Performance Evaluation of the Turkey Creek Subdivision Outfall Improvements

Final Report

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Prepared for:

City of Palm Bay

Prepared By:

ERD

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SECTION 1

INTRODUCTION

The Turkey Creek Subdivision is a single-family residential community which is located on the east side of Turkey Creek, north of Malabar Road and west of Troutman Blvd. in the City of Palm Bay. The Turkey Creek Subdivision was constructed prior to implementation of existing stormwater management regulations, and as a result, discharges untreated stormwater runoff directly into Turkey Creek. A location map for the Turkey Creek Subdivision area is given on Figure 1-1. This area is thought to be a significant contributor of nutrients and suspended solids into Turkey Creek. Turkey Creek, an Outstanding Florida Water (OFW), feeds directly into the Indian River Lagoon, an Estuary of National Significance.

During 2001, the City of Palm Bay entered into an Agreement with the St. Johns River Water Management District (SJRWMD) to implement several new and innovative pollution control devices within the Turkey Creek Subdivision to reduce annual mass loadings of nutrients and suspended solids to Turkey Creek and to demonstrate the performance efficiency and feasibility of utilizing the evaluated pollution control devices as general BMPs within the City of Palm Bay. The evaluated pollution control devices include a precast concrete Stormceptor Unit, a hanging inlet filter called the Ultra-Urban Filter, and a catch basin insert marketed by the name of Hydro-Kleen Filtration System. Construction and installation of the three units was completed during July 2005. An evaluation of the performance efficiency of the baffle box structure was performed by Environmental Research & Design, Inc. (ERD) from September 2005-February 2006.

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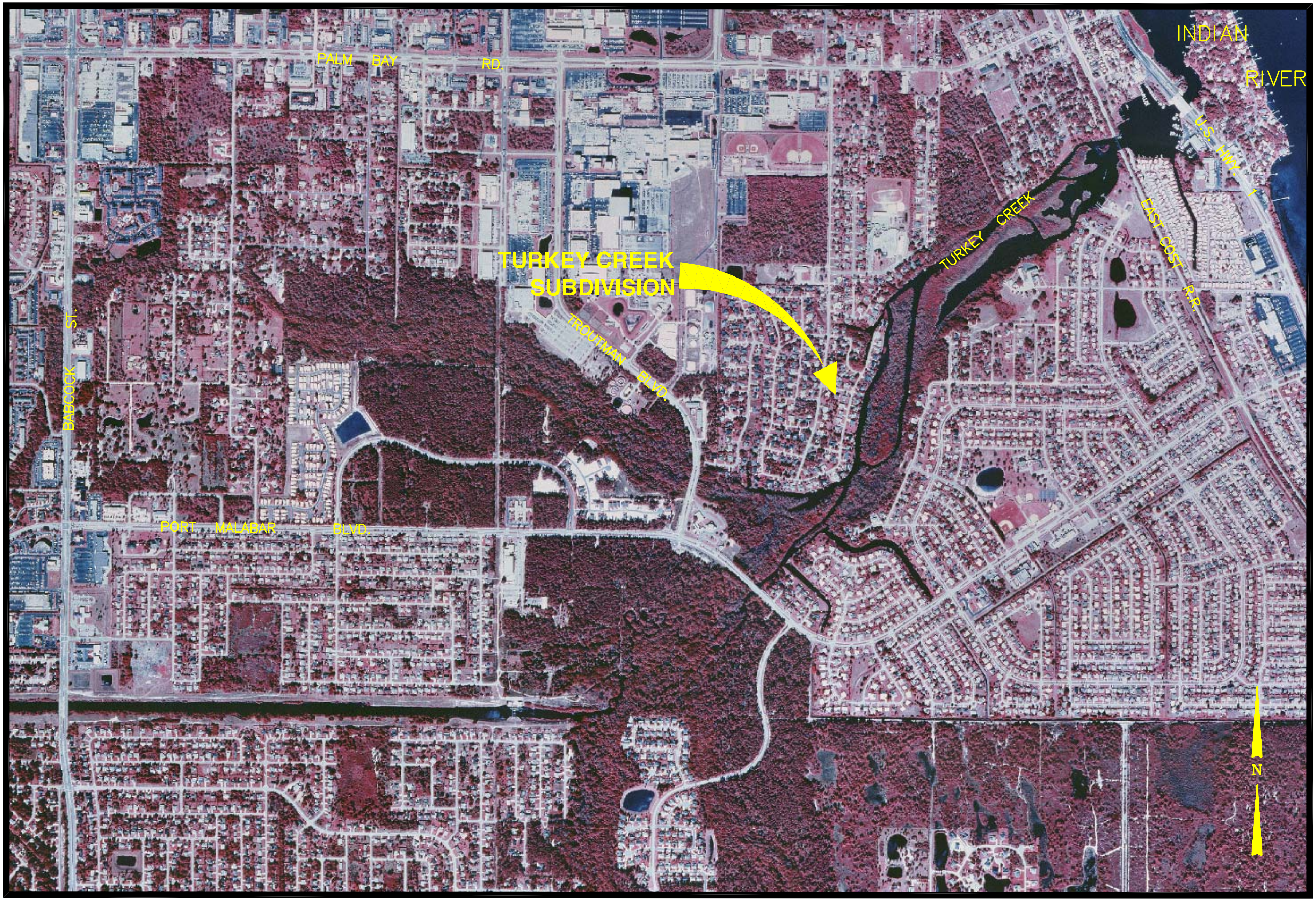


Figure 1-1. Location Map for Turkey Creek and the Turkey Creek Subdivision.

Continuous monitoring of discharges from baseflow and stormwater runoff into the Stormceptor Unit was conducted by ERD from September 2005-February 2006. However, due to the unusual logistics and difficult sampling conditions involved with the Hydro-Kleen and Ultra-Urban Filter Systems, performance evaluations for these units were conducted at the ERD office using a constructed flume system which allowed precise quantification of the hydrologic and mass inputs and losses for each system. Twelve separate pilot tests were conducted on each unit which included an evaluation of hydraulic performance and quantification of separate performance efficiencies for nutrients as well as suspended solids. Extensive particle size distributions were also conducted to quantify the particle sizes captured by each of the three units.

The analyses and conclusions expressed in this report are based upon field monitoring, pilot testing, and laboratory analyses performed by ERD from September 2005-February 2006. Field monitoring was initiated during September 2005, and data were collected to estimate the percent reductions in loadings of total nitrogen, total phosphorus and suspended solids achieved by each of the three pollution control devices. The contract between ERD and the City of Palm Bay specified a three-month field monitoring period, although field monitoring activities were performed by ERD over a period of approximately six months.

This report has been divided into three separate sections for presentation and analysis of the field and laboratory activities. Section 1 contains an introduction to the report and provides a summary of the work efforts performed by ERD. Section 2 contains a discussion of the characteristics of each of the evaluated pollution control devices and anticipated removal processes. Section 3 contains a description of the field monitoring and laboratory analyses conducted by ERD. A discussion of the results of the field and laboratory activities is given in Section 4.

SECTION 2

CHARACTERISTICS OF THE EVALUATED POLLUTION CONTROL DEVICES

A discussion of the physical characteristics and anticipated pollutant removal mechanisms for each of the evaluated pollution control devices is given in the following sections. This information was derived exclusively from the respective manufacturer's representations for each device. Photographs and schematic drawings for each of the pollution control devices are also based upon the manufacturer's data.

2.1 Stormceptor Unit

Stormceptor is a patented oil/sediment separator unit which is manufactured by the Stormceptor Company, located in Toronto, Canada. The design for the Stormceptor Unit installed within the Turkey Creek Subdivision was provided to the City of Palm Bay by Stormceptor based upon site-specific information provided by the City of Palm Bay. A schematic of the Stormceptor Unit designed for the Turkey Creek Subdivision outfall project is given in Figure 2-1. The unit is designated as Model STC 450i with a 335-gallon (45 ft^3) sump capacity and an oil capacity of 85 gallons.

Water enters the unit through the inlet pipe which consists of a 24-inch RCP for this particular installation. The water initially falls onto a sloped containment area where the water then enters the sump area of the Stormceptor Unit after passing through a semi-conical shaped trash guard with approximately 0.5-inch vertical slots. Larger materials in the flow are trapped and settle onto the bottom of the sump. Water discharges from the sump through an outlet riser pipe which extracts water from the sump below the normal water level. This causes floating oils and greases which have entered the sump to be excluded from the outlet pipe. The water

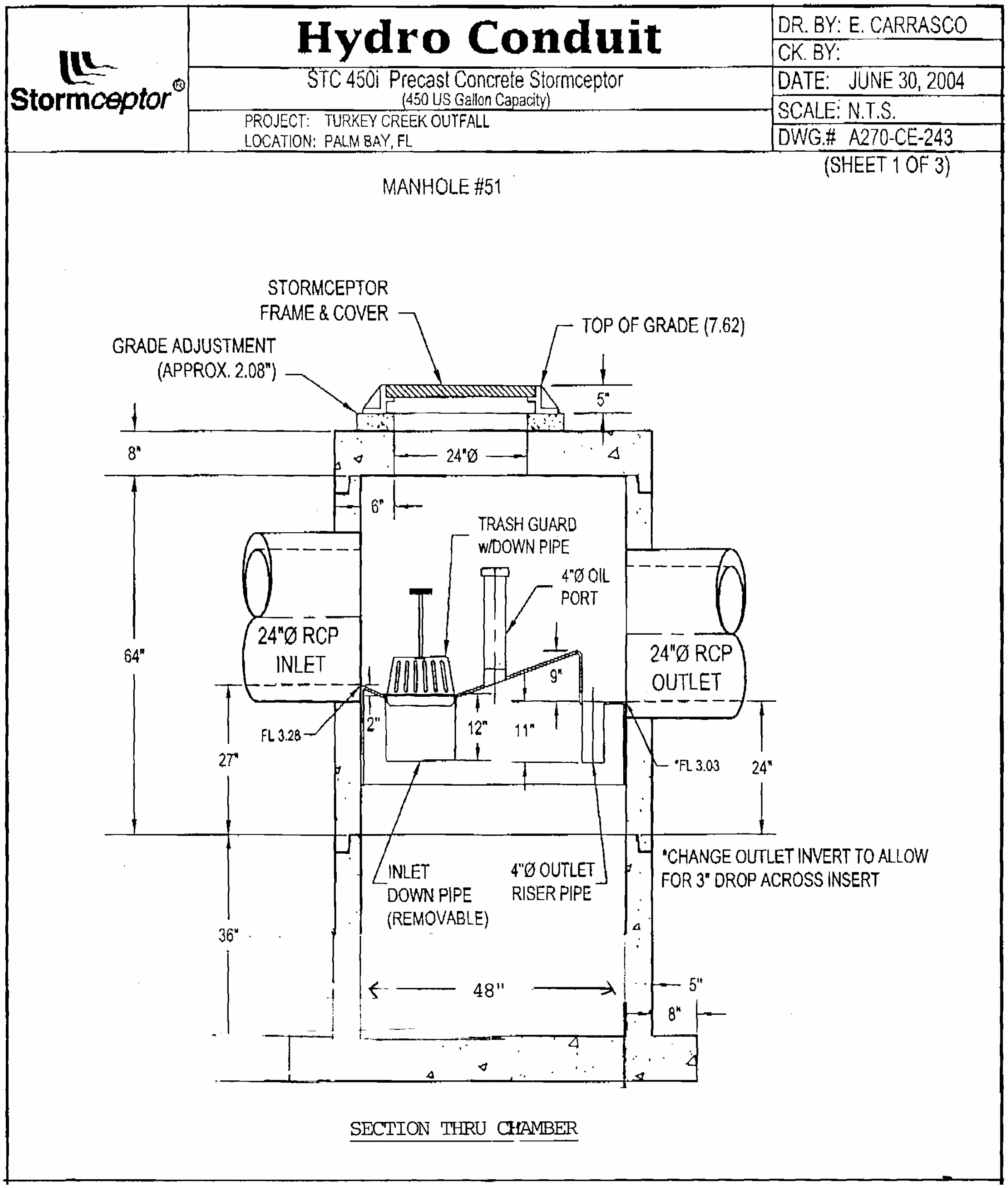


Figure 2-1. Schematic of the Turkey Creek Subdivision Stormceptor Unit.

discharging through the outlet riser pipe then enters the 24-inch RCP discharge from the structure and ultimately enters Turkey Creek. A minimum difference of 1 inch is required between the inlet and outlet pipe elevations to operate the separator unit. If the design includes multiple pipe inlets, a 3-inch difference between the inlet pipe inverts and outlet pipe invert is required. If the trash guard becomes clogged, the water level can rise and discharge over the sloped containment area directly into the outlet pipe.

Maintenance of the Stormceptor Unit occurs through the top-mounted manhole cover. After this cover is removed, the trash guard and down pipe are removed, allowing access into the lower sump area by a vacuum truck hose connection. The accumulated solids are then removed from the unit, and the trash guard and down pipe are then replaced. A photograph of the Stormceptor Unit beneath the manhole cover is shown in Figure 2-2. Additional information and technical details on Stormceptor Units is included in Appendix A.

Figure 2-2. Photograph of the Stormceptor Unit Beneath the Manhole Cover.

According to information currently on the Stormceptor website, the Stormceptor Unit is designed to remove "oil and sediments from stormwater runoff and effectively reduce nonpoint source pollution from reaching receiving waters downstream". The sample technical specifications provided by Stormceptor indicate that the unit is capable of removing 50-80% of the total suspended sediment load and 60-95% of the floatable free oil. The specifications further state that the separator is capable of trapping silt and clay sized particles in addition to larger particles.

2.2 Ultra-Urban Filter

The Ultra-Urban Filter is a curb inlet insert manufactured by AbTech Industries in Scottsdale, Arizona. A schematic of the Ultra-Urban Filter System designed for the City of Palm Bay by AbTech Industries is given in Figure 2-3.

The Ultra-Urban Filter is a plasticized corrugated container which contains a layer of absorbent media material which is placed across the bottom and sides of the unit. Stormwater runoff entering through the curb inlet flows into a series of filter boxes which are designed to span the opening of the curb inlet. Areas of the curb inlet which do not directly discharge into the filter units are diverted into the units using a flow collector system, similar to the one indicated on Figure 2-3. The system designed for the City of Palm Bay application contained three separate filter units.

According to the manufacturer, the absorbent material used within the Ultra-Urban Filter has been given the trademarked name of "Smart Sponge" which was developed by AbTech Industries. AbTech Industries states that "the Ultra-Urban Filter absorbs oil and grease and captures trash and sediment from stormwater runoff before it enters the storm drain system". The unit is designed so that trash and sediment collect in the upper basket chamber, while oil and grease are absorbed in the filtration media. The filtration units utilized by the City of Palm Bay are designated as Model CO1414H which are designated as "half size" filter units. These units have a depth of 13 inches compared with depth of 22.5 inches for the normal size units. According to design specifications provided by AbTech Industries, the acceptance flow rate for

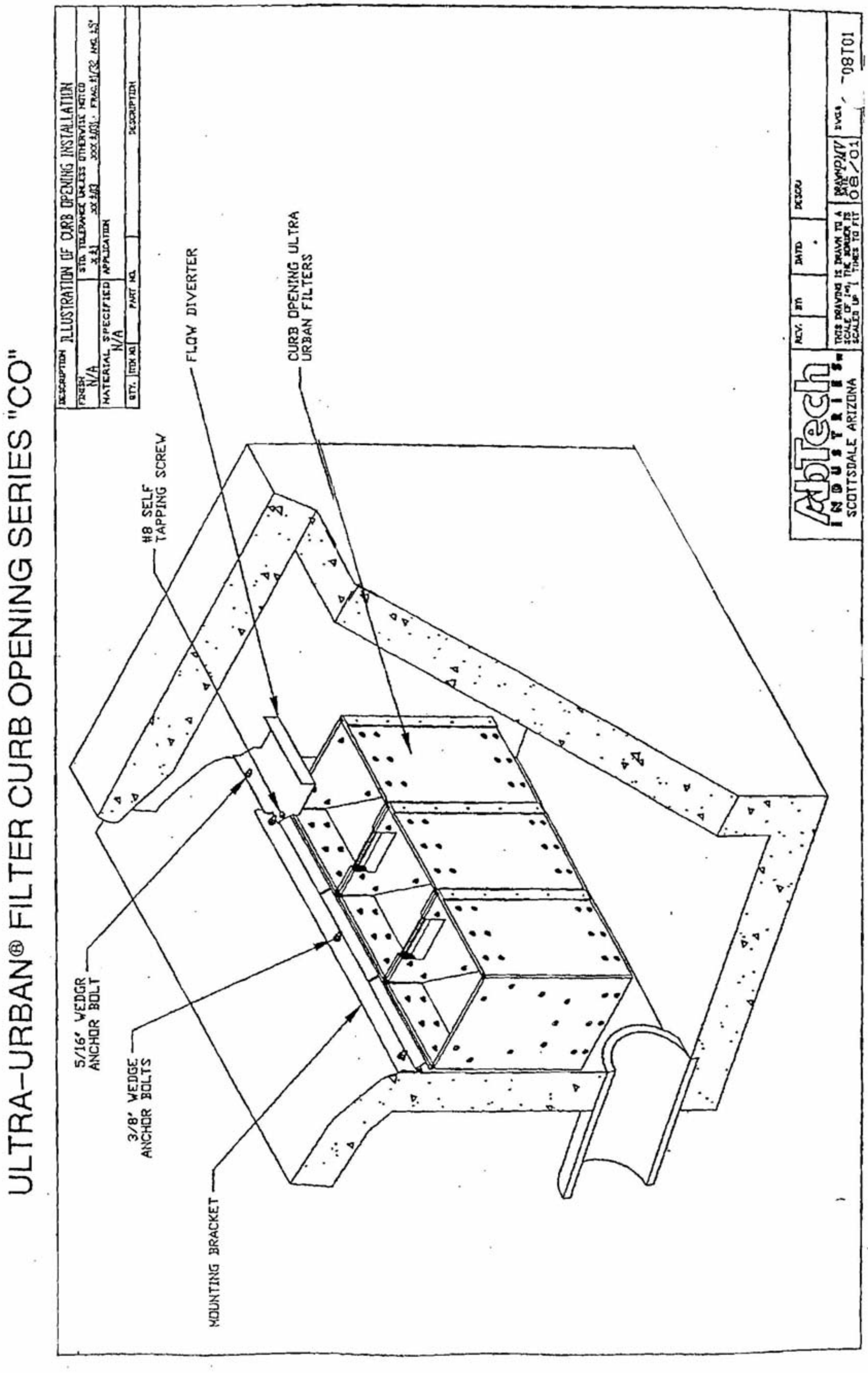


Figure 2-3. Schematic of the Turkey Creek Subdivision Ultra-Urban Filter Unit.

the unit exceeds 170 gallons per minute, with a trash and debris capacity of 0.8 ft^3. Stormwater which enters the filter unit flows downward by gravity through the Smart Sponge material and discharges through a wire mesh material on the bottom of the filter unit. The filtered stormwater then enters the stormsewer conveyance system for transport to the ultimate receiving waterbody.

A photograph of an Ultra-Urban Filter Unit from the City of Palm Bay installation is given in Figure 2-4. This filter is one of the three units which were initially installed at the Ultra-Urban Filter sites. A photograph of the filter units installed within the curb inlet structure is given in Figure 2-5. The units have been slid apart to show the stormsewer line which discharges through the curb inlet structure. Under normal operating conditions, the units are joined together by a stainless steel clip which prevents the incoming stormwater flow from passing between the individual units. Additional product information for the Ultra-Urban Filter Systems is included in Appendix B.

Figure 2-4. Ultra-Urban Filter Unit from the City of Palm Bay Installation.

Figure 2-5. Ultra-Urban Filters Installed in Curb Inlet Structure.

2.3 Hydro-Kleen Filtration System

The Hydro-Kleen Stormwater Filtration System is a patented multi-media filtration design which combines a pre-settling sedimentation compartment with filtration through media packets designed for specific pollutant removal. The Hydro-Kleen Filtration System is manufactured by Hydro Compliance Management, Inc. in Ann Arbor, Michigan. Schematics of a typical Hydro-Kleen Filtration System and a completed installation are given in Figures 2-6 and 2-7, respectively.

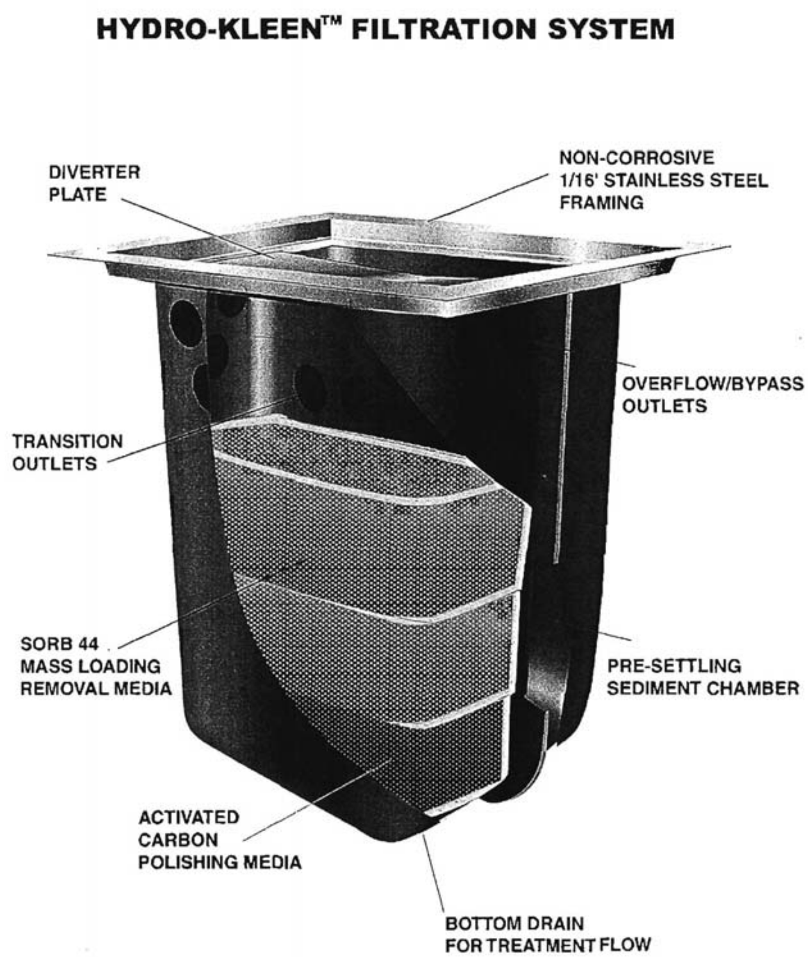
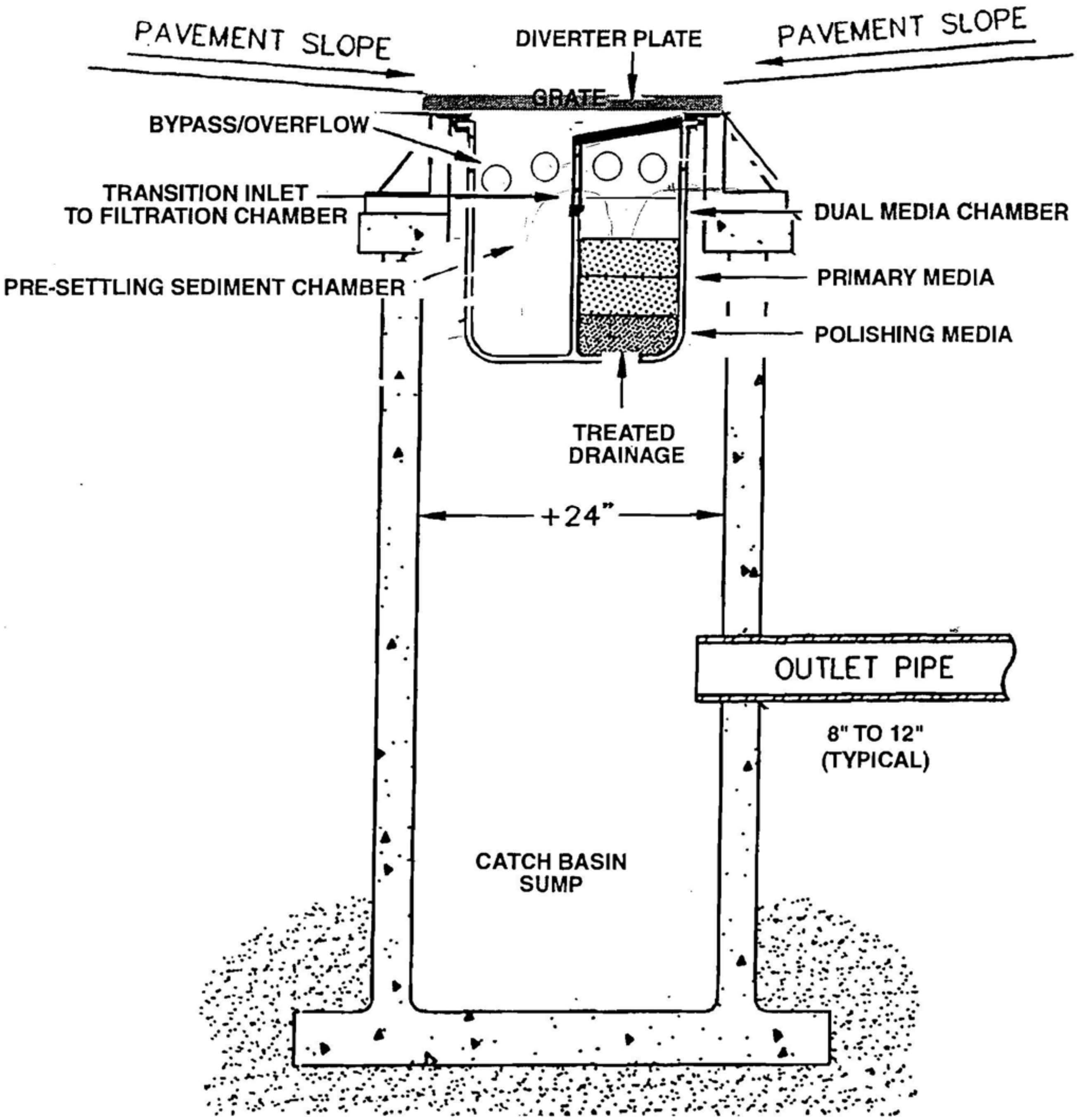


Figure 2-6. Schematic of the Hydro-Kleen Filtration System.

