inlet was 54 pounds for annual cleaning, 70 pounds for semi-annual and quarterly cleaning, and 160 pounds for monthly cleaning. For catch basins draining industrial uses, monthly cleaning increased total annual sediment collected to six times the amount collected by annual cleaning (180 pounds versus 30 pounds). These results suggest that, at least for industrial uses, more frequent cleaning of catch basins may improve efficiency. However, the cost of increased operation and maintenance costs needs to be weighed against the improved pollutant removal.

In some regions, it may be difficult to find environmentally acceptable disposal methods for collected sediments. The sediments may not always be land-filled, land-applied, or introduced into the sanitary sewer system due to hazardous waste, pretreatment, or ground water regulations. This is particularly true when catch basins drain runoff from hot spot areas.

## H. Effectiveness

What is known about the effectiveness of catch basins is limited to a few studies. Table 1 outlines the results of some of these studies.

**Table 1:** Pollutant removal of catch basins (percent)

| Study | Notes | Pollutant Type/Percent Removed | | | | | |
|---|---|---|---|---|---|---|---|
| | | $TSS_1$ | $COD_1$ | $BOD_1$ | $TN_1$ | $TP_1$ | Metals |
| Pitt, et al 1997 | | 32 | NA | NA | NA | NA | NA |
| Aronson et al, 1983 | Only very small storms were monitored in this study. | 60-97 | 10-56 | 54-88 | NA | NA | NA |
| Moineart and Singh, 1994 | Annual load reduction estimated based on concentrations and mass of catch basin sediment. | NA | NA | NA | NA | NA | For Cu (3-4% with annual cleaning) (15% w/ monthly cleaning) |

[1] TSS=total suspended solids; COD=chemical oxygen demand; BOD=biological oxygen demand; TN=total nitrogen; TP=total phosphorus

## I. Cost considerations

A typical pre-cast catch basin costs between $2,000 and $3,000. The true pollutant removal cost associated with catch basins, however, is the long-term maintenance cost. A vactor truck, the most common method of catch basin cleaning, costs between $125,000 and $150,000. This initial cost may be high for smaller Phase II communities. However, it may be possible to share a vactor truck with another community. Typical vactor trucks can store between 10 and 15 cubic yards of material, which is enough storage for three to five catch basins with the "optimal" design and an 18 inch inflow pipe. Assuming semi-annual cleaning, and that the vactor truck could be filled and material disposed of twice in one day, one truck would be sufficient to clean between 750 and 1,000 catch basins. Another maintenance cost is the staff time needed to operate the truck. Depending on the regulations within a community, disposal costs of the sediment captured in catch basins may be significant. Retrofit catch basin inserts range from as little as $400 for a "drop-in" type to as much as $10,000 or more for more elaborate designs.

## References

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