The Hydro-Kleen Filtration System installed by the City of Palm Bay contains three individual filtration packets. Two of the media packets contain material identified as “Sorb-44” which is designed to trap hydrocarbons through adsorption to a hydrophobic cellulose material. The third filtration packet is a special blend of activated carbon (AC-10) which is designed to remove any remaining hydrocarbons as well as a variety of other organic compounds, metals, and other contaminants from the runoff. After passing through these media packets, the water discharges through the bottom of the unit and enters the outfall stormsewer system. According to Hydro Compliance Management, Inc., the Hydro-Kleen Filtration Unit is designed to handle 40-50 gallons per minute through the media chamber. Maintenance of the unit is accomplished by vacuuming sediment loadings from the sedimentation chamber and replacing the filters at an interval of approximately 4-6 months depending on the application.

HYDRO-KLEEN™ FILTRATION SYSTEM
SPECIFICATION



1. UNIT SHIPPED READY TO INSTALL WITH ONE EXTRA SET OF REPLACEMENT MEDIA.
2. UNIT DOES NOT INCLUDE CATCH BASIN OR GRATE FRAME.
3. PRINT SHOULD DESIGINATE HYDRO-KLEEN FILTRATION SYSTEM (HKFS) NEXT TO DESIGNATED CATCH BASIN.

Figure 2-7. Typical Hydro-Kleen Installation.

Photographs of the Hydro-Kleen installation at the Turkey Creek Subdivision are given in Figure 2-8. Figure 2-8a shows the completed Hydro-Kleen unit inside the inlet box. Stormwater enters the unit through the concrete channel at the bottom of the picture. A photograph of the Hydro-Kleen unit with the top grate removed is given in Figure 2-8b. Water initially discharges into the sedimentation chamber, located in the foreground of the picture, before discharging through the filtration media. A photograph of the Hydro-Kleen unit with the media cover removed is given in Figure 2-8c indicating the stacked media cartridges. A photograph of the Hydro-Kleen chamber with the filter packets removed is given in Figure 2-8d. Additional product information and literature on the Hydro-Kleen Filtration System is given in Appendix C.

a. Hydro-Kleen Unit Inside Inlet Box

b. Hydro-Kleen Unit with Grate Removed

Figure 2-8. Photos of the Hydro-Kleen Installation at the Turkey Creek Subdivision.

c. Hydro-Kleen Unit with Media Cover Removed

d. Hydro-Kleen Chamber with Filter Packets Removed

Figure 2-8. Photos of the Hydro-Kleen Installation at the Turkey Creek Subdivision (continued).

SECTION 3

FIELD AND LABORATORY ACTIVITIES

Field and laboratory investigations were conducted from September 2005-February 2006 to evaluate the effectiveness of the three pollution control devices installed in the Turkey Creek Subdivision. Performance efficiency monitoring for the Stormceptor Unit was conducted in the field at the site of the Stormceptor Unit. This monitoring included a continuous record of inflows and outflows from the Stormceptor Unit, as well as collection of flow-weighted composite inflow and outflow samples. Performance efficiency monitoring for the Hydro-Kleen and Ultra-Urban filter units was performed in a series of pilot tests conducted at the ERD office and laboratory. Specific details of monitoring efforts performed for each of the individual pollution control units are given in the following sections.

3.1 Field Instrumentation, Monitoring, and Pilot Testing

3.1.1 Stormceptor Testing

The Stormceptor Unit was constructed by the City of Palm Bay in a single-family residential area within the Turkey Creek Subdivision adjacent to Turkey Creek. The location of the Stormceptor Unit, along with a delineation of the contributing watershed, is indicated on Figure 3-1. The watershed boundary was determined by ERD based on field reconnaissance and observations of flow patterns during rain events. The watershed discharging to the unit covers an area of approximately 5.92 acres.

A schematic of the monitoring locations used to evaluate the performance efficiency of the Stormceptor Unit is given in Figure 3-2. Instrumentation was installed to provide continuous measurements of discharges through the Stormceptor Unit, under both storm event and baseflow conditions, as well as to collect flow-weighted samples from the inflow and outflow to the unit under a wide range of flow conditions. The sampling equipment was installed by ERD during August 2005. Formal monitoring was initiated on September 1, 2005 and continued for a period of 170 days until February 17, 2006.

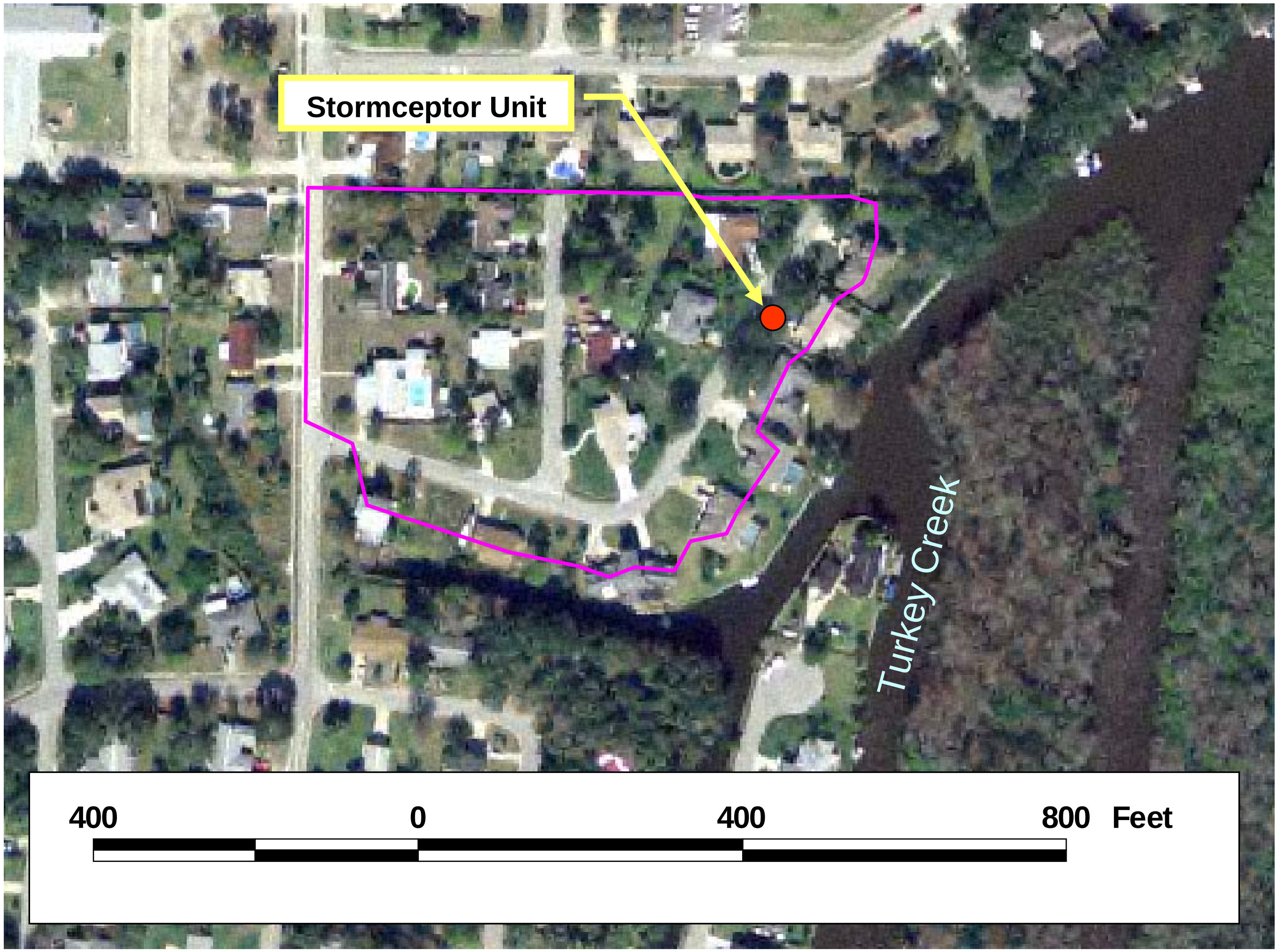


Figure 3-1. Contributing Watershed for the Stormceptor Unit (Basin 1).

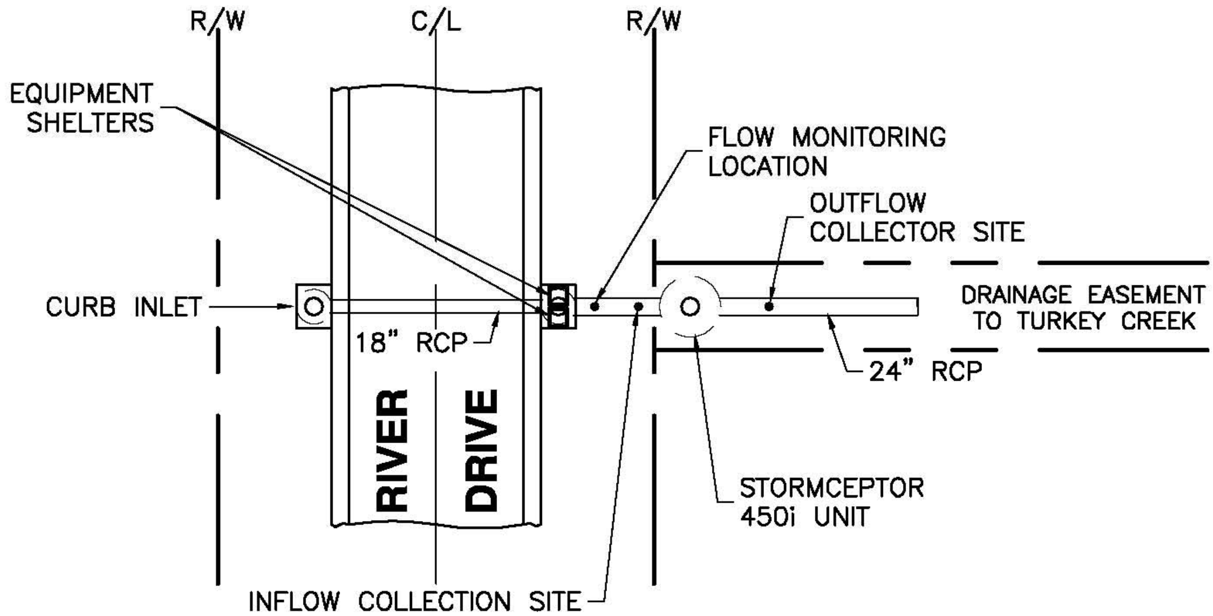
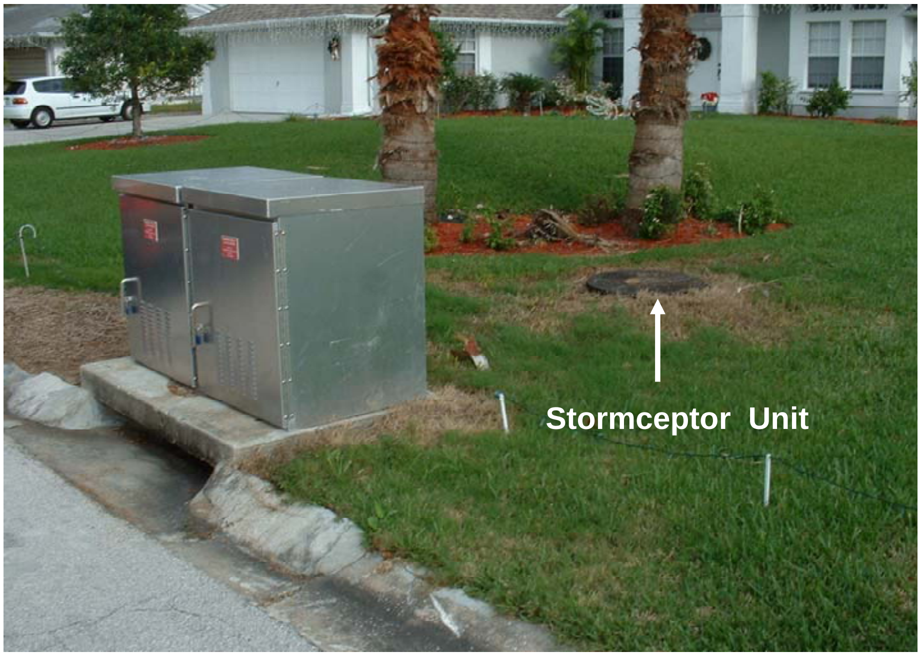


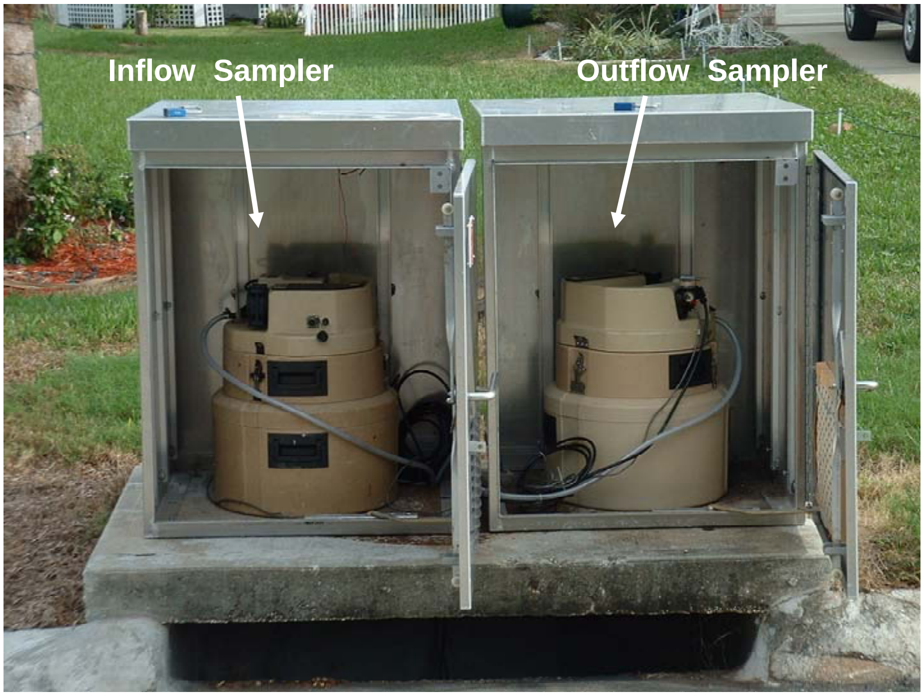
Figure 3-2. Schematic of the Stormceptor Monitoring Locations.

Continuous monitoring of discharges into the Stormceptor Unit and collection of pre-treatment inflow samples was conducted in the 24-inch RCP which extended between the curb inlet manhole and the Stormceptor Unit east of River Drive. Inflow into the Stormceptor Unit included storm drains on each side of River Drive which collect drainage from a 5.92-acre watershed area. Monitoring of outflow from the Stormceptor Unit was conducted in the 24-inch RCP which extended from the Stormceptor Unit into Turkey Creek.

An automatic sequential stormwater sampler with integral flow meter, manufactured by Sigma (Model No. 900 MAX), was installed adjacent to the Stormceptor Unit to provide a continuous hydrograph record of inflow into the unit and to collect flow-weighted composite samples of inflow during baseflow and storm event conditions. The automatic sampler was housed inside an insulated aluminum shelter installed near the edge of River Drive. Sensor cables and sample tubing were extended from the sampler into the 24-inch RCP to the point of sample collection. The integral flow meter was programmed to provide a continuous record of hydraulic inputs into the Stormceptor Unit, with measurements stored into internal memory at 10-minute intervals. Photographs of the Stormceptor monitoring equipment are given in Figure 3-3.



a. Inflow and Outflow Equipment Shelters



b. Inflow and Outflow Autosamplers

Figure 3-3. Monitoring Equipment for the Stormceptor Unit.

A second automatic sequential stormwater sampler, manufactured by Sigma (Model No. 900 MAX), was also installed at the site to collect samples of the outflow from the Stormceptor Unit. The outflow automatic sampler was housed inside a second insulated aluminum shelter which was installed near the edge of River Drive. Sample tubing was extended from the sampler into the 24-inch RCP discharging from the Stormceptor Unit. The outflow autosampler was electronically connected to the inflow collector so that outflow samples were collected simultaneously with inflow samples at the site.

Each of the two automatic stormwater samplers contained a single 5-gallon polyethylene bottle. The inflow sampler was programmed to collect inflow samples in a flow-weighted mode, without flow samples collected simultaneously with the inflow samples. Since 120 VAC power was not available at the site, the automatic collectors were operated on gel cell batteries which were replaced on a weekly basis. A total of 15 separate flow-weighted composite samples of inflow and 15 composite outflow samples was collected at the inflow site during the monitoring program (30 samples total). All collected composite samples were analyzed in the ERD Laboratory for total nitrogen, total phosphorus, total suspended solids (TSS), and turbidity.

Flow measurements were performed at the monitoring site using a pressure transducer sensor which transforms sensitive measurements of water depth into a flow rate using the Manning Equation and pipe geometry. A pressure transducer depth probe was inserted into the 24-inch RCP immediately upstream from the Stormceptor Unit which performed continuous measurements of water depth. The depth measurements were converted into a cross-sectional area based upon the geometry of the pipe and the velocity of flow was calculated using the Manning Equation. Discharge was then calculated by the flow meter using the Continuity Equation ($Q = A \times V$) in cubic feet per second (cfs).

Rainfall at the site was monitored using a continuous rainfall recorder attached to a 4-inch x 4-inch wooden post adjacent to the baffle box which was monitored by ERD in a previous project. The rainfall recorder (Texas Electronics Model 1014-C) produced a continuous record of all rainfall which occurred at the site This record is used to provide information on general rainfall characteristics in the vicinity of the Stormceptor Unit during the monitoring program and to assist in evaluation of hydrologic inputs from the watershed area. However, due to equipment malfunction, continuous monitoring of rainfall was not initiated until September 22, 2005. Rainfall information for earlier parts of September were obtained from records maintained by the sewage treatment plant located immediately west of the Turkey Creek Subdivision.

As indicated on Figure 2-1, the Stormceptor Unit contains a lower sump area which is designed to collect accumulated solids and debris. At the initiation of the field monitoring by ERD, the Stormceptor Unit had been in service for several months and had already accumulated solid material within the sump area. The initial solids contained within the sump area were removed by ERD on August 30, 2005 using a 3-inch centrifugal pump. The solids material was pumped into a 300-gallon polyethylene tank and taken to an off-site location for disposal. Field monitoring of inflow and outflow from the Stormceptor Unit was then initiated on September 1, 2005 and continued until February 17, 2006. Photographs of sump pump-out activities for the Stormceptor Unit are given in Figure 3-4.

At the completion of the monitoring program, the accumulated solids were again removed by ERD field personnel on February 17, 2006 and returned to the ERD Laboratory in a 300-gallon polyethylene tank. The accumulated solids were transferred into 50-gallon polyethylene barrels (Figure 3-5), allowed to settle for approximately one week, and the water layer was carefully decanted. The remaining solids were then dried, weighed, and submitted for laboratory analysis of total nitrogen, total phosphorus, total solids, and particle size distribution. In addition, total nitrogen and total phosphorus content was also measured on each of the collected particle fractions from the unit.

Figure 3-4. Sump Pump-Out Activities for the Stormceptor Unit.

Figure 3-5. Stormceptor Sump Solids Transferred to 50-Gallon Barrels for Drying.

3.1.2 Ultra-Urban and Hydro-Kleen Filter Testing

Approximate locations for the Hydro-Kleen and Ultra-Urban Filter Units installed by the City of Palm Bay are indicated on Figure 3-6. These units are located approximately three blocks south of the Stormceptor unit location, illustrated on Figure 3-1. Similar to the Stormceptor Units, the Hydro-Kleen and Ultra-Urban Filter Units are installed in an area of single-family homes within the Turkey Creek Subdivision area. The contributing watershed for the Hydro-Kleen Filter Unit is approximately 3.65 acres, while the watershed area for the Ultra-Urban Filter Unit covers approximately 6.93 acres.

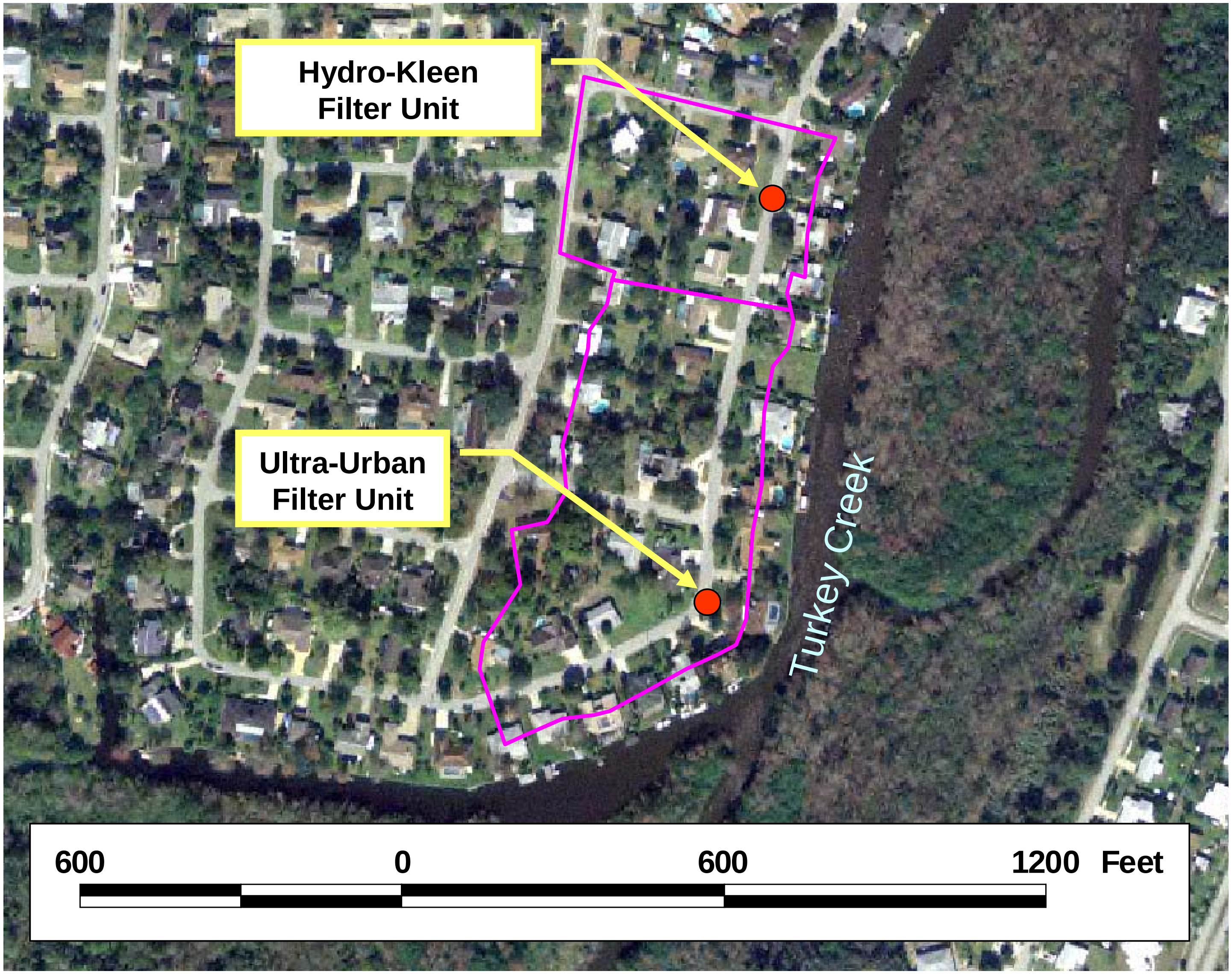


Figure 3-6. Contributing Watershed for the Hydro-Kleen (Basin 2) and Ultra-Urban (Basin 3) Filter Units.

The initial intention of this performance efficiency evaluation was to perform field monitoring for each of the two units over a continuous period of approximately three months. However, after consideration of the hydrologic and hydraulic characteristics of the watershed and stormsewer system, along with the physical characteristics for each of the two filter units, it was determined that field monitoring of the two units was not feasible for several reasons. First, the Hydro-Kleen and Ultra-Urban Filter Units are designed to remove suspended sediments, soils, leaves, and other vegetation. However, traditional autosamplers often perform poorly at collection of representative samples for suspended sediments and soils in stormwater runoff, and the strainer unit and corresponding size of the intake tubing for the autosampler excludes virtually all leaves and other vegetation from the collected sample. As a result, autosamplers often provide a poor representation of stormwater which contains sediments and vegetated matter.

Second, both the Hydro-Kleen and Ultra-Urban Filter Units were connected to inlet structures which have cross connections to other inlets. Even if a representative sample of the inflow into each unit could be collected, the outflow from the catch basin reflected a combination of discharge through the respective filter units and untreated flows from the connecting stormsewer lines. This situation substantially complicated the ability to collect representative samples of the treated water discharging from each of the filter units. Consideration was given to constructing troughs under each of the filter units which would collect only runoff which had flowed through the filter unit. However, the manhole structures at each of the two locations were very shallow, and even a relatively small accumulation of stormwater within the system would create submerged conditions within the trough.

Finally, inflow into each of the two filter units occurs through a Miami-type curb and gutter system. Collection of inflow samples from this system would require placement of flow monitoring equipment and collection tubing within the gutter which would subject it to damage by vehicular traffic. In addition, the water level within the curb and gutter system during smaller storm events may not be sufficient to register as a measurable water level by the flow monitoring equipment. In general, a minimum water level of several inches is required to accurately register flow conditions. Construction of a weir within the curb and gutter system may have been necessary to increase the water level sufficiently to register on the flow probe. However, construction of the weir would create a settling area for suspended solids which would alter the monitoring of the inflow characteristics into the unit.

In view of these significant obstacles for efficient field monitoring at the two sites, it was decided to perform pilot testing for each of the two units at the ERD office in Orlando. A new Ultra-Urban Filter Unit was provided to ERD by the City of Palm Bay for use in this testing. The containment structure for the Hydro-Kleen Filter Unit was removed from its housing inside the manhole structure and returned to the ERD office. Three new Hydro-Kleen filter inserts were provided by the City of Palm Bay for use in pilot testing. Therefore, pilot testing with each of the two units was conducted with entirely new media and cleaned containment structures.

A photograph of the pilot testing apparatus for the Hydro-Kleen and Ultra-Urban Filters is given in Figure 3-7. The apparatus consisted of a 500-gallon polyethylene storage tank which was placed on top of an elevated platform. The tank was filled with water from Lake Conway which is located adjacent to the pilot test site.

Figure 3-7. Pilot Testing Apparatus for the Hydro-Kleen and Ultra-Urban Filters.

Particulate matter for testing purposes was obtained from a single-family residential watershed adjacent to the ERD office. This watershed area is similar to the Turkey Creek Subdivision in terms of unit densities and hydrologic characteristics. A photograph of the residential area adjacent to the ERD office is given in Figure 3-8. Representative samples of sediments, soils, vegetation, and other debris were collected from the watershed area on three separate occasions by vacuuming portions of the curb and gutter and roadway system using a shop vac. The vacuuming process was continued until approximately 5 gallons of solid material was collected for us in testing purposes. A photograph of the solids collection activities is given in Figure 3-9.

The collected material was dried, weighed, and subjected to a grain size distribution analysis using a combination of standard sieves and nylon filters to trap smaller particle sizes. Details of this process are provided in a subsequent section. Each of the collected particle fractions was analyzed for total nitrogen, total phosphorus, total suspended solids, and volatile suspended solids. After evaluation of grain size characteristics, the separated samples were then combined back together into a composite sample for testing purposes.

A total of 12 separate pilot tests were conducted for the Hydro-Kleen and Ultra-Urban Filter Units. To begin each test, the initial hydraulic capacity of the filter unit was evaluated by adding water from the 500-gallon storage tank into the filter unit until the rate of water inflow caused the water to begin flowing over the top of the unit. A photograph of hydraulic performance testing for the Ultra-Urban Filter is given in Figure 3-10. This process was repeated prior to the initiation of each of the 12 pilot tests performed for each filter. The rate at which water could be introduced into each of the two filters without overflowing is defined as the initial hydraulic capacity of the filter unit.

Figure 3-8. Residential Area Adjacent to ERD Office.

Figure 3-9. Solids Collection Activities.

Figure 3-10. Hydraulic Performance Testing Using the Ultra-Urban Filter.

After the initial hydraulic performance testing, the water flow rate was reduced to approximately half of the initial hydraulic inflow rate, and approximately 400-800 g (1-2 lbs) of the collected composite solids was slowly sprinkled into the flowing water stream within the plastic trough which conveyed the water from the storage tank to the test filter apparatus. This process simulated the transport of solids and vegetation through the curb and gutter system during an actual storm event. Addition of the solids into the flowing water stream occurred at a slow rate such that the overall time required for addition of the solids was approximately 15-30 minutes. The exact volume of water which passed through the filter unit was recorded for each test. Photographs of pilot testing using the Ultra-Urban and Hydro-Kleen Filters are given in Figure 3-11.

a. Ultra-Urban Filter

b. Hydro-Kleen Filter

Figure 3-11. Pilot Testing with the Ultra-Urban Filter.

During each testing procedure, outflow samples from each of the two filter units were collected on a continuous basis. These outfall samples were designed to evaluate migration of nutrients and suspended solids through the filter media, as well as evaluate potential leaching of previously collected materials during subsequent testing conditions. The collected samples from the bottom of the filter units were combined into a large plastic carboy until completion of each experiment. The water within the carboy was then well mixed and a sub-sample was collected for laboratory analysis and particle size evaluation. A photograph of the collection of outflow samples from the Ultra-Urban Filter System is given in Figure 3-12.

Figure 3-12. Collection of Outflow Samples for the Ultra-Urban Filter.

3.2 Laboratory Testing

3.2.1 Evaluation of Grain Size Distribution for Collected Solids

Standard laboratory sieve analyses were conducted on the solids collected from the sump area within the CDS unit, as well as the solids collected for use in the pilot testing for the Hydro-Kleen and Ultra-Urban Filter Units. Sieve analyses were conducted using standard sieve sizes of 10, 20, 40, 60, 80, 100, 120, 200, and the bottom pan. Each of the collected particle fractions was weighed to reflect the representative fraction of the overall sample, and a sub-sample of each fraction was analyzed for total nitrogen, total phosphorus, and organic content.

Bulk water samples of baseflow and stormwater runoff from the Stormceptor site, as well as inflow and outflow samples from the pilot tests, were analyzed to evaluate the physical and chemical characteristics of particles entrained in water. The bulk water samples were generated by combining equal volumes of all stormwater samples and equal volumes of all baseflow samples generated during each full month of the monitoring program. Each of the monthly composite baseflow samples (4 total) and stormwater samples (4 total) were then evaluated in the ERD Laboratory for particle size distribution.

Bulk water samples of the inflow and outflow collected during the pilot testing for the Hydro-Kleen and Ultra-Urban Filter Systems were also analyzed for particle size distribution. Each of the lake water inflow samples used in the pilot testing was evaluated for particle size distribution. However, the 500-gallon storage tank was sufficient for several separate pilot tests, and a single particle size distribution analysis was sufficient for each test used with a single water source. Individual particle size analyses were performed for each of the 24 outfall samples collected during testing of the Hydro-Kleen (12 samples) and Ultra-Urban (12 samples) filters.

Suspended sediment particles were separated from the baseflow and stormwater samples using a series of nylon net filters manufactured by Millipore. A sequential series of filtrations was performed using the net filters with pore sizes of 180 µm, 140 µm, 100 µm, 60 µm, 30 µm, and 11 µm. A 32-liter water sub-sample of the composite baseflow and stormwater samples was used for the separation.

Filtration of the sample was performed using a standard 47 mm glass filter holder mounted on top of a 12-liter polycarbonate carboy. Four carboys were used for the test. When one became filled with the filtrate, it was replaced with a rinsed empty carboy. The filtration was performed with very low or no applied vacuum to avoid embedding the particles into the filters. When the flow rate through the filters became too slow, the filter was removed and placed in a 250-ml polycarbonate bottle and labeled with the filter pore size. For larger pore sizes, only one or two filters were necessary to filter the entire sample. However, for the smaller pore sizes, more filters were needed. A 10-liter sample, sub-sampled from the 32-liter water sample, was filtered through the 11 μm filter to reduce the number of total filters needed. The filtrate from the 11 μm filter was filtered through a 1 μm glass fiber TCLP filter and then through a 1 μm glass fiber suspended solids filter.

The filters were segregated by pore size and placed in 250-ml polycarbonate bottles labeled with the appropriate pore size. Deionized water (50 ml) was added to each bottle and shaken for fifteen minutes on a shaker table to resuspend the sediment particles from the filters. The resuspended particulate solution was then analyzed for total nitrogen, total phosphorus, total suspended solids, and volatile suspended solids.

3.2.2 <u>Laboratory Analyses</u>

A summary of laboratory methods and MDLs for analyses conducted on water samples collected during this project is given in Table 3-1. All laboratory analyses were conducted in the ERD Laboratory. Details on field operations, laboratory procedures, and quality assurance methodologies are provided in the FDEP-approved Comprehensive Quality Assurance Plan No. 870322G for Environmental Research & Design, Inc. In addition, a Quality Assurance Project Plan (QAPP), outlining the specific field and laboratory procedures to be conducted for this project, was submitted and approved by SJRWMD prior to initiation of any field and laboratory activities. A summary of laboratory methods and MDLs for analyses conducted on sediment samples collected during this project is given in Table 3-2.

TABLE 3-1

ANALYTICAL METHODS AND DETECTION LIMITS FOR LABORATORY ANALYSES

PARAMETER	METHOD OF ANALYSIS	METHOD DETECTION LIMITS (MDLs)[1]
Total Nitrogen	Alkaline Persulfate Digestion[2]	0.001 mg/l
Total Phosphorus	Alkaline Persulfate Digestion[2]	0.001 mg/l
TSS	EPA-83, Sec. 160.2[3]	0.7 mg/l
Turbidity	EPA-83, Sec. 180.1[3]	0.1 NTU
VSS	EPA-83, Sec. 160.4[3]	1.0 mg/l

1. MDLs are calculated based on the EPA method of determining detection limits
2. FDEP-approved alternate method
3. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised March 1983.

TABLE 3-2

SUMMARY OF LABORATORY METHODS AND DETECTION LIMITS FOR SEDIMENT ANALYSES

PARAMETER	METHOD OF ANALYSIS	METHOD DETECTION LIMITS
Moisture Content	EPA/CE-81-1[1]; p. 3-54, p. 3-58	0.1%
Organic Content	EPA/CE-81-1; pp. 3-59 and 3-60	0.1%
Total P	EPA-83[2], Sec. 365.4	0.005 mg/kg
Total N	EPA/CE-81-1; p. 3-205	0.010 mg/kg
Particle Size	EPA/CE-81-1; pp. 3-33 to 3-47	1%

1. Procedures for Handling and Chemical Analysis of Sediments and Water Samples, EPA/Corps of Engineers, EPA/CE-81-1, 1981.
2. Methods for Chemical Analysis of Water and Wastes, EPA/4-79-020, Revised March 1983.

SECTION 4
RESULTS

Field monitoring, sample collection, pilot testing, and laboratory analyses were conducted by ERD from September 2005-February 2006 to evaluate the hydraulic and pollutant removal efficiencies of Stormceptor, Hydro-Kleen, and Ultra-Urban filter units installed in the Turkey Creek Subdivision in the City of Palm Bay. A discussion of the results of these efforts is given in the following sections.

4.1 Stormceptor Unit

4.1.1 Site Hydrology

4.1.1.1 Rainfall Characteristics

A continuous record of rainfall characteristics was collected at the baffle box site from September 1, 2005-February 17, 2006 using a tipping-bucket rainfall collector with a resolution of 0.01 inch and a digital data logging recorder. However, due to equipment malfunction, the digital rainfall record from September 1-21 was lost. Therefore, supplemental rainfall records for this period were obtained from the City of Palm Bay Sewage Treatment Plant (STP) located immediately west of the Turkey Creek Subdivision. The rainfall records collected at the STP site are daily totals only.

The characteristics of individual rain events measured in the vicinity of the Stormceptor site from September 1, 2005-February 17, 2006 are given in Table 4-1. Rainfall data from September 1-21 is based on records collected at the Palm Bay STP site, while the remainder of the rainfall record was collected by the rain gauge at the baffle box site. Information on total rainfall, event start time, event end time, event duration, average rainfall intensity, and antecedent dry period are included in Table 4-1 for each individual rain event measured at the baffle box site. Average rainfall intensity is calculated as the total rainfall divided by the total event duration. Since the data collected at the STP represent daily totals, details of individual rainfall event characteristics are not available for the period from September 1-21, 2005.

TABLE 4-1

SUMMARY OF RAINFALL MEASURED IN THE VICINITY OF THE STORMCEPTOR SITE FROM SEPTEMBER 1, 2005 – FEBRUARY 17, 2006

EVENT START		EVENT END		TOTAL RAINFALL (inches)	DURATION (hours)	ANTECEDENT DRY PERIOD (days)	AVERAGE INTENSITY (inches/hour)
DATE	TIME	DATE	TIME				
9/1/05	-----	9/1/05	-----	0.11	-----	-----	-----
9/2/05	-----	9/2/05	-----	1.04	-----	1.0	-----
9/4/05	-----	9/4/05	-----	0.21	-----	2.0	-----
9/5/05	-----	9/5/05	-----	0.54	-----	1.0	-----
9/6/05	-----	9/6/05	-----	0.94	-----	1.0	-----
9/7/05	-----	9/7/05	-----	0.30	-----	1.0	-----
9/8/05	-----	9/8/05	-----	0.44	-----	1.0	-----
9/20/05	-----	9/20/05	-----	0.15	-----	12.0	-----
9/21/05	-----	9/21/05	-----	3.01	-----	1.0	-----
9/27/05	14:36	9/27/05	14:46	0.02	0.16	6.6	0.12
9/28/05	18:26	9/28/05	20:32	0.66	2.11	1.2	0.31
10/3/05	5:03	10/3/05	6:57	0.05	1.90	4.4	0.03
10/3/05	16:54	10/3/05	19:32	0.09	2.64	0.4	0.03
10/4/05	1:11	10/4/05	9:15	0.49	8.07	0.2	0.06
10/4/05	16:21	10/4/05	18:08	0.07	1.78	0.3	0.04
10/4/05	21:16	10/4/05	21:28	0.03	0.19	0.1	0.15
10/5/05	1:13	10/5/05	7:39	0.26	6.44	0.2	0.04
10/5/05	20:53	10/5/05	22:04	0.36	1.18	0.6	0.30
10/6/05	15:05	10/6/05	22:22	0.43	7.28	0.7	0.06
10/24/05	11:11	10/24/05	13:51	2.19	2.67	17.5	0.82
11/1/05	18:51	11/2/05	2:34	0.73	7.71	8.2	0.09
11/14/05	10:03	11/14/05	10:03	0.01	---	12.3	---
11/15/05	4:18	11/15/05	4:18	0.01	---	0.8	---
11/15/05	20:11	11/15/05	21:32	0.15	1.35	0.7	0.11
11/16/05	1:18	11/16/05	1:20	0.02	0.03	0.2	0.70
11/16/05	4:41	11/16/05	4:41	0.02	0.00	0.1	72.00
11/22/05	10:58	11/22/05	11:00	0.02	0.03	6.3	0.64
11/28/05	15:05	11/28/05	19:51	0.30	4.77	6.2	0.06
12/8/05	0:37	12/8/05	16:08	2.33	15.50	9.2	0.15
12/17/05	8:32	12/17/05	11:20	0.14	2.80	8.7	0.05
12/18/05	9:20	12/18/05	9:20	0.01	---	0.9	---
12/19/05	7:31	12/19/05	7:33	0.02	0.05	0.9	0.43
12/29/05	7:11	12/29/05	7:31	0.02	0.32	10.0	0.06
1/18/06	3:33	1/18/06	5:40	0.31	2.12	19.8	0.15
1/20/06	11:40	1/20/06	11:40	0.01	---	2.3	---
1/30/06	5:42	1/30/06	5:57	0.15	0.27	9.8	0.57
2/3/06	11:54	2/4/06	11:24	1.58	23.51	4.2	0.07
2/11/06	21:06	2/12/06	2:02	0.49	4.93	7.4	0.10
			TOTAL:	**17.71**			

A total of 17.71 inches of rainfall fell in the vicinity of the Stormceptor Unit over the 170-day monitoring period from a total of 38 separate storm events. A summary of rainfall characteristics measured at the baffle box rain gauge site from September 22, 2005-February 17, 2006 is given in Table 4-2. Individual rainfall amounts measured at the baffle box site range from 0.01-2.33 inches, with an average of 0.47 inches/event. Durations for events measured at the site range from 0.01-23.5 hours, with antecedent dry periods ranging from 0.1-19.8 days.

TABLE 4-2

SUMMARY OF RAINFALL CHARACTERISTICS IN THE VICINITY OF THE STORMCEPTOR SITE FROM SEPTEMBER 2005-FEBRUARY 2006[1]

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	MEAN EVENT VALUE
Event Rainfall	inches	0.01	2.33	0.47
Event Duration	hours	0.01	23.5	3.91
Average Intensity	inches/hour	0.03	72.0	3.09
Antecedent Dry Period	days	0.1	19.8	4.32

1. Based on data collected at the baffle box rain gauge site only

A comparison of measured and typical "average" rainfall in the vicinity of the Stormceptor Unit is given in Figure 4-1. Measured rainfall presented in this figure is based upon the field-measured rain events at the STP and baffle box monitoring sites presented in Table 4-1, summarized on a monthly basis. "Average" rainfall conditions are based upon historical monthly rainfall averages recorded at the Melbourne Meteorological Station over the 60-year period from 1942-2001. This site appears to be the closest long-term meteorological station for the Stormceptor monitoring site. Comparisons between measured and average rainfall are provided only for the months of September 2005-January 2006 since measurements performed at the baffle box site during February 2006 represent only a partial month. Total measured rainfall during the months of September 2005-January 2006 is 17.71 inches.

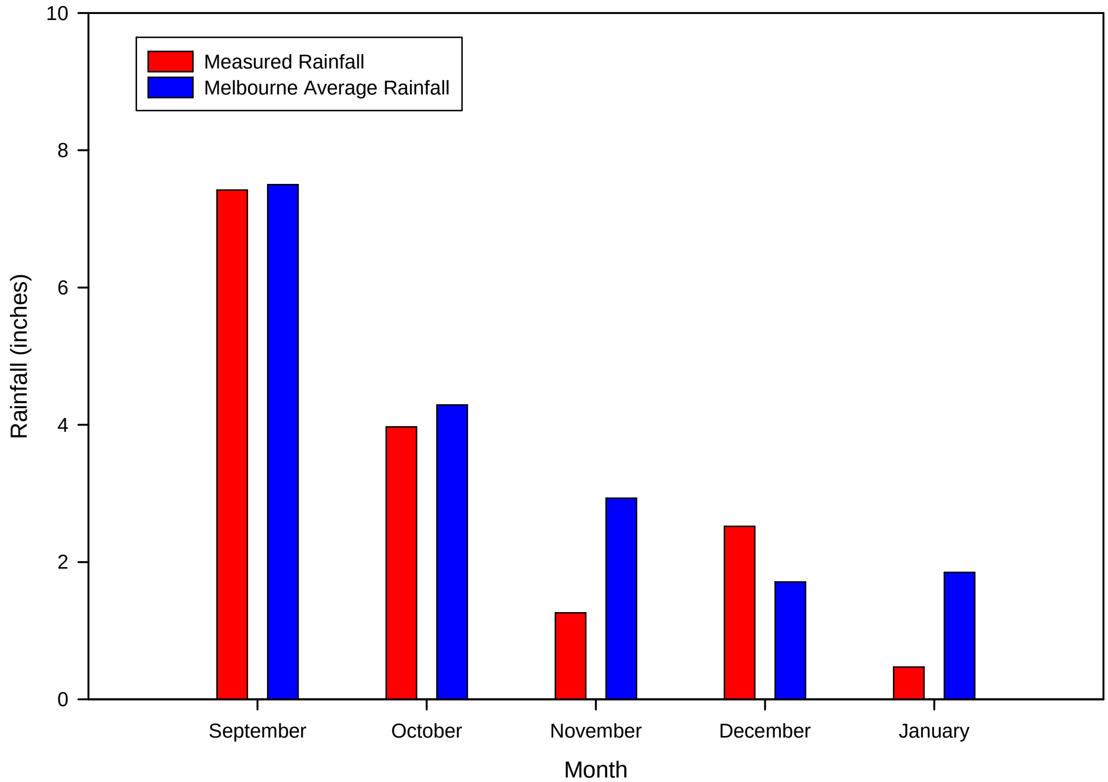


Figure 4-1. Comparison of Average and Measured Rainfall in the Vicinity of the Palm Bay Stormceptor Site.

As seen in Figure 4-1, measured rainfall in the vicinity of the Stormceptor site was greater than “normal” during only one of the five complete months included in the monitoring program. Measured rainfall during September and October was slightly less than “normal”, while rainfall during November and January was much less than “normal”. Overall, the measured rainfall of 17.71 inches from September 2005-January 2006 is approximately 3% less than the “average” rainfall of 18.28 inches which typically occurs during the period from September-January in the Palm Bay area.

4.1.1.2 <u>Hydrologic Inputs</u>

Continuous hydrographs were recorded at the inflow to the Stormceptor Unit at 10-minute intervals from September 1, 2005-February 17, 2006. The hydrographs provided information on inflow rates into the unit as well as total daily volume and cumulative total volume for the period of record.

Inflow hydrographs measured in the 24-inch RCP inflow into the Stormceptor Unit are summarized in Figure 4-2. A summary of total daily rainfall, based upon the information provided in Table 4-1, is also included for comparison purposes. In general, inflow hydrographs into each of the Stormceptor Units appear to correspond with rainfall events for much of the hydrograph record summarized in Figure 4-2. However, significant inflow hydrographs were recorded at the Stormceptor site during most of October 2005 during a time when little rainfall was observed at the site. In addition, a relatively high hydrograph peak was observed during mid-December from a rainfall event of only 0.14 inches. Similarly, a hydrograph peak was also observed in mid- to late-January which does not correspond to measurable rainfall in the vicinity of the site.

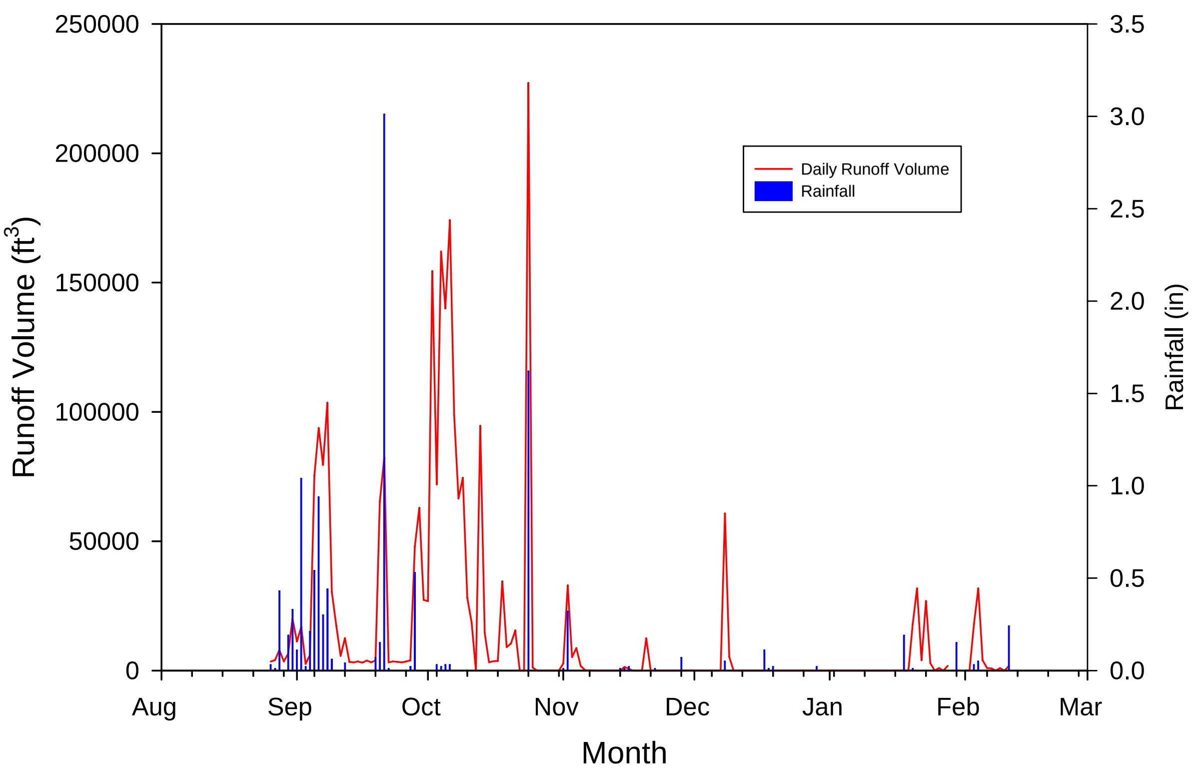


Figure 4-2. Inflow Hydrographs into the Stormceptor Unit from September 2005-February 2006.

The unusual peaks in the inflow hydrographs indicated on Figure 4-2 are flow measurement errors caused by raised water level conditions resulting from a clogged inflow into the Stormceptor Unit. As discussed in Section 2.1, and illustrated on Figure 2-1, the Stormceptor Unit contains a semi-conical shaped trash guard with approximately 0.5-inch vertical slots. A photograph of the Stormceptor trash guard removed from the unit is given in Figure 4-3. All water which enters the Stormceptor Unit must pass through this trash guard. Due to the small size of the openings in the trash guard, the slots were easily clogged with vegetation and grass clippings from the residential area and was observed to be heavily clogged during many of the weekly visits by ERD field personnel even though all vegetation was removed during each visit. Clogged conditions were particularly apparent on field visits which followed significant rain events. In fact, the photograph of the Stormceptor Unit inside the manhole, given in Figure 2-2, shows a clogged trash guard inlet.

Figure 4-3. Stormceptor Trash Guard Device.

When the trash guard becomes clogged, inflow from the stormsewer can no longer enter into the Stormceptor Unit, causing water to back-up through the stormsewer system until the level of the overflow weir for the Stormceptor Unit is reached. All inflow through the stormsewer then bypasses the unit and discharges directly through the downstream stormsewer system. A photograph of water discharging over the top of the Stormceptor Unit as a result of a clogged trash grate is given in Figure 4-4. Visible floating oil and grease within the stormsewer system can be seen bypassing the Stormceptor Unit and entering the outfall pipe discharging to Turkey Creek.

Figure 4-4. Stormsewer Inflow Bypassing the Stormceptor Unit Due to a Clogged Trash Grate.

A low level baseflow was periodically present at the monitoring site due to discharges of water into the gutter from a heat pump system located at a residence northwest of the Stormceptor Unit. Once the trash grate became clogged, the low level baseflow would cause water elevations within the stormsewer to be elevated for extended periods of time. Since the flow probe utilized by ERD measures flow rate as a function of water depth using the Manning Equation, the increases in water elevation within the system caused the flow probe to indicate conditions of relatively high flow within the stormsewer. This phenomenon is directly responsible for the hydrograph peaks observed on Figure 4-2 which do not appear to correlate with significant rain events.

After carefully reviewing the hydrographs provided on Figure 4-2, it was decided that the information is not an accurate representation of the flow volume which reached the Stormceptor Unit during the monitoring program. Therefore, it was decided to use a hydrologic model to estimate the generated runoff volume associated with each of the individual monitored rainfall events summarized in Table 4-1. The results of this modeling exercise would then be used to represent the total runoff volume which reached the Stormceptor Unit during the monitoring program.

The SCS curve number methodology was used to generate estimates of the runoff volumes produced within the drainage sub-basin area for each of the rainfall events listed in Table 4-1. The SCS methodology utilizes the hydrologic characteristics of the drainage basin, including impervious area, directly connected impervious area, and soil curve numbers to estimate runoff volumes for modeled storm events. Hydrologic characteristics of the Stormceptor basin area were determined by ERD based upon aerial photography and a field reconnaissance of the sub-basin area. A summary of these hydrologic characteristics is given in Table 4-3. As indicated previously, the total basin area discharging to the Stormceptor Unit is approximately 5.92 acres. Approximately 2.39 acres of the basin is considered impervious area, with 1.17 acres considered to be directly connected impervious area (DCIA). The SCS curve number for the pervious area within the basin is 57.6.

TABLE 4-3

CHARACTERISTICS OF THE STORMCEPTOR BASIN AREA

PARAMETER	BASIN
Total Area (acres)	5.92
Impervious Area (acres)	2.39
DCIA (acres)	1.17
DCIA (%)	19.8
Pervious CN	57.6
Non-DCIA CN	68.0
S (inches)	4.72

After estimating the hydrologic characteristics of the basin area, the runoff volume for each rainfall event is calculated by adding the rainfall excess from the non-DCIA portion to the rainfall excess created from the DCIA portion for the basin. Rainfall excess from the non-DCIA areas is calculated using the following set of equations:

$$Soil\ \ Storage,\ S\ =\ \left(\frac{1000}{nDCIA\ \ CN}\ -\ 10\right)$$

$$nDCIA\ \ CN\ =\ \frac{[CN\ *\ (100\ -\ IMP)]\ +\ [98\ (IMP\ -\ DCIA)]}{(100\ -\ DCIA)}$$

$$Q_{nDCIA_i}\ =\ \frac{(P_i\ -\ 0.25\ )^2}{(P_i\ +\ 0.85)}$$

where:

CN	=	curve number for pervious area
IMP	=	percent impervious area
DCIA	=	percent directly connected impervious area
nDCIA CN	=	curve number for non-DCIA area
P_i	=	rainfall event
Q_{nDCIAi}	=	rainfall excess for non-DCIA for rainfall event

For the DCIA portion, rainfall excess is calculated using the following equation:

$$Q_{DCIA_i} = (P_i - 0.1)$$

When P_i is less than 0.1, Q_{DCIAi} is equal to zero.

A summary of modeled runoff volumes for rainfall events measured at the Stormceptor site from September 1, 2005-February 17, 2006 is given in Table 4-4 using the methodology outlined previously. During the 170-day monitoring program, approximately 67,799 ft^3 of runoff was generated within the Stormceptor basin area. Based upon the total measured rainfall depth of 17.71 inches during the 170-day monitoring program, a total rainfall volume of 380,581 ft^3 fell within a 5.92-acre watershed area for the Stormceptor Unit. Using the measured runoff volume of 67,799 ft^3, the overall basin runoff coefficient during the monitoring program is approximately 0.178. This value suggests that approximately 17.8% of the rainfall volume becomes stormwater runoff within the Stormceptor basin.

A summary of monthly runoff inputs to the Stormceptor Unit is given in Table 4-5. In general, runoff inputs are proportional to the amount of rainfall which fell within the basin during any given month. Runoff inputs to the Stormceptor Unit range from a high of 30,576 ft^3 during September 2005 to a low of 1104 ft^3 during January 2006. The value listed for February of 7942 ft^3 reflects rainfall measured only through the 17^{th} day of the month.

TABLE 4-4

MODELED RUNOFF VOLUMES FOR RAINFALL EVENTS AT THE STORMCEPTOR SITE FROM SEPTEMBER 1, 2005-FEBRUARY 17, 2006

DATE	RAINFALL DEPTH (inches)	RUNOFF VOLUME (ft^3)
9/1/2005	0.11	3125
9/2/2005	1.04	3992
9/4/2005	0.21	467
9/5/2005	0.54	1869
9/6/2005	0.94	3568
9/7/2005	0.30	849
9/8/2005	0.44	1444
9/20/2005	0.15	212
9/21/2005	3.01	12359
9/27/2005	0.02	0
9/28/2005	0.66	2690
10/3/2005	0.05	0
10/3/2005	0.09	0
10/4/2005	0.49	1656
10/4/2005	0.07	0
10/4/2005	0.03	0
10/5/2005	0.26	680
10/5/2005	0.36	1104
10/6/2005	0.43	2482
10/24/2005	2.19	8876
11/1/2005	0.73	2676
11/14/2005	0.01	0
11/15/2005	0.01	0
11/15/2005	0.15	212
11/16/2005	0.02	0
11/16/2005	0.02	0
11/22/2005	0.02	0
11/28/2005	0.30	849
12/8/2005	2.33	9471
12/17/2005	0.14	170
12/18/2005	0.01	0
12/19/2005	0.02	0
12/29/2005	0.02	0
1/18/2006	0.31	892
1/20/2006	0.01	0
1/30/2006	0.15	212
2/3/2006	1.58	6286
2/11/2006	0.49	1657
Generated Volume (ft^3/yr)		67,799
Weighted Basin "C" Value		0.178

TABLE 4-5

SUMMARY OF MONTHLY RUNOFF INPUTS TO THE STORMCEPTOR UNIT

MONTH	RAINFALL (inches)	RUNOFF VOLUME (ft^3)
September 2005	7.42	30,576
October 2005	3.97	14,798
November 2005	1.26	3,737
December 2005	2.52	9,641
January 2006	0.47	1,104
February 2006	2.07	7,942
TOTAL:	**17.71**	**67,799**

4.1.2 Characteristics of Monitored Inflow and Outflow

The chemical characteristics of inflow and outflow from the Stormceptor Unit were monitored on a continuous basis from September 2005-February 2006. A total of 15 separate flow-weighted inflow and outflow samples (30 samples total) was collected during the monitoring program. Each inflow and outflow sample was collected as a flow-weighted composite between the beginning and ending period for each sample. A complete listing of the chemical characteristics of individual inflow and outflow samples collected during the monitoring program is given in Table 4-6. A discussion of the chemical characteristics of collected inflow and outflow samples is given in the following sections.

TABLE 4-6

SUMMARY OF MONITORED INFLOW AND OUTFLOW AT THE STORMCEPTOR SITE FROM SEPTEMBER 1, 2005 – FEBRUARY 17, 2006

COLLECTION DATES		INFLOW CHARACTERISTICS				OUTFLOW CHARACTERISTICS			
Begin	End	TSS (mg/l)	VSS (mg/l)	Total N (µg/l)	Total P (µg/l)	TSS (mg/l)	VSS (mg/l)	Total N (µg/l)	Total P (µg/l)
9/1/05	9/9/05	30.2	7	1553	456	20.1	11.6	947	205
9/9/05	9/26/05	18.3	12.6	1499	366	12.6	8.4	1312	325
9/26/05	9/29/05	8	4.3	1407	232	6.4	2	3443	321
9/29/05	10/3/05	8.8	4.2	936	181	34.3	30	1457	360
10/3/05	10/14/05	8.4	5.4	597	75	2.2	0.4	676	75
10/14/05	10/20/05	31.2	23.4	1790	310	34.2	28.5	2167	557
10/20/05	10/27/05	30.2	15.6	2070	470	6.8	2.7	2306	548
10/27/05	11/4/05	26.5	23.2	2342	637	22.1	6.2	1239	435
11/4/05	11/11/05	1.3	1	598	95	9.1	3.2	512	64
11/11/05	11/22/05	29.6	13.1	3070	834	29.8	6.2	2959	537
11/22/05	12/16/05	32.1	18.1	2027	652	9.4	6.4	913	378
12/16/05	12/20/05	35.5	20.2	3181	581	32.1	18.5	2880	483
12/20/05	1/25/06	55	37.2	3013	1067	40.3	27.4	4102	1672
1/25/06	2/10/06	83	51.5	2638	997	23.9	17	2576	640
2/10/06	2/17/06	68.2	48.4	2954	812	25.9	16.9	4104	487
AVERAGE		**31.1**	**19.0**	**1978**	**518**	**20.6**	**12.4**	**2106**	**472**
MINIMUM		**1.3**	**1.0**	**597**	**75**	**2.2**	**0.4**	**512**	**64**
MAXIMUM		**83.0**	**51.5**	**3181**	**1067**	**40.3**	**30.0**	**4104**	**1672**

4.1.2.1 Inflow Characteristics

In general, a relatively high degree of variability was observed between minimum and maximum measured values for each of the evaluated inflow parameters. Measured total nitrogen concentrations in the inflow ranged from relatively low (597 µg/l) to moderately elevated (3181 µg/l) in value. However, the overall mean concentration of 1978 µg/l for total nitrogen in runoff is typical of total nitrogen concentrations typically observed in urban runoff from residential areas.

A relatively high degree in variability was also observed for measured concentrations of total phosphorus in the inflow samples, with measured values ranging from 75-1067 μg/l. However, the overall mean total phosphorus concentration of 518 μg/l observed in stormwater runoff is high in value compared with concentrations commonly observed in urban runoff from residential areas.

A significant degree of variability was observed in measured TSS concentrations in the inflow samples, with measured values ranging from 1.3-83 mg/l. However, the overall mean TSS concentration of 31.1 mg/l observed in inflow entering the Stormceptor Unit is relatively low in value compared with concentrations commonly observed in urban runoff. A relatively high degree of variability was also observed in measured concentrations of volatile suspended solids (VSS) in the inflow samples, with measured values ranging from 1.0-51.5 mg/l. However, the overall mean VSS concentration of 19.0 mg/l is relatively low in value compared with concentrations commonly observed in urban runoff. The measured VSS concentrations suggests that approximately 61% of the measured TSS (19.0 divided by 31.1) is organic in composition.

4.1.2.2 Outflow Characteristics

In general, measured concentrations of TSS and VSS in outflow samples appear to have substantially less variability than observed in inflow samples for the two parameters. However, a somewhat higher degree of variability is apparent for measured concentrations of total nitrogen and total phosphorus in the outflow compared with the inflow.

Measured concentrations of TSS in the outflow range from 2.2-40.3 mg/l, with an overall mean of 20.6 mg/l. The mean outflow concentration of 20.6 mg/l is approximately 34% lower than the inflow TSS concentration of 31.1 mg/l.

Measured VSS concentrations in outflow samples collected at the Stormceptor site ranged from 0.4-30.0 mg/l, with an overall mean of 12.4 mg/l. The mean outflow concentration of 12.4 mg/l is approximately 35% lower than the mean inflow VSS concentration of 19.0 mg/l.

Measured concentrations of total nitrogen in outflow samples ranged from 512-4104 μg/l, with an overall mean of 2106 μg/l. The mean outflow concentration for total nitrogen of 2106 μg/l reflects an increase of approximately 6% compared with mean total nitrogen concentrations measured in the inflow samples to the Stormceptor Unit.

Measured concentrations of total phosphorus in outflow samples ranged from 64-1672 μg/l, with an overall mean of 472 μg/l. The mean outflow concentration of 474 μg/l reflects a decrease of approximately 9% from the mean inflow concentration of 518 μg/l during the monitoring program.

4.1.2.3 Comparison of Inflow and Outflow Characteristics

A statistical comparison of inflow and outflow samples for the Stormceptor Unit for total nitrogen, total phosphorus, TSS, and VSS is given in Figure 4-5. A graphical summary of data at each site is presented in the form of Tukey box plots, also often called "box and whisker plots". The bottom line of the box portion of each plot represents the lower quartile, with 25% of the data points lying below this value. The upper line of the box represents the 75% upper quartile, with 25% of the data lying above this value. The horizontal line within the box represents the median value, with 50% of the data lying both above and below this value. The vertical lines, also known as "whiskers", represent the 5 and 95 percentiles for the data sets. Individual values which lie outside of the 5-95 percentile range, sometimes referred to as "outliers", are indicated as red dots.

As discussed previously, the median concentrations for TSS and VSS appear to be lower in the outflow than in the inflow samples. In addition, a lower degree of variability is apparent in outflow samples for both TSS and VSS compared with inflow concentrations.

The median concentration for total phosphorus in the outflow appears to be slightly lower than the median value for the inflow. In addition, the range reflected by the 25% and 75% quartiles is also lower for total phosphorus in the outflow than in the inflow. However, in contrast, the median concentration for total nitrogen appears to be slightly greater in the outflow, and the 25% and 75% quartile values exhibit a larger range in the outflow than in the inflow.

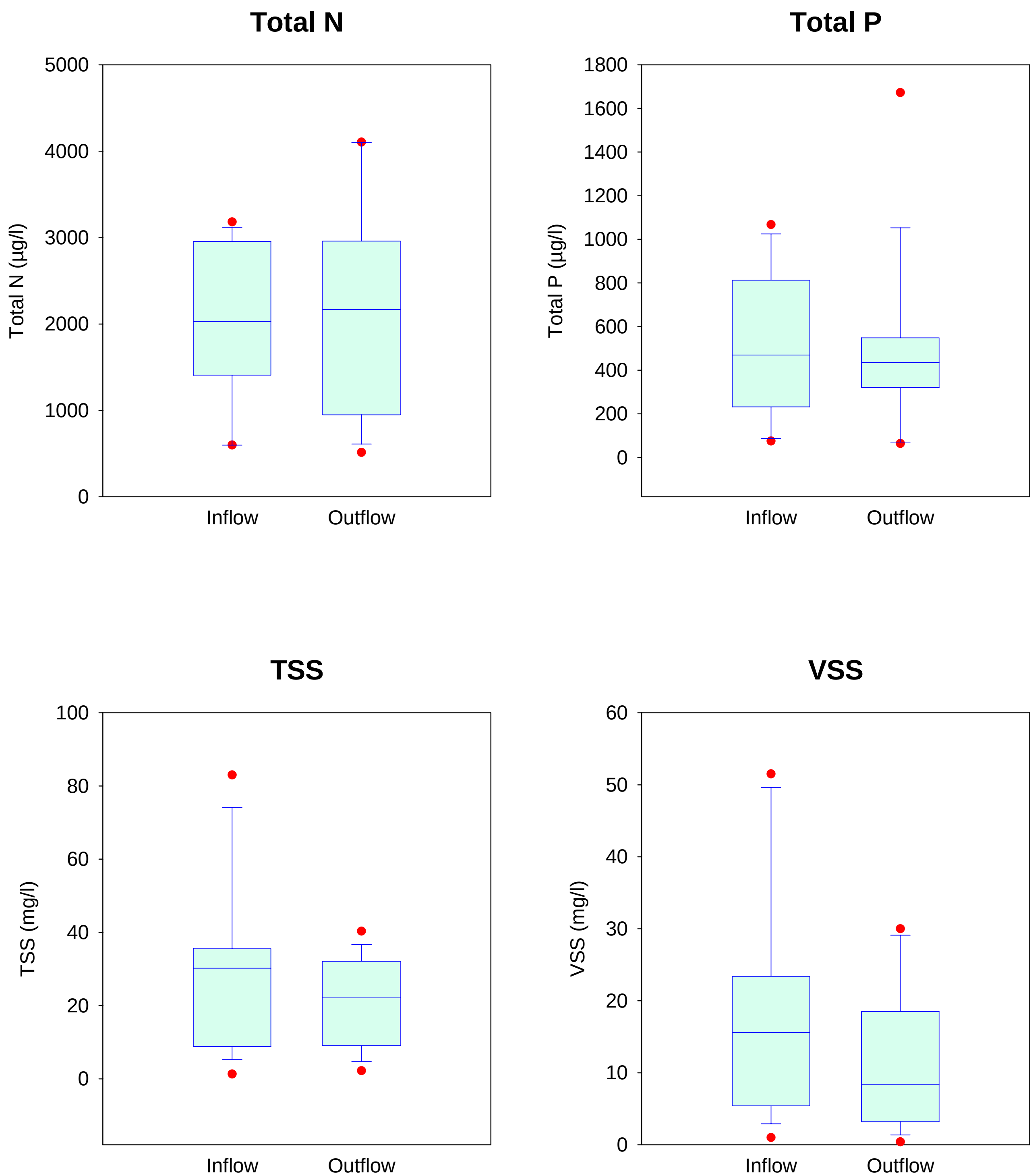


Figure 4-5. Statistical Comparison of Inflow and Outflow Characteristics for the Stormceptor Site.

4.1.2.4 Estimated Mass Removal Efficiency

The overall mass removal efficiency of the Stormceptor Unit was estimated by comparing calculated mass loadings of TSS, VSS, total nitrogen, and total phosphorus in the inflow and outflow to the unit over the 170-day monitoring period. These estimates were performed by multiplying the estimated monthly inflow volumes, summarized in Table 4-5, times the mean monthly chemical characteristics of the inflow and outflow, based upon the information provided in Table 4-6. This procedure resulted in an estimated mass loading for the inflow and outflow at the Stormceptor Unit for each month of the monitoring program.

A summary of estimated mass inflow and outflow at the Stormceptor Unit is given in Table 4-7. The Stormceptor Unit appears to have removed measurable quantities of TSS, VSS, and total phosphorus from the inflow stream. However, an apparent increase in mass loadings of total nitrogen was observed in the monitoring data.

A summary of estimated overall mass removal efficiencies for the Stormceptor Unit from September 1, 2005-February 17, 2006 is given in Table 4-8. The mass removal efficiencies are calculated by comparing the measured inflow and outflow mass for each evaluated parameter. During the 170-day monitoring program, the Stormceptor Unit removed approximately 28% of the incoming TSS and 24% of the incoming mass loading of VSS. However, a net increase of approximately 18% was observed for total nitrogen between the inflow and outflow of the unit. Overall reduction in total phosphorus over the monitoring period is approximately 3%.

The measured mass removal efficiency of 28% for TSS in the Stormceptor Unit is approximately half of the removal efficiency of 50-80% claimed in the Stormceptor Technical Specifications. An argument could be made that the measured performance efficiency of the unit during this study is skewed since some of the inflow bypassed the unit due to clogging of the trash grate. However, the trash grate is part of the Stormceptor Unit installed at the City of Palm Bay site and, therefore, limitations on system performance imposed by this component must be included in the overall performance efficiency of the unit. The trash grate causes virtually all vegetation to be excluded from entering the Stormceptor Unit. Unfortunately, this is exactly the type of contaminant present in residential subdivision areas which has significant pollution potential in receiving waterbodies.

TABLE 4-7

ESTIMATED MASS INFLOW AND OUTFLOW AT THE STORMCEPTOR UNIT FROM SEPTEMBER 1, 2005 – FEBRUARY 17, 2006

Inflow Mass Load (kg)

MONTH	VOLUME	TSS	VSS	TOTAL N	TOTAL P
September	30,576	14.1	6.1	1.17	0.27
October	14,798	10.1	7.1	0.71	0.16
November	3,737	2.2	1.1	0.20	0.06
December	9,641	12.3	7.8	0.84	0.22
January	1,104	2.6	1.6	0.08	0.03
February	7,942	15.3	10.9	0.66	0.18
Mean	**67,799**	**56.6**	**34.6**	**3.67**	**0.92**

Outflow Mass Load (kg)

MONTH	VOLUME	TSS	VSS	TOTAL N	TOTAL P
September	30,576	15.9	11.2	1.55	0.26
October	14,798	6.8	4.0	0.67	0.17
November	3,737	1.7	0.6	0.15	0.03
December	9,641	9.9	6.3	0.95	0.29
January	1,104	0.7	0.5	0.08	0.02
February	7,942	5.8	3.8	0.92	0.11
Mean	**67,799**	**40.8**	**26.3**	**4.32**	**0.89**

TABLE 4-8

ESTIMATED OVERALL MASS REMOVAL EFFICIENCY FOT THE STORMCEPTOR UNIT FROM SEPTEMBER 1, 2005 – FEBRUARY 17, 2006

PARAMETER	TOTAL INFLOW (kg)	TOTAL OUTFLOW (kg)	MASS REMOVAL (%)
TSS	56.6	40.8	28
VSS	34.6	26.3	24
Total N	3.67	4.32	-18
Total P	0.92	0.89	3

The Stormceptor Unit installed in the City of Palm Bay appears to be best suited for removal of sediments and oils and greases and not the stormwater stream typical of residential areas. It is virtually certain that the unit would have performed much more effectively if the trash grate device had been removed and all inflow had been allowed to enter into the sump area of the Stormceptor Unit. The existing Stormceptor configuration with the trash grate will only perform effectively in areas, such as parking lots, which have no vegetation or trash components that can clog the strainer device. ERD recommends strongly that the City of Palm Bay permanently remove the trash grate device from the Stormceptor Unit to enhance the overall performance of the system.

4.1.2.5 <u>Particle Fractionation of Inflow and Outflow Samples</u>

Each of the composite samples of inflow and outflow to the Stormceptor Unit was subjected to particle fractionation procedures to evaluate the physical and chemical characteristics of particles entrained in the inflow and outflow samples. This analysis is intended to evaluate changes in particle characteristics during migration through the Stormceptor Unit and to identify the range of particle fractions which can be successfully captured by the unit. A complete listing of the results of the individual fractionation studies on the inflow and outflow samples is given in Appendix D.

A statistical comparison of TSS particle distribution in the inflow and outflow to the Stormceptor Unit is given in Figure 4-6 in the form of box and whisker plots. Substantial reductions in both mean concentrations and variability in measured values is apparent between the inflow and outflow for particles greater than (>) 180 microns (μm), 140-180 μm, 100-140 μm, and 60-100 μm. However, at particle sizes less than (<) 60 μm, differences in characteristics between inflow and outflow samples become less apparent, with virtually no difference in the particle size distribution between inflow and outflow for particles in the range of 11-30 μm and <11 μm. It appears that the lower limit of particles which can be successfully removed by the Stormceptor Unit is approximately 60 μm.

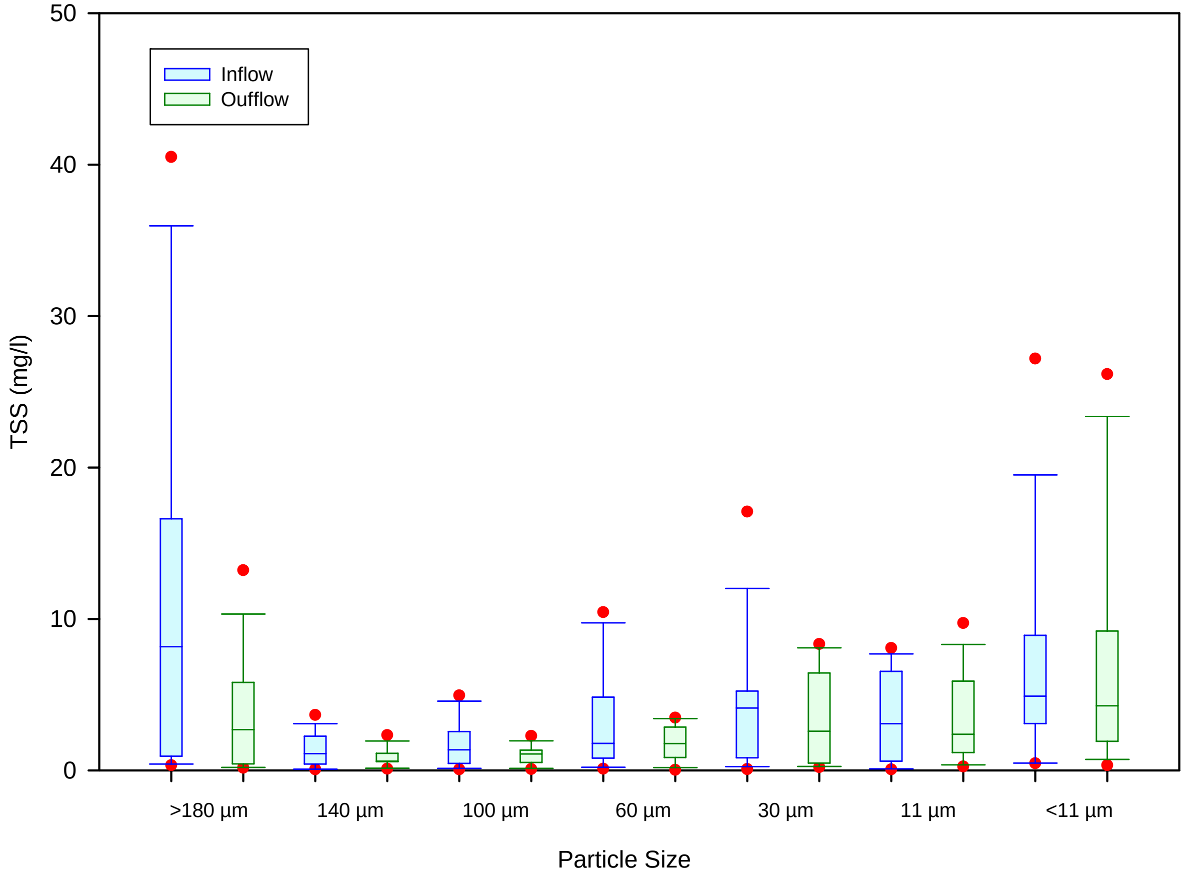


Figure 4-6. Statistical Comparison of TSS Particle Distribution in the Inflow and Outflow to the Stormceptor Unit.

A statistical comparison of VSS particle distribution in the inflow and outflow to the Stormceptor Unit is given in Figure 4-7. The distribution for VSS particles in the inflow and outflow appears to be very similar to that observed for TSS. Substantial differences in inflow and outflow VSS concentrations are apparent, both in terms of mean concentration and variability of measured concentrations, for particles as low as 60 µm. However, below 60 µm, differences between inflow and outflow samples become substantially less, particularly for particles in the 11-30 µm range and <11 µm.

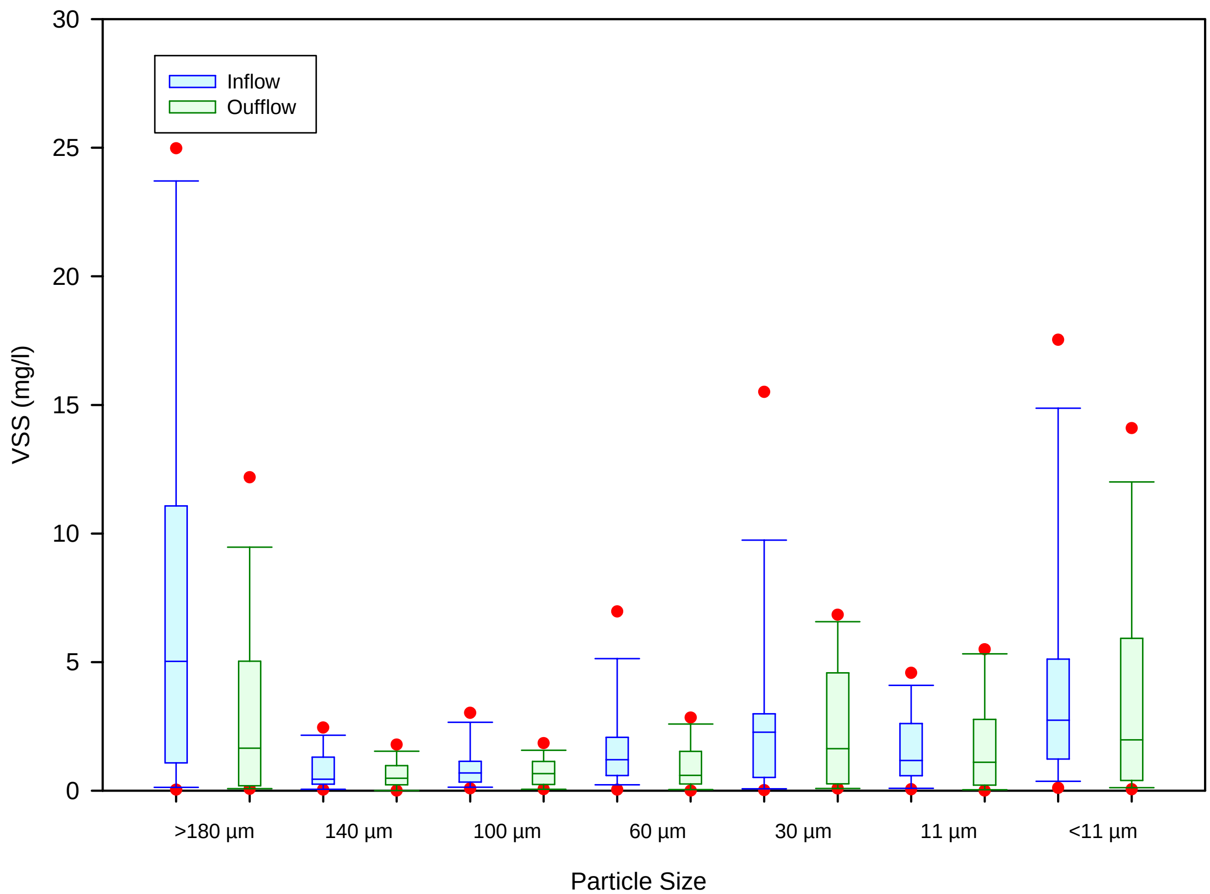


Figure 4-7. Statistical Comparison of VSS Particle Distribution in the Inflow and Outflow to the Stormceptor Unit.

A statistical comparison of total nitrogen particle distribution in the inflow and outflow to the Stormceptor Unit is given in Figure 4-8. Total nitrogen particles >180 µm in size appear to be lower in both concentration and variability in the outflow than measured in the inflow. However, no significant difference is apparent between inflow and outflow particulate nitrogen for any of the remaining particle fractions. In fact, outflow particles <11 µm in size appear to be greater in concentration as well as higher in variability than measured in inflow samples for total nitrogen.

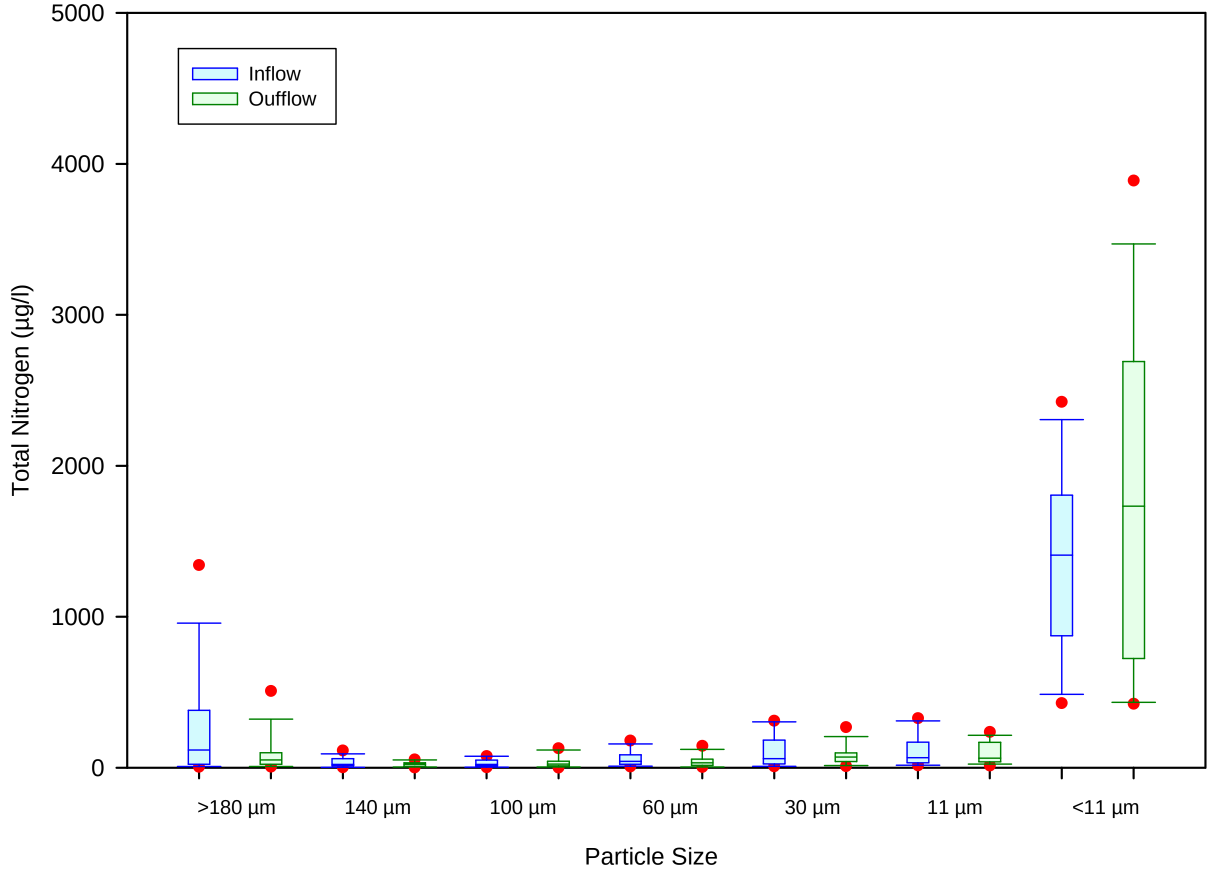


Figure 4-8. Statistical Comparison of Total Nitrogen Particle Distribution in the Inflow and Outflow to the Stormceptor Unit.

A statistical comparison of total phosphorus particle distribution in the inflow and outflow to the Stormceptor Unit is given in Figure 4-9. Phosphorus concentrations in particles >180 µm appear to be lower in mean value as well as lower in variability in the outflow compared with the inflow. However, no significant difference is apparent in particle phosphorus fractionation for inflow and outflow samples at smaller particle sizes. In fact, a higher level of variability is apparent for outflow phosphorus particles <11 µm compared with inflow samples.

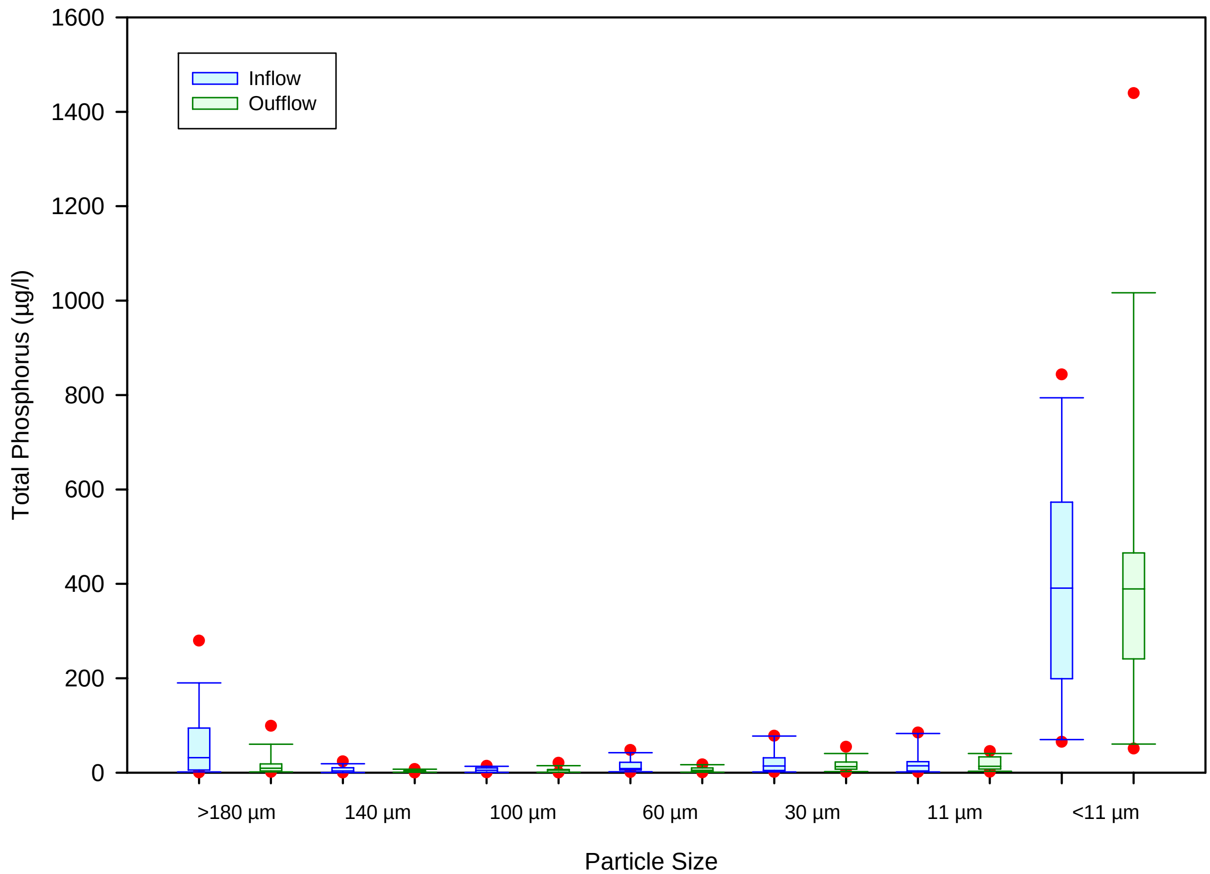


Figure 4-9. Statistical Comparison of Total Phosphorus Particle Distribution in the Inflow and Outflow to the Stormceptor Unit.

4.1.2.6 <u>Characteristics of Collected Solids</u>

As discussed previously, accumulated solids from the sump of the Stormceptor Unit were removed on February 17, 2006. The accumulated solids reflect the total solids removed by the unit over the 170-day monitoring period. The solids were returned to the ERD Laboratory where they were dried, weighed, and analyzed for organic content, total nitrogen, total phosphorus, and particle size distribution. A photograph of semi-dry solids collected from the Stormceptor sump is given in Figure 4-10. The solids had a strong septic odor which remained even after drying.

Figure 4-10. Sample of Solids Removed from Stormceptor Sump.

A summary of general characteristics of the solids collected from the Stormceptor Unit sump is given in Table 4-9. A total of 15.704 kg of dry solids was removed from the unit.

TABLE 4-9

GENERAL CHARACTERISTICS OF SOLIDS COLLECTED FROM THE STORMCEPTOR SUMP

PARAMETER	VALUE
Total Dry Weight	15.704 kg
Total N	21,926 µg Total N/g solids 2.2% Total N by weight 0.344 kg Total N total
Total P	6,149 µg Total P/g solids 0.6% Total P by weight 0.097 kg Total P total

Grain size analyses were also conducted on the solids removed from the Stormceptor sump. The complete listing of grain size measurements for the collected solids is given in Appendix E. A summary of the grain size distribution of solids removed from the Stormceptor sump is given in Figure 4-11. The majority of solids removed from the unit were approximately 180 μm in size or larger. Each of these fractions represented approximately 13% or more of the solids collected from the sump. Substantially smaller amounts of solids were collected from particle sizes of approximately 150 μm or less. It appears that the Stormceptor Unit is most effective in removing particles of approximately 180 μm in size or greater.

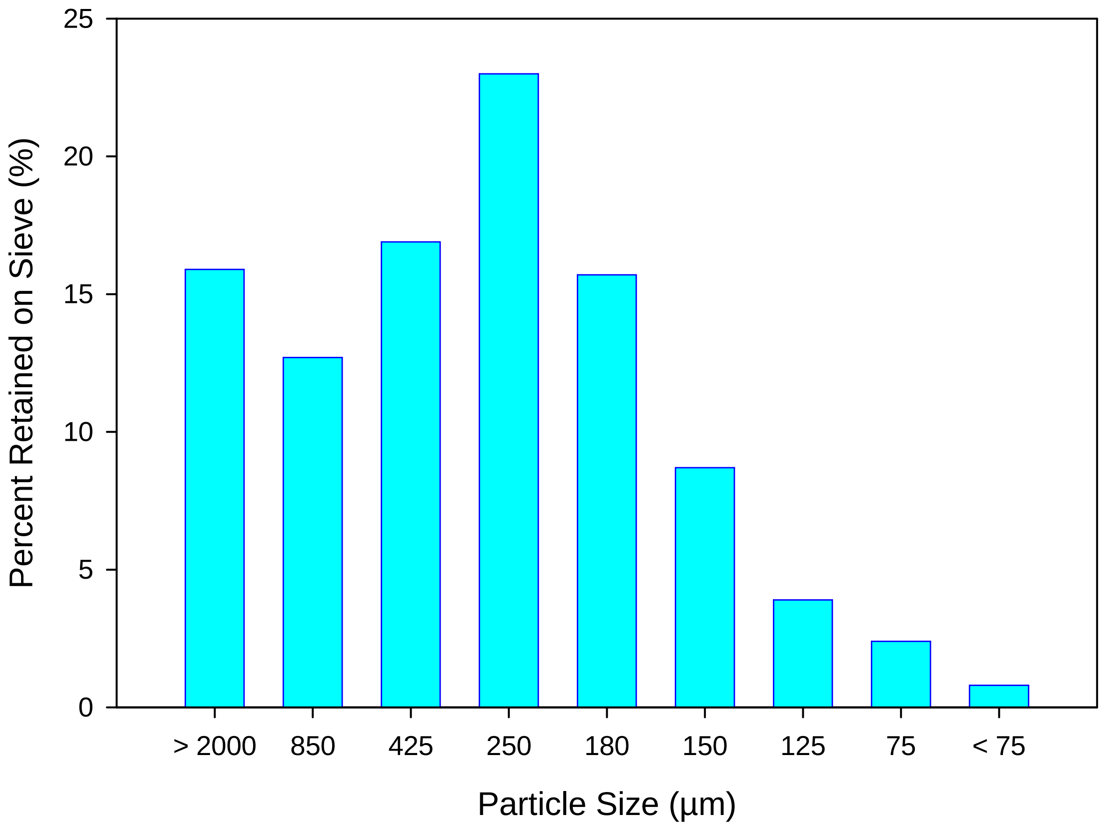


Figure 4-11. Grain Size Distribution of Solids Removed from the Stormceptor Sump.

As indicated previously, monitoring was conducted at the Stormceptor site over a 170-day period from September 1, 2005-February 17, 2006. During this time, a total of 67,799 ft^3 of water passed through the Stormceptor Unit (Table 4-5), and a total of 15.704 kg of dried solids was collected. These solids contained a total of 344 g of total nitrogen and 96.6 g of total phosphorus. The collected mass of dry solids divided by the inflow volume of 67,799 ft^3 equate to a mean TSS removal of 8.2 mg/l by the Stormceptor Unit. Based on the summary of monitored inflow and outflow characteristics summarized in Table 4-6, the mean inflow TSS concentration into the Stormceptor Unit was 31.1 mg/l, with a mean outflow concentration of 20.6 mg/l, for a field measured removal of approximately 10.5 mg/l. The mean TSS concentration removed, calculated based on sediments collected from the Stormceptor sump, provides close agreement with the removal of 10.5 mg/l for TSS calculated based on inflow and outflow water samples.

The nutrient content was measured for each of the particle size ranges, indicated on Figure 4-11, for the solids removed from the Stormceptor sump. A summary of these analyses is given in Table 4-10. First, the concentration of nitrogen and phosphorus was measured in raw particles collected in each of the particle size ranges. Particles <75 μm in size were found to have the highest concentration of total nitrogen and total phosphorus. Particles in this size range often consist of silt particles and ground-up vegetation which are high in nutrients. Elevated levels of nitrogen and phosphorus were also measured in particles >2000 μm and in the 850 μm range, which are often associated with larger vegetation particles. Particles between these two extremes are often associated with soil particles and have a lower raw nutrient content.

The contribution of nitrogen and phosphorus from each particle size range to the overall composite raw sample is also summarized in the final two columns of Table 4-10. Although particles <75 μm in size have the highest raw concentrations for total nitrogen and total phosphorus, only a small amount of these particles were present in the raw sample, and as a result, particles in this range contributed the smallest amount of nitrogen and phosphorus to the composite raw sample. The largest amounts of nitrogen and phosphorus were contributed by particles >2000 µm, due to a combination of elevated concentrations and high particle mass associated with this fraction. In general, the contributions of various particle fractions to nitrogen and phosphorus in the raw sample appear to decrease with decreasing particle size.

TABLE 4-10

NUTRIENT CONTENT IN SOLIDS REMOVED FROM THE STORMCEPTOR SUMP

PARTICLE SIZE (µm)	CONCENTRATION OF RAW PARTICLES (µg/g)		CONTRIBUTION TO COMPOSITE RAW SAMPLE (µg/g)	
	Total N	Total P	Total N	Total P
> 2000	43,702	16,711	6,949	2,657
850	33,365	7,327	4,237	931
425	22,587	4,152	3,817	702
250	13,448	2,706	3,093	622
180	9,572	2,915	1,503	458
150	9,351	3,346	814	291
125	11,130	3,755	434	146
75	25,781	7,701	619	185
< 75	57,616	19,669	461	157
		TOTALS:	**21,926**	**6,149**

4.2 Ultra-Urban Filter Unit

As discussed in Section 3.1.2, performance testing for the Ultra-Urban Filter Unit was performed in a series of pilot tests conducted at the ERD Laboratory in Orlando. Particulate matter for testing purposes was obtained from a single-family residential watershed adjacent to the ERD Office which is similar in terms of unit densities and hydrologic characteristics to the Turkey Creek Subdivision.

Twelve separate pilot tests were conducted using the Ultra-Urban Filter System. A pre-measured portion of collected solids from the residential area was added into a flowing water stream which deposited the solids into the Ultra-Urban Filter Unit. A summary of the quantity of residential solids used in pilot testing for the Ultra-Urban Filter Unit is given in Table 4-11. The weight of solids used in the 12 pilot test experiments ranged from 290.3-3980.8 g per test. For comparison purposes, this value was converted to an equivalent runoff TSS concentration based on the watershed area of 6.93 acres for the Ultra-Urban Filter, a rainfall depth of 0.25 inches, and a runoff coefficient of 0.200. Using the runoff generated from a hypothetical 0.25-inch rain event and the weight of solids used for each experiment, the equivalent runoff TSS concentration used in the pilot test experiments ranged from 7.9-112 mg/l. Concentrations within this range are typical of the variability observed in TSS concentrations from residential areas over an annual cycle.

TABLE 4-11

SUMMARY OF RESIDENTIAL SOLIDS USED IN PILOT TESTING FOR THE ULTRA-URBAN FILTER UNIT

EXPERIMENT NO.	MASS OF DRY SOLIDS USED (g)	EQUIVALENT RUNOFF TSS CONCENTRATION[1] (mg/l)
1	2969.41	83.4
2	3043.28	85.5
3	3980.78	112
4	927.03	26.0
5	823.48	23.1
6	756.69	21.3
7	329.95	9.3
8	280.06	7.9
9	371.60	10.4
10	293.69	8.3
11	290.30	8.1
12	329.91	9.3
TOTAL:	**14,396.18**	

1. Based on a watershed area of 6.93 acres for the Ultra-Urban Filter, a rainfall of 0.25 inches, and a runoff coefficient of 0.200

The solids utilized in the pilot testing consisted of a combination of leaves, vegetation, small gravel, sand, and silt which was collected from the residential area. A photograph of accumulated solids in the Ultra-Urban Filter Unit during the pilot testing is given in Figure 4-12.

Figure 4-12. Accumulated Solids in the Ultra-Urban Filter Unit.

4.2.1 Hydraulic Characteristics of the Ultra-Urban Filter Unit

The hydraulic characteristics of the Ultra-Urban Filter Unit were measured prior to each pilot test experiment. A photograph of this initial hydraulic performance testing is given in Figure 3-10. During each hydraulic evaluation, clean water was allowed to discharge into the filter unit until an equilibrium inflow was reached where the water level inside the filter rose to the top of the unit without overflowing. Once this flow rate was established, the volume of water added over a measured period of time was used to determine the hydraulic flow rate through the filter unit.

A summary of the results of the hydraulic testing performed on the Ultra-Urban Filter Unit is given in Table 4-12 for each of the 12 experiments. The initial flow rate of the system exceeded 134 gallons per minute (gpm). This is the maximum rate at which water could be introduced into the unit using the pilot test equipment. Even at this relatively high flow rate, the water within the filter unit did not rise to the top, indicating that additional flow capacity was available within the unit. It is likely that the initial flow rate was near the design acceptance flow rate for the unit of 170 gpm stated by AbTech Industries.

TABLE 4-12

HYDRAULIC CHARACTERISTICS OF THE ULTRA-URBAN FILTER UNIT MEASURED PRIOR TO EACH PILOT TEST EXPERIMENT

PILOT TEST EXPERIMENT NO.	VOLUME OF WATER ADDED (gallons)	TIME (minutes)	FLOW RATE (gpm)
1	150	1.12	134.33
2	35	1.35	25.93
3	40	3.88	10.30
4	4	0.83	4.80
5	3	0.45	6.67
6	3	1.03	2.90
7	2	2.85	0.70
8	2	4.07	0.49
9	1	3.28	0.30
Unit cleaned			
10	26	4.43	5.86
11	22	2.92	7.54
12	9	1.40	6.43

After the initial experiment, the hydraulic characteristics of the Ultra-Urban Filter Unit declined rapidly, decreasing to a flow rate of only 0.3 gpm after pilot test experiment #9. After nine pilot test events, the filter unit would have received the suspended solids equivalent of approximately 9 rain events of 0.25 inches or 2.25 inches of total rainfall.

Due to the poor performance of the unit after pilot test experiment #9, the unit was cleaned by turning it upside down and hitting it forcefully against the pavement to dislodge any embedded solids within the filter in hopes of restoring hydraulic capacity. After this cleaning procedure, the final pilot tests (numbers 10-12) were conducted. The clean-out procedure improved the hydraulic capacity to approximately 5.9 gpm, but this value is still substantially less than the initial flow rate for the filter. A graphical representation of the hydraulic performance of the Ultra-Urban Filter Unit during pilot testing is given in Figure 4-13.

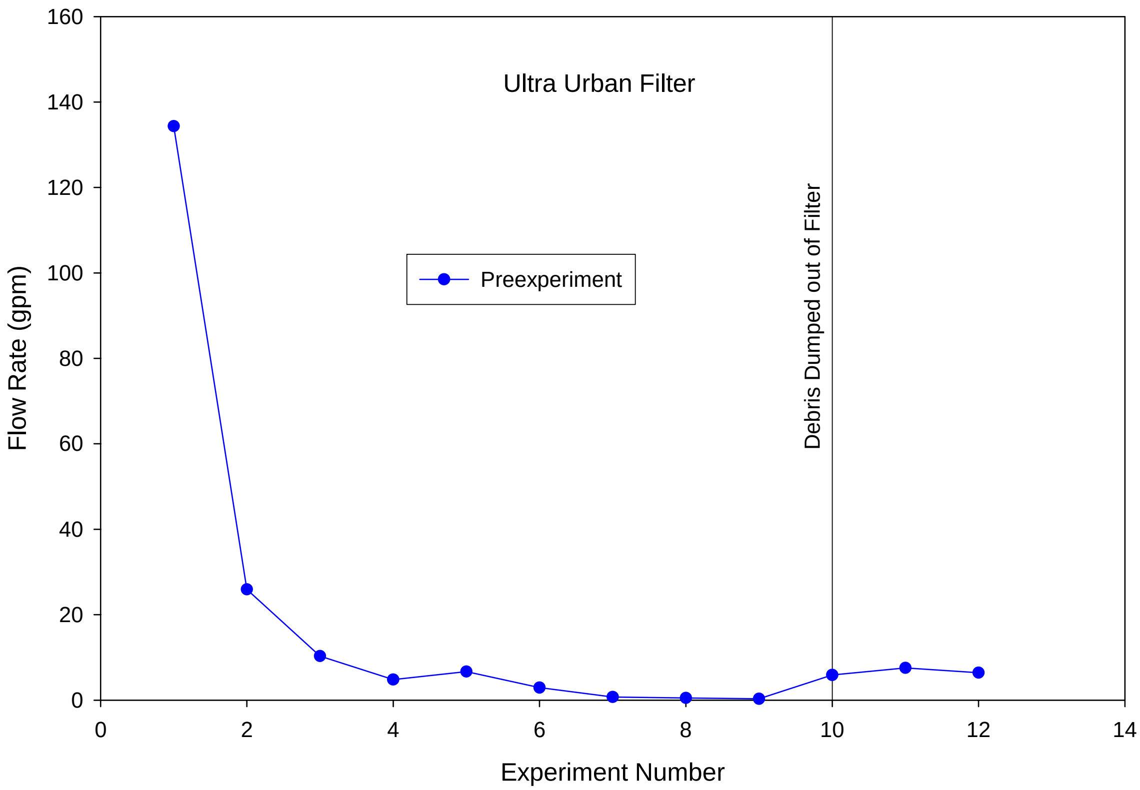


Figure 4-13. Hydraulic Performance of the Ultra-Urban Filter Unit During Pilot Testing.

A comparison of the hydraulic characteristics of pilot tests conducted with the Ultra-Urban Filter Unit is given in Table 4-13. In general, pilot testing was conducted at flow rates of approximately 25-75% of the maximum hydraulic capacity of the unit at the time of each pilot test experiment. This range of inflow values was selected to avoid overflowing of the filter and loss of solids in the overflow.

TABLE 4-13

HYDRAULIC CONDITIONS DURING ULTRA-URBAN FILTER PILOT TESTING

PILOT TEST EXPERIMENT NO.	VOLUME OF WATER USED (gallons)	TIME (minutes)	MEAN FLOW RATE (gpm)
1	65	1.93	33.68
2	55	4.38	12.56
3	74	11.92	6.21
4	24	13.93	1.72
5	14	14.33	0.98
6	11	11.22	0.98
7	14	30.60	0.46
8	10	31.63	0.32
9	11	36.33	0.30
Unit cleaned			
10	29	5.53	5.24
11	26	4.90	5.31
12	21	6.67	3.15

Whenever the inflow into the filter unit began to approach the hydraulic capacity of the unit during pilot testing, floating debris (primarily consisting of leaves) would begin to overflow the unit, and in a real application, would enter into the outfall stormsewer line. Discharge of floating leaves in the overflow of the Ultra-Urban Filter Unit is illustrated in Figure 4-14. Overflow of the unit begins to be a more significant problem as the filter begins to become clogged and the hydraulic flow rate begins to drop, in some tests to values <1 gpm. This inflow rate would be exceeded by virtually any storm event, causing overflow and discharge of floatable debris not only in the incoming stormwater flow but also from material which had previously accumulated within the unit.

Figure 4-14. Loss of Leaves During Overflow of the Ultra-Urban Filter Unit.

4.2.2 Pilot Test Results

4.2.2.1 Characteristics of Residential Solids

Twelve separate pilot test experiments were conducted with the Ultra-Urban Filter Unit with dried solids masses ranging from 290.30-3980.78 g per test. Standard grain size analyses were performed on each of the 12 solids samples used during the pilot testing. The results of the individual grain size analyses for the 12 solids samples are given in Appendix F.1.

A statistical comparison of the distribution of particle sizes in residential solids used in the Ultra-Urban pilot testing is given in Figure 4-15 in the form of box and whisker plots. The largest particle fractions, in terms of sample mass, are the >2000 μm and 250 μm fractions. The >2000 μm fraction consists primarily of organic matter and debris, while the 250 μm fraction consists primarily of fine sand. Particle fractions <250 μm in size make up less than 10% each of the total mass of solids used in the pilot test experiments. The smallest mass of particles collected from the residential area is contributed by the <75 μm category.

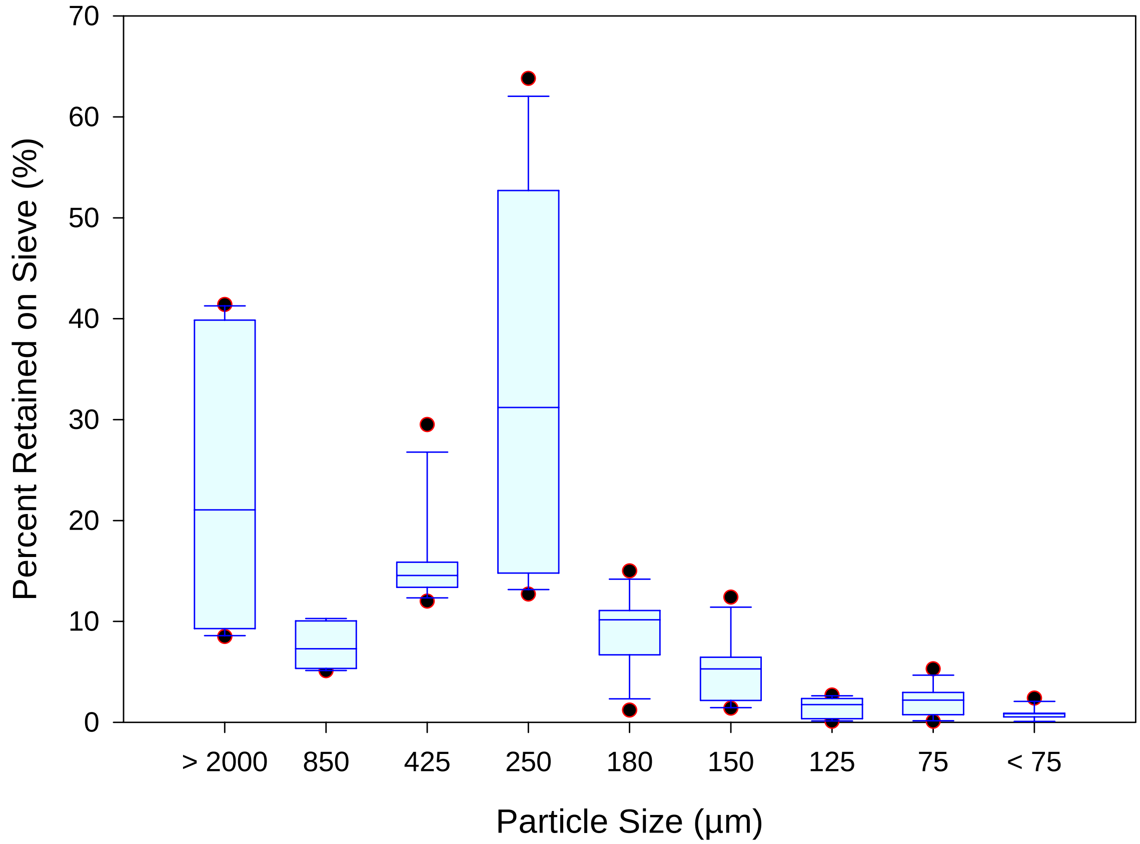


Figure 4-15. Distribution of Particle Sizes in Residential Solids Used in the Ultra-Urban Pilot Testing.

The results of lab analyses of nitrogen and phosphorus in the residential solids used in pilot test experiments are given in Appendix F.2. Concentrations of total nitrogen by particle size in residential solids used in the Ultra-Urban pilot testing are summarized in Figure 4-16. Although particles <75 µm in size represent the smallest mass of particles present in the residential solids, these particles contain the highest concentrations of total nitrogen, with a mean concentration of approximately 60,000 µg total nitrogen per gram of particle for this range. Relatively elevated concentrations of total nitrogen were also observed in the >2000 µm and 850 µm categories, with mean concentrations of approximately 25,000 and 35,000 µg/g, respectively. A nitrogen concentration of approximately 25,000 µg/g was also observed in the 75 µm particle range. The remaining particle sizes contained approximately 10,000-15,000 µg total nitrogen per gram of solids in each range.

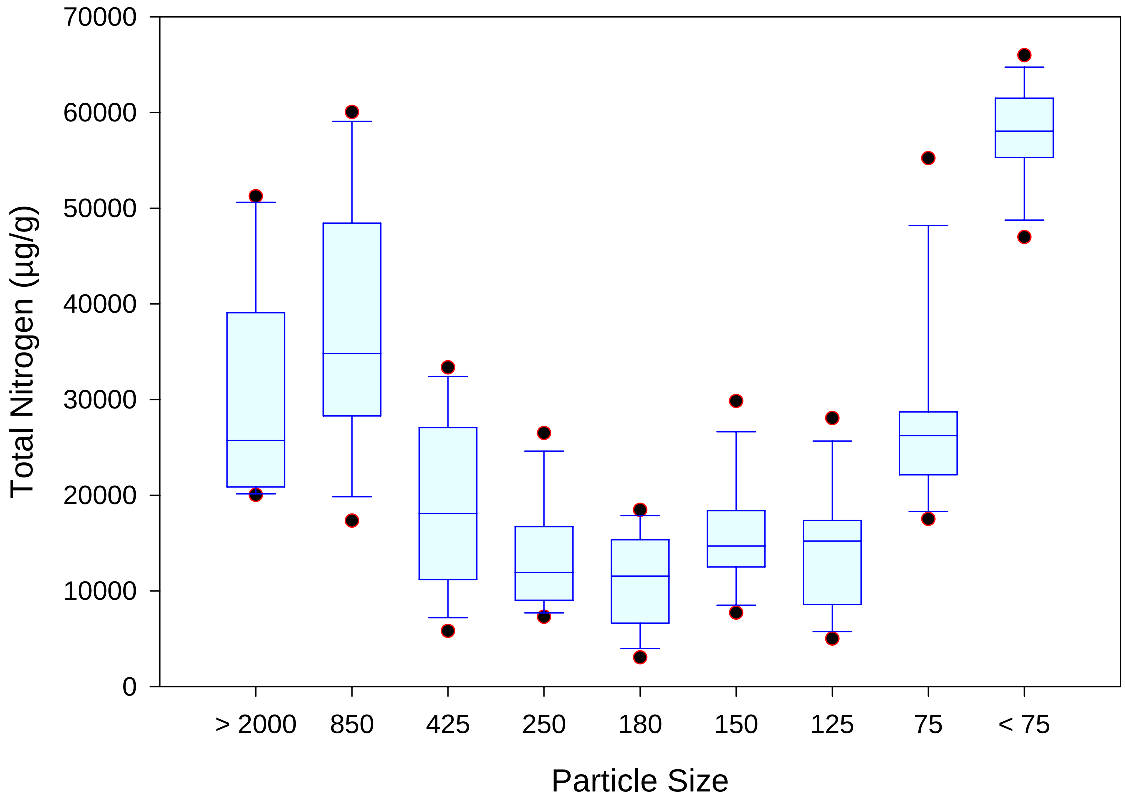


Figure 4-16. Concentrations of Total Nitrogen by Particle Size in Residential Solids Used in the Ultra-Urban Pilot Testing.

A statistical comparison of concentrations of total phosphorus by particle size in residential solids used in the Ultra-Urban pilot testing is given in Figure 4-17. Similar to the results observed for total nitrogen, the highest total phosphorus concentrations were measured in the <75 µm particles (with a concentration of ~16,000 µg total phosphorus per gram), followed by the >2000 and 850 µm (~5000 µg total phosphorus per gram), and 75 µm particle ranges (~7500 µg total phosphorus per gram). Concentrations of total phosphorus in the remaining particle sizes appears to be approximately 50% of the concentrations measured in the >2000 µm and 850 µm ranges.

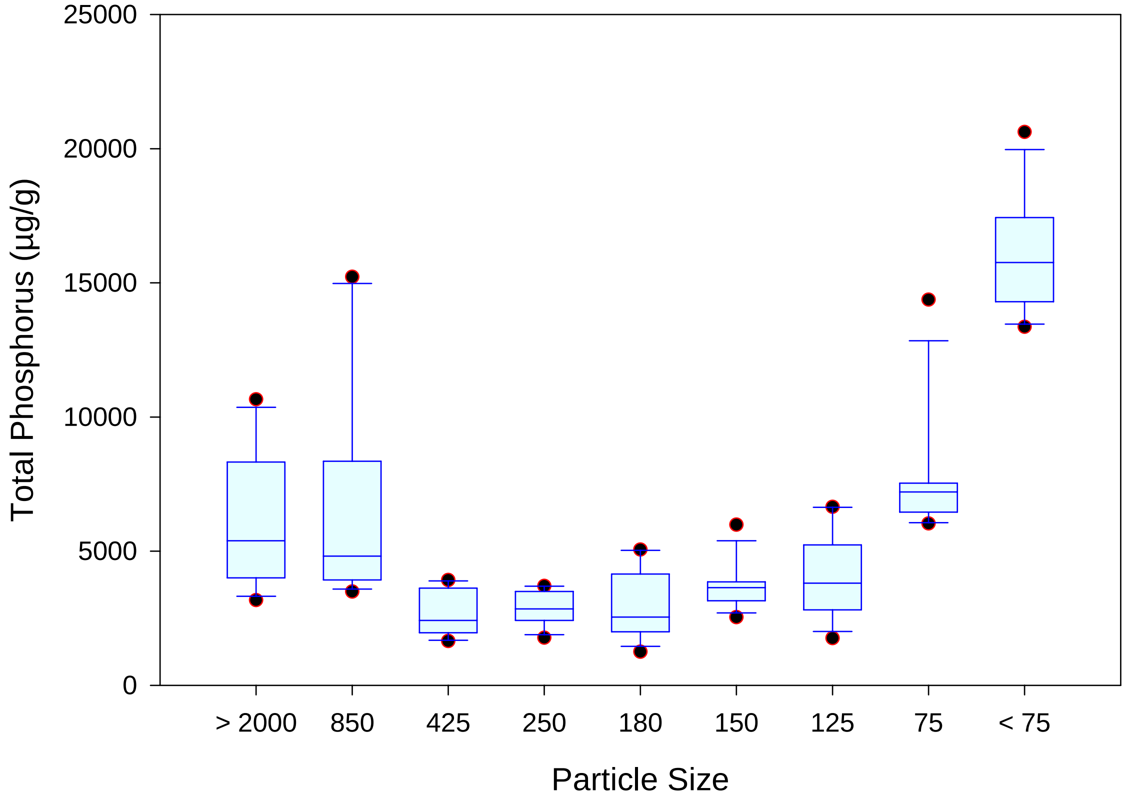


Figure 4-17. Concentrations of Total Phosphorus by Particle Size in Residential Solids Used in the Ultra-Urban Pilot Testing.

The relative mass of total nitrogen contributed by various particle sizes in the residential solids used in the Ultra-Urban pilot testing is given in Figure 4-18. This figure provides a summary of the relative mass of total nitrogen contained within the solids sample which is contributed by each of the evaluated particle size fractions. The largest contribution of total nitrogen occurs from particles >2000 µm in size. This fraction appears to contribute one-third of the total nitrogen contained within the test samples. Approximately 15-20% of the total nitrogen is contributed by nitrogen contained in each of the 850, 425, and 250 µm particle size fractions. Relatively small contributions of total nitrogen are contributed by particle sizes <250 µm in size. Although the highest nitrogen content was observed in particle sizes <75 µm, these particles contribute a relatively small percentage of the total mass of nitrogen present in each of the pilot test samples.

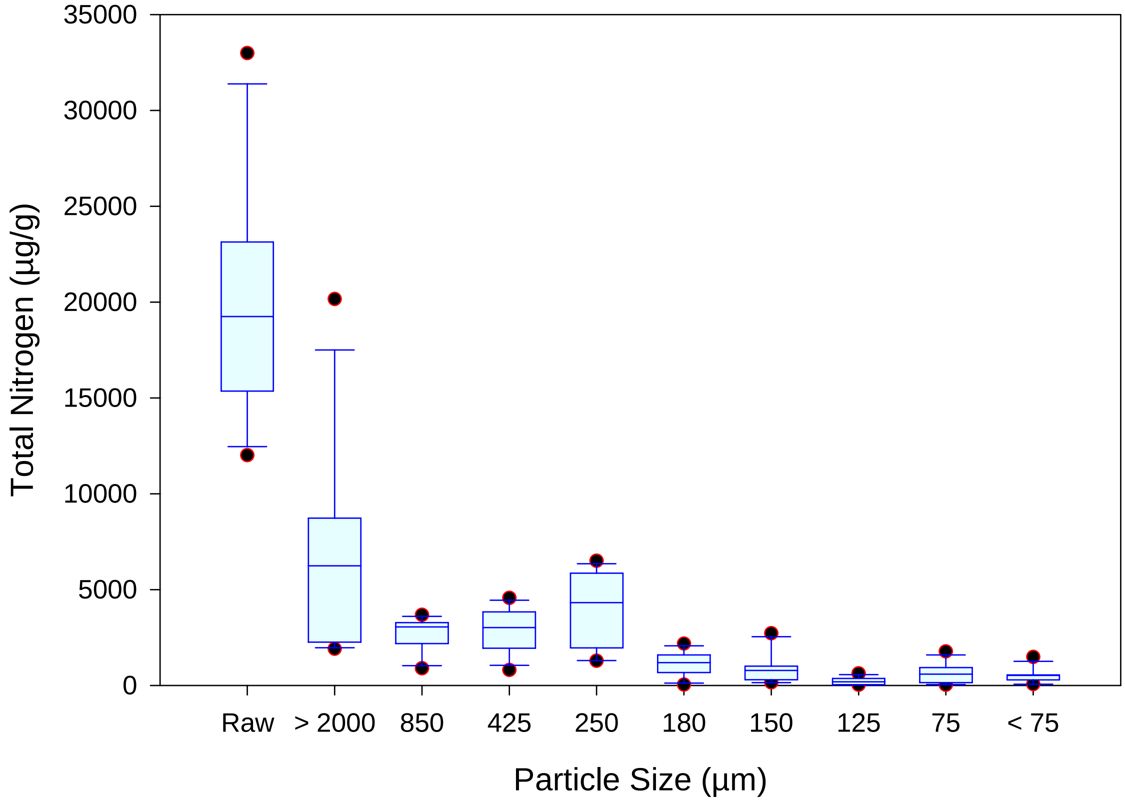


Figure 4-18. Relative Contributions of Total Nitrogen by Particle Size in Residential Solids Used in the Ultra-Urban Pilot Testing.

Relative contributions of total phosphorus by particle size in the residential solids used in the Ultra-Urban pilot testing are summarized in Figure 4-19. The largest contributions of total phosphorus are provided by particles >2000 µm in size and particles in the 250 µm range. Particles in these categories each contribute approximately 20-25% of the total phosphorus present in the raw sample. Particles in the 850 and 425 µm range contribute approximately 5% each of the total phosphorus present in the raw sample. Substantially smaller contributions of total phosphorus are provided by particles >250 µm in size. Similar to the situation observed for total nitrogen, a relatively small portion of the overall total phosphorus content is provided by particles <75 µm in size, even though these particles contain the highest unit concentration of total phosphorus.

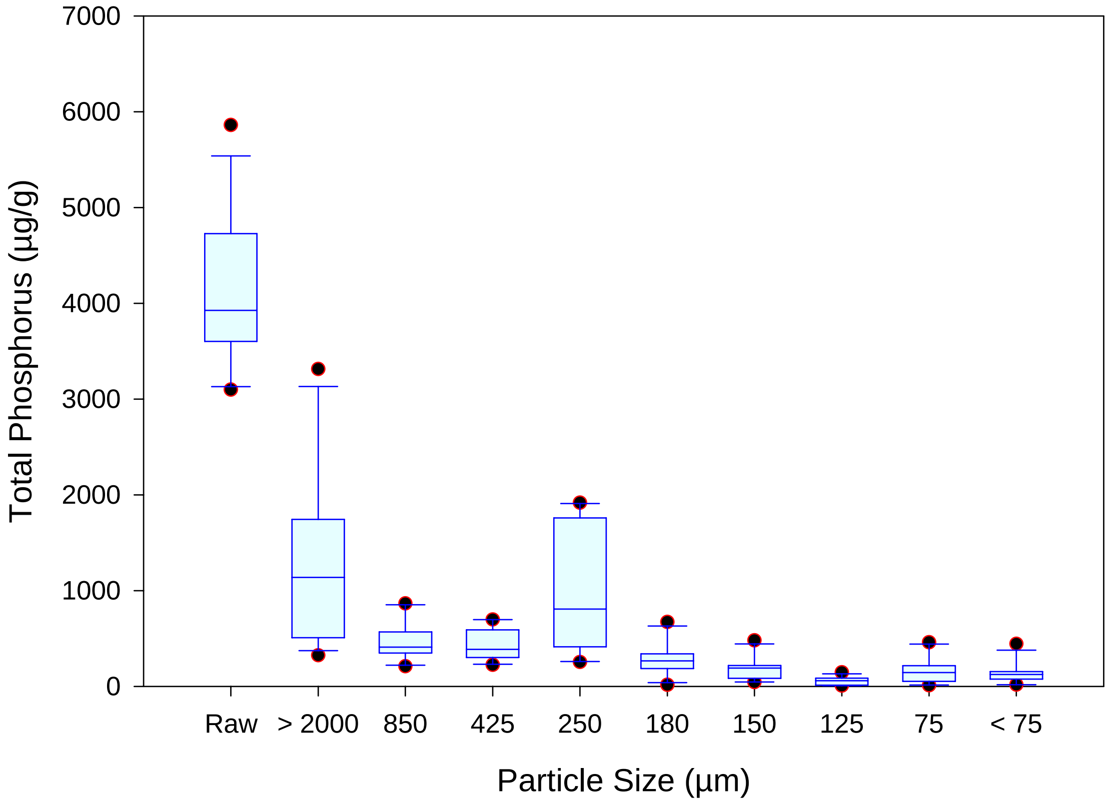


Figure 4-19. Relative Contributions of Total Phosphorus by Particle Size in Residential Solids Used in the Ultra-Urban Pilot Testing.

4.2.2.2 <u>Characteristics of Raw Water Samples</u>

As discussed in Section 3.1.2, bulk water used in pilot testing for the Ultra-Urban Filter was obtained from Lake Conway which is located adjacent to the ERD pilot test site. Lake Conway is an oligotrophic lake which typically maintains extremely low levels of both total nitrogen and total phosphorus. This source was selected since it would contribute relatively little additional loading to the suspended solids used during each experiment. However, to provide a complete mass balance for each experiment, particle size characteristics of the raw water samples used in the pilot testing were also evaluated.

During pilot testing for the Ultra-Urban Filter, each 500-gallon tank of lake water was used for three separate pilot tests, with one tank of water used for experiments 1-3, another tank of water used for experiments 4-6, another tank used for experiments 7-9, and a final tank used for experiments 10-12. Suspended solids were separated from the bulk water samples using the nylon net filters, as described in Section 3.2.1. Solids collected from each of the filters were analyzed for total nitrogen, total phosphorus, TSS, and VSS.

A summary of the characteristics of raw water samples used in pilot testing for the Ultra-Urban Filter is given in Table 4-14. The raw water samples are characterized by a mean TSS concentration of approximately 5.4 mg/l. Approximately 17% of the TSS in the raw water samples is comprised of particles >180 µm, with 39% of the TSS comprised of particles of approximately 11 µm or less. The remaining suspended solids are distributed approximately equally in the remaining particle sizes.

The raw water sample is characterized by a mean VSS concentration of 3.7 mg/l. Similar to the trend observed for TSS, approximately 22% of the VSS is comprised of particles >180 µm, with 32% contributed by particles of approximately 11 µm or less. VSS concentrations are distributed approximately equally between the remaining particle sizes.

The raw water samples are characterized by a mean total nitrogen concentration of approximately 578 µg/l. Of this amount, approximately 88% is comprised of particles <11 µm in size, reflecting a combination of algal cells and dissolved nitrogen constituents. Approximately 3% of the total nitrogen measured in the lake water sample is comprised of particles >180 µm in size. Nitrogen concentrations in particles collected from the remaining filter sizes contribute only a small portion of the total nitrogen measured.

The raw water samples are characterized by a mean total phosphorus concentration of approximately 21 µg/l. Of this amount, approximately 77% is comprised of particles <11 µm which consist of algal cells and dissolved phosphorus compounds. Approximately 7% of the phosphorus measured in the samples is attached to particles >180 µm in size. Phosphorus concentrations are distributed approximately equally between the remaining particle fractions.

TABLE 4-14

CHARACTERISTICS OF RAW WATER SAMPLES USED IN ULTRA-URBAN FILTER PILOT TESTING

EXPERIMENT NO.	TSS CONCENTRATION (mg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.1	0.1	0.1	0.2	0.2	0.8	2.5	4.0
4-6	1.3	0.4	0.7	1.0	0.5	1.3	0.6	5.8
7-9	1.3	0.9	0.9	0.7	0.5	1.3	0.3	5.9
10-12	1.1	0.8	0.7	1.4	0.5	0.9	1.0	6.4
Mean	**0.9**	**0.5**	**0.6**	**0.8**	**0.4**	**1.0**	**1.1**	**5.4**

EXPERIMENT NO.	VSS CONCENTRATION (mg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.0	0.1	0.0	0.1	0.1	0.4	1.3	2.0
4-6	1.0	0.4	0.4	0.6	0.4	0.6	0.4	3.8
7-9	1.0	0.6	0.4	0.5	0.4	0.8	0.1	3.8
10-12	1.1	0.8	0.6	1.0	0.4	0.8	0.8	5.5
Mean	**0.8**	**0.4**	**0.4**	**0.5**	**0.3**	**0.6**	**0.6**	**3.7**

EXPERIMENT NO.	TOTAL NITROGEN CONCENTRATION (µg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	5.6	4.6	5.1	3.3	6.8	24.3	437	487
4-6	27.7	4.9	6.3	10.6	10.2	31.0	566	657
7-9	17.9	11.9	10.1	10.7	6.8	25.2	436	519
10-12	6.7	3.4	5.6	11.6	4.5	16.9	599	648
Mean	**14.5**	**6.2**	**6.8**	**9.0**	**7.1**	**24.3**	**510**	**578**

EXPERIMENT NO.	TOTAL PHOSPHORUS CONCENTRATION (µg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.1	0.1	0.1	0.1	0.1	0.2	18.4	19
4-6	3.5	0.4	0.5	1.2	0.7	2.1	19.6	28
7-9	0.7	0.8	0.4	0.6	0.3	1.0	7.2	11
10-12	1.3	0.4	0.9	1.8	0.6	1.4	19.6	26
Mean	**1.4**	**0.4**	**0.5**	**0.9**	**0.4**	**1.2**	**16.2**	**21**

4.2.2.3 Characteristics of Filter Outflow

Composite samples of outflow from the Ultra-Urban Filter were collected during each of the 12 pilot test experiments and analyzed for TSS, VSS, total nitrogen, and total phosphorus by particle size fraction. A complete listing of lab analyses for TSS, total nitrogen, and total phosphorus on outflow samples from the Ultra-Urban Filter by particle size is given in Appendix G.1. A statistical distribution of TSS in the outflow from the Ultra-Urban Filter during pilot testing as a function of particle size is given in Figure 4-20. In general, low TSS concentrations were observed for each of the evaluated particle sizes, although elevated outlier concentrations were observed for TSS in particles >180 µm and <11 µm. Distribution of VSS in the outflow from the Ultra-Urban Filter during pilot testing is illustrated in Figure 4-21. In general, the distribution of VSS particles is similar to that exhibited by TSS. VSS concentrations appear to be extremely low in value for each of the evaluated particle size fractions.

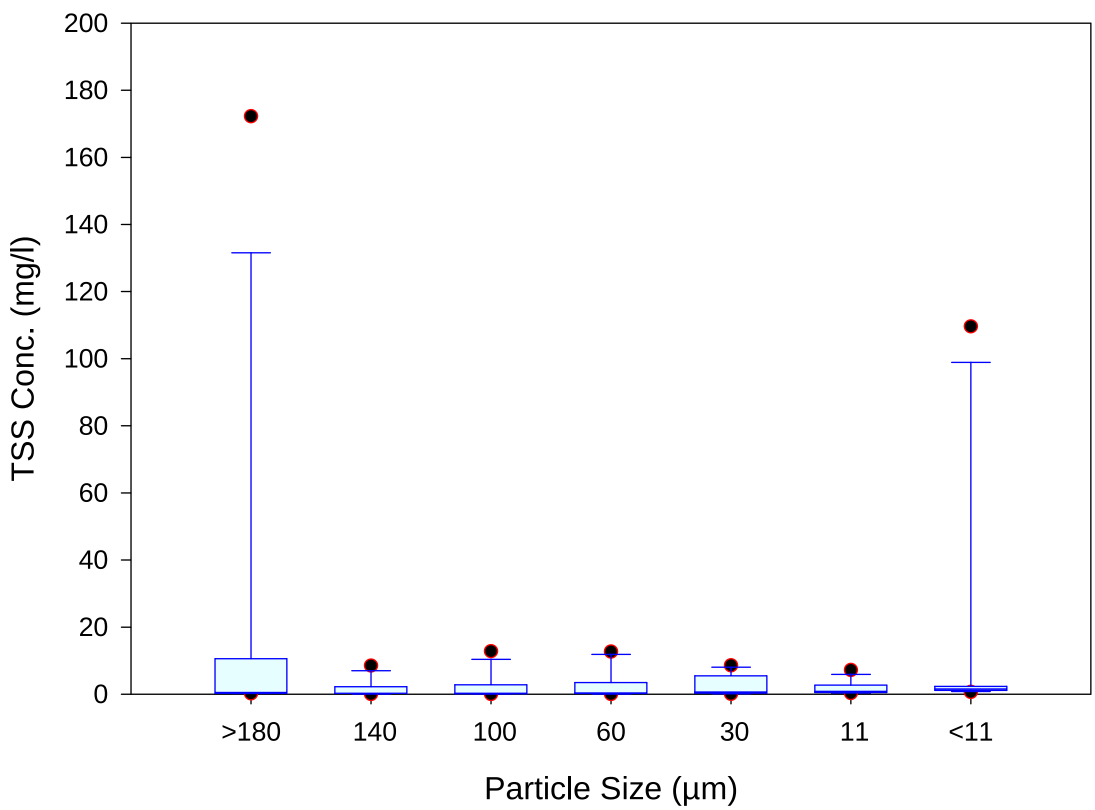


Figure 4-20. Distribution of TSS in the Outflow from the Ultra-Urban Filter During Pilot Testing.

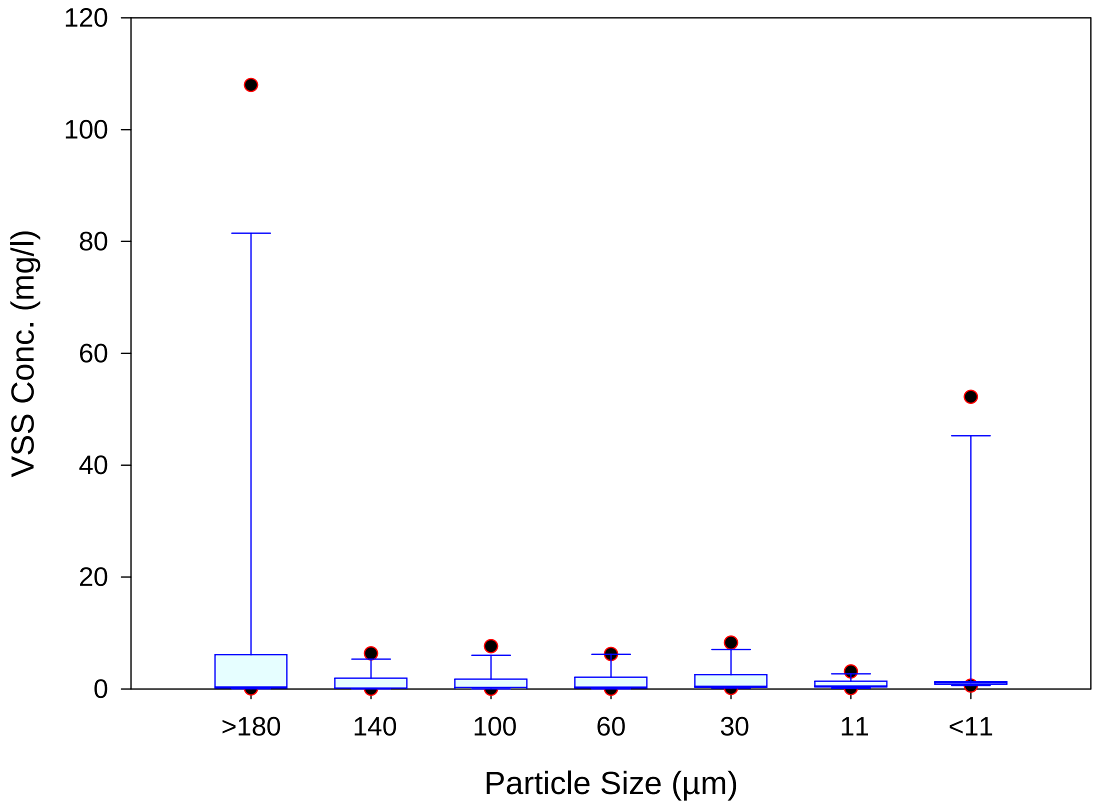


Figure 4-21. Distribution of VSS in the Outflow from the Ultra-Urban Filter During Pilot Testing.

Distribution of total nitrogen particles in the outflow from the Ultra-Urban Filter during pilot testing is illustrated in Figure 4-22. In general, extremely low nitrogen concentrations were measured for particle sizes of 11 µm or greater. However, for particle sizes <11 µm, a substantially elevated total nitrogen concentration was observed. This value reflects a combination of small particles which may have passed through the filter as well as dissolved nitrogen species.

A distribution of total phosphorus particles in the outflow from the Ultra-Urban Filter during pilot testing is illustrated in Figure 4-23. Similar to the trend observed for total nitrogen, extremely low phosphorus concentrations were observed for particle sizes of 11 µm and greater. However, an elevated total phosphorus concentration was observed for particles <11 µm which reflects the combination of small particles passing through the filter and dissolved phosphorus species.

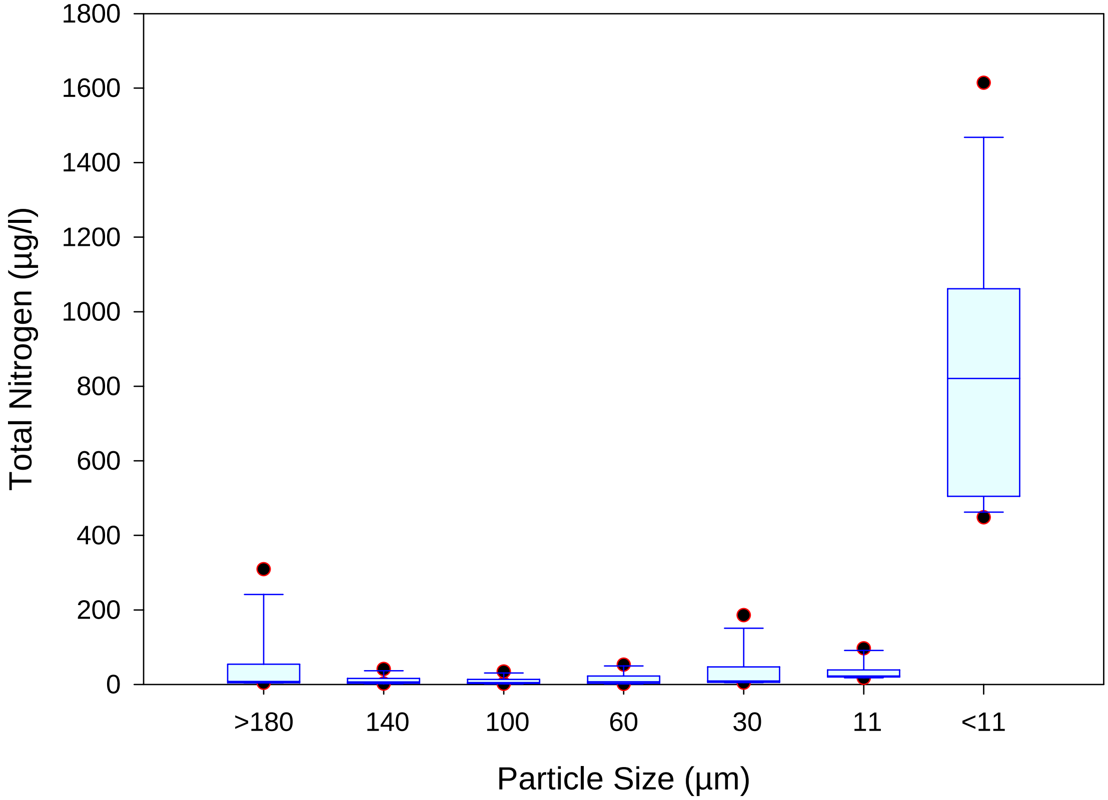


Figure 4-22. Distribution of Total Nitrogen in the Outflow from the Ultra-Urban Filter During Pilot Testing.

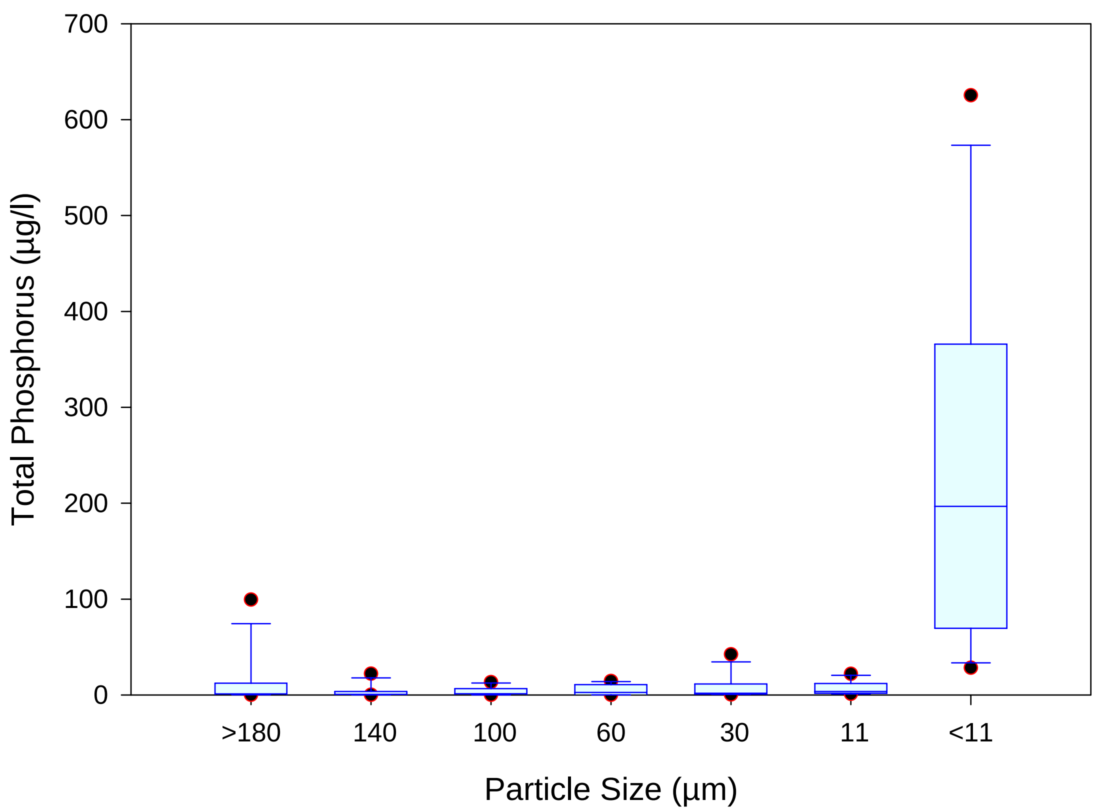


Figure 4-23. Distribution of Total Phosphorus in the Outflow from the Ultra-Urban Filter During Pilot Testing.

4.2.2.4 Removal Effectiveness

Estimates of the mass removal effectiveness of the Ultra-Urban Filter were calculated for TSS, total nitrogen, and total phosphorus for each of the 12 pilot test experiments. The concentration of TSS, total nitrogen, and total phosphorus measured in each particle fraction discharging from the filter was multiplied times the volume of water used during each pilot test experiment, summarized in Table 4-13, to obtain an estimate of the total mass of suspended solids, nitrogen, and phosphorus discharged through the filter for each particle fraction. The mass associated with each particle fraction was then added together to provide an estimate of the total mass discharged from the filter. The inflow into the filter was calculated as the mass of suspended solids, total nitrogen, and total phosphorus contained in the raw solids sample as well as in the water volume used during each experiment. The difference between the inflow and outflow mass is used to calculate percent removal for each experiment.

Calculated mass removal efficiencies of the Ultra-Urban Filter during pilot testing of TSS removal are summarized in Table 4-15. Removal efficiencies for TSS, total nitrogen, and total phosphorus exceeded 98% during each of the 12 pilot test experiments, with an overall TSS removal of >99.9%, total nitrogen removal of 99.2%, and an overall total phosphorus removal of 99.1%. It appears that the Ultra-Urban Filter is extremely effective in retaining particulate matter within the filter and in producing extremely high removal efficiencies for the water volume which passes through the filter.

However, as discussed previously, the hydraulic efficiency of the Ultra-Urban Filter decreased rapidly during the pilot test experiments. The amount of solids added during each pilot test experiment is roughly equivalent to the amount of suspended solids which would be deposited onto the Ultra-Urban Filter during a typical 0.25-inch rain event within the contributing watershed. A hydrologic model was developed for the Ultra-Urban Filter, similar to the hydrologic model discussed in Section 4.1.1.2 for the Stormceptor Unit, to generate estimates of runoff volumes which would reach the Ultra-Urban Filter site during each of the measured rain events during the field monitoring program from September 2005-February 2006. The plot

TABLE 4-15
CALCULATED MASS REMOVAL EFFECTIVENESS OF THE ULTRA-URBAN FILTER DURING PILOT TESTING

Exp. #	Volume (gal)	Outflow TSS Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
1	65	0.042	0.000	0.003	0.002	0.002	0.001	0.027	0.077	2969.41	>99.9
2	55	0.008	0.002	0.000	0.003	0.002	0.001	0.015	0.031	3043.28	>99.9
3	74	0.003	0.001	0.001	0.001	0.002	0.001	0.001	0.010	3980.78	>99.9
4	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	927.03	>99.9
5	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	823.48	>99.9
6	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	756.69	>99.9
7	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	329.95	>99.9
8	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	280.06	>99.9
9	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	371.60	>99.9
10	29	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.003	293.69	>99.9
11	26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	290.30	>99.9
12	21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	329.91	>99.9
	Mean	**0.005**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.004**	**0.010**	**1199.682**	**>99.9**

Exp. #	Volume (gal)	Outflow Total Nitrogen Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
1	65	0.007	0.002	0.003	0.004	0.004	0.005	0.233	0.257	55.14	99.5
2	55	0.018	0.004	0.004	0.011	0.014	0.016	0.103	0.170	57.77	99.7
3	74	0.016	0.011	0.004	0.006	0.052	0.011	0.125	0.226	62.28	99.6
4	24	0.001	0.001	0.000	0.000	0.000	0.003	0.102	0.108	62.20	99.8
5	14	0.000	0.000	0.000	0.000	0.000	0.001	0.041	0.043	11.17	99.6
6	11	0.000	0.000	0.000	0.000	0.000	0.001	0.044	0.046	12.62	99.6
7	14	0.000	0.000	0.000	0.000	0.000	0.001	0.085	0.088	10.91	99.2
8	10	0.000	0.000	0.000	0.000	0.000	0.001	0.039	0.041	5.55	99.3
9	11	0.000	0.000	0.000	0.000	0.000	0.001	0.036	0.038	10.29	99.6
10	29	0.034	0.003	0.004	0.005	0.006	0.011	0.066	0.128	10.33	98.8
11	26	0.004	0.001	0.001	0.002	0.001	0.003	0.049	0.062	7.11	99.1
12	21	0.000	0.000	0.000	0.000	0.000	0.001	0.041	0.043	6.03	99.3
	Mean	**0.007**	**0.002**	**0.001**	**0.002**	**0.007**	**0.005**	**0.080**	**0.104**	**25.950**	**99.4**

Exp. #	Volume (gal)	Outflow Total Phosphorus Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
1	65	0.003	0.001	0.001	0.001	0.001	0.001	0.056	0.063	13.79	99.5
2	55	0.003	0.001	0.003	0.003	0.003	0.004	0.034	0.050	14.47	99.7
3	74	0.004	0.006	0.002	0.003	0.012	0.004	0.013	0.044	15.95	99.7
4	24	0.000	0.000	0.000	0.000	0.000	0.000	0.057	0.057	15.95	99.6
5	14	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.020	2.87	99.3
6	11	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.014	3.08	99.5
7	14	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.025	1.58	98.4
8	10	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.013	1.00	98.7
9	11	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.006	1.49	99.6
10	29	0.011	0.001	0.001	0.001	0.002	0.002	0.003	0.021	1.49	98.6
11	26	0.001	0.000	0.000	0.000	0.000	0.000	0.007	0.008	1.72	99.5
12	21	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.93	99.3
	Mean	**0.002**	**0.001**	**0.001**	**0.001**	**0.002**	**0.001**	**0.021**	**0.027**	**6.194**	**99.3**

of hydraulic performance vs. time for the Ultra-Urban Filter Unit, presented in Figure 4-13, is used to model decreases in the infiltration capacity of the filter over time. Each pilot test experiment is assumed to represent 0.25 inches of rainfall, and the infiltration capacity of the unit is assumed to decrease based on cumulative rainfall measured at the monitoring site. After a total rainfall of 2.5 inches, removal efficiencies are calculated for equilibrium filter flow rates of 0.5 gpm (uncleaned conditions) and 6.6 gpm (cleaned conditions). The hydraulic simulation assumes that the Ultra-Urban Filter will accept water at the applicable hydraulic rate during storm events, with the remainder of the runoff volume bypassing the unit and entering directly into the downstream stormsewer system.

A summary of the estimated mass removal efficiency of the Ultra-Urban Filter Unit for TSS, total nitrogen, and total phosphorus under actual field conditions is given in Table 4-16. These efficiencies are calculated based on an assumed mass removal of 99% for TSS, total nitrogen, and total phosphorus which passes through the Ultra-Urban Filter. At an equilibrium flow rate of 0.5 gpm, the estimated mass removal efficiency for TSS, total nitrogen, and total phosphorus over the 170-day monitoring period would be 0.4%. If the equilibrium filter flow rate is increased to 6.6 gpm, the mass treatment removal efficiency increases to 4.3%. If the equilibrium filter flow rate could be maintained at the manufacturer’s stated flow capacity of 160 gpm, the filter would have provided a 52.0% removal for TSS, total nitrogen, and total phosphorus, assuming that leaching of materials from the filter does not occur over time.

TABLE 4-16

ESTIMATED OVERALL MASS REMOVAL EFICIENCY OF THE ULTRA-URBAN UNIT FOR TSS, TOTAL NITROGEN , AND TOTAL PHOSPHORUS UNDER ACTUAL FIELD CONDITIONS

EQUILIBRIUM FILTER FLOW RATE (gpm)	MASS TREATMENT EFFICIENCY (%)
0.5	0.4
6.6	4.3
160	52.0

4.2.2.5 Summary

In summary, it appears the Ultra-Urban Filter is extremely effective in removing and retaining solids in stormwater runoff to particle sizes as low as 11 μm. Measured removal efficiencies for TSS, total nitrogen, and total phosphorus, based upon the equilibrium acceptance flow rate for the filter unit, exceed 99%. However, it appears that the hydraulic performance of the system decreases rapidly, reaching levels less than 1% of the initial flow capacity after only 1-2 inches of rainfall. Based upon the actual field conditions for the Palm Bay installation, the estimated removal for TSS, total nitrogen, and total phosphorus at the Ultra-Urban Filter site would have been approximately 5% or less, based upon an equilibrium filter flow rate of 6.6 gpm or less.

4.3 Hydro-Kleen Filter Unit

As discussed in Section 3.1.2, performance testing for the Hydro-Kleen Filter Unit was conducted in a series of pilot tests at the ERD Laboratory in Orlando. Particulate matter for testing purposes was obtained from a single-family residential watershed adjacent to the ERD Office which is similar in terms of unit densities and hydrologic characteristics to the Turkey Creek Subdivision.

Twelve separate pilot tests were conducted using the Hydro-Kleen Filter System. A pre-measured portion of collected solids from the residential area was added into a flowing water stream which deposited the solids into the Hydro-Kleen Filter Unit. A summary of the quantity of residential solids used in pilot testing for the Hydro-Kleen Filter Unit is given in Table 4-17. The weight of solids used in the 12 pilot test experiments ranged from 225.56-792.02 g per test.

TABLE 4-17

SUMMARY OF RESIDENTIAL SOLIDS USED IN PILOT TESTING FOR THE HYDRO-KLEEN FILTER UNIT

EXPERIMENT NO.	MASS OF DRY SOLIDS USED (g)	EQUIVALENT RUNOFF TSS CONCENTRATION[1] (mg/l)
1	777.78	41.5
2	594.34	31.7
3	655.25	34.9
4	792.02	42.2
5	535.26	28.5
6	761.21	40.6
7	637.11	34.0
8	700.97	37.4
9	691.80	36.9
10	300.97	16.1
11	225.56	12.0
12	301.08	16.1
TOTAL:	**6973.35**	

1. Based on a watershed area of 3.65 acres for the Hydro-Kleen Filter, a rainfall of 0.25 inches, and a runoff coefficient of 0.200

For comparison purposes, the amount of residential solids used in each of the 12 pilot test experiments was converted to an equivalent runoff TSS concentration based on the watershed area of 3.65 acres for the Hydro-Kleen Filter, a rainfall depth of 0.25 inches, and a runoff coefficient of 0.200. Using the runoff generated from a hypothetical 0.25-inch rain event and the weight of solids used for each experiment, the equivalent runoff TSS concentration used in the pilot test experiments was calculated for each test. A summary of this information is given in Table 4-17. The equivalent runoff TSS concentrations for the 12 test runs ranged from 12.0-42.2 mg/l. Concentrations within this range are typical of the variability observed in TSS concentrations from residential areas over an annual cycle.

The solids utilized in the pilot testing consisted of a combination of leaves, vegetation, small gravel, sand, and silt which was collected from the residential area. A photograph of accumulated solids in the Hydro-Kleen Filter Unit during the pilot testing is given in Figure 4-24.

Figure 4-24. Accumulated Solids in the Hydro-Kleen Filter Unit.

4.3.1 <u>Hydraulic Characteristics of the Hydro-Kleen Filter Unit</u>

The hydraulic characteristics of the Hydro-Kleen Filter Unit were measured prior to each pilot test experiment. During each hydraulic evaluation, clean water was allowed to discharge into the unit until an equilibrium inflow was reached where the water level inside the filter rose to the top of the unit without overflowing. Once this flow rate was established, the volume of water added over a measured period of time was used to determine the hydraulic acceptance rate through the filter unit.

A summary of the results of the hydraulic testing performed on the Ultra-Urban Filter Unit is given in Table 4-18 for each of the 12 experiments. The initial flow rate of the system, performed using new filter cartridges provided by the City of Palm Bay, was slightly >16 gpm. This is the maximum rate at which water could be introduced into the unit without overflow through the orifice holes. This initial test value is substantially lower than the rated flow capacity of 40-50 gpm for the unit stated by Hydro Compliance Management, Inc.

TABLE 4-18

HYDRAULIC CHARACTERISTICS OF THE HYDRO-KLEEN FILTER UNIT MEASURED PRIOR TO EACH PILOT TEST EXPERIMENT

PILOT TEST EXPERIMENT NO.	VOLUME OF WATER ADDED (gallons)	TIME (minutes)	FLOW RATE (gpm)
1	25.5	1.58	16.14
2	14	1.38	10.12
3	11.5	1.30	8.85
4	9	1.62	5.57
5	6.75	2.38	2.84
6	7	2.35	2.98
7	7.5	2.90	2.59
8	8	3.52	2.27
9	7.25	3.57	2.03
10	7.75	3.82	2.03
11	8.25	4.00	2.06
12	4.75	2.35	2.02

However, after the initial experiment, the hydraulic characteristics of the Hydro-Kleen Filter Unit declined rapidly, decreasing to an equilibrium flow rate of approximately 2 gpm after pilot test experiment #8. After eight pilot test events, the filter unit would have received the suspended solids equivalent of approximately 8 storm events with a rainfall depth 0.25 inches or 2.00 inches of total rainfall. A graphical representation of the hydraulic performance of the Hydro-Kleen Filter Unit during pilot testing is given in Figure 4-25.

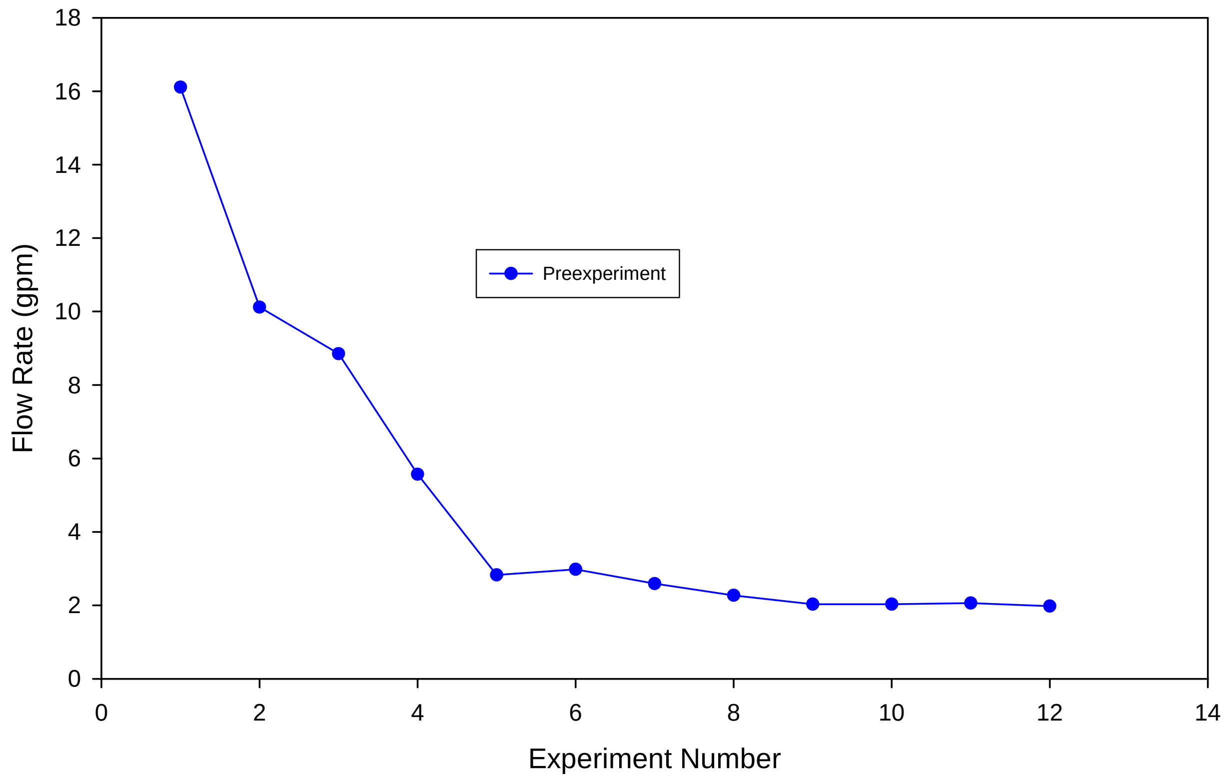


Figure 4-25. Hydraulic Performance of the Hydro-Kleen Filter Unit During Pilot Testing.

After the ninth pilot test experiment, visible debris resting on top of the filter cartridges was removed in an attempt to restore hydraulic capacity to the unit. Since the Hydro-Kleen unit contains cartridges, it did not seem feasible to attempt to remove debris by turning the unit upside down similar to the activities performed on the Ultra-Urban Filter System. However, removing the accumulated solids from the top of the filter cartridges did not appear to enhance the performance efficiency of the unit which remained at an equilibrium flow of approximately 2 gpm.

A comparison of the hydraulic characteristics of pilot tests conducted with the Hydro-Kleen Filter Unit is given in Table 4-19. In general, pilot testing was conducted at flow rates of approximately 20-50% of the maximum hydraulic capacity of the unit at the time of each pilot test experiment. This range of inflow values was selected to avoid overflowing of the filter and loss of solids in the overflow.

TABLE 4-19

HYDRAULIC CONDITIONS DURING HYDRO-KLEEN FILTER PILOT TESTING

PILOT TEST EXPERIMENT NO.	VOLUME OF WATER USED (gallons)	TIME (minutes)	MEAN FLOW RATE (gpm)
1	12.5	2.05	6.10
2	8	1.95	4.10
3	6.5	2.42	2.42
4	6.5	4.03	1.61
5	7.5	4.38	1.71
6	4.5	6.68	0.67
7	4	6.15	0.65
8	5.5	6.28	0.88
9	4	7.57	0.53
10	4.75	7.68	0.62
11	4.25	7.42	0.57
12	4.25	7.32	0.58

Similar to the condition observed with the Ultra-Urban Filter, whenever the inflow into the Hydro-Kleen Filter Unit began to approach the hydraulic capacity of the unit, floating debris (primarily consisting of leaves) would begin to overflow the unit and, in a real application, would enter into the outfall stormsewer line. Discharge of floating leaves in the overflow of the Hydro-Kleen Filter Unit is illustrated in Figure 4-26. Although overflow of the unit is less of a problem when the unit operates at the maximum hydraulic capacity for the filter at a given time, it becomes much more significant as the filter begins to become clogged and the hydraulic flow rate begins to drop to approximately 2 gpm. This inflow rate would be exceeded by virtually any storm event, causing overflow and discharge of floatable debris not only in the incoming stormwater flow but also from material which had previously accumulated within the unit.

Figure 4-26. Loss of Leaves During Overflow of the Hydro-Kleen Filter Unit.

4.3.2 Pilot Test Results

4.3.2.1 Characteristics of Residential Solids

Twelve separate pilot test experiments were conducted with the Hydro-Kleen Filter Unit with dried solids masses ranging from 225.56-792.02 g per test. Standard grain size analyses were performed on each of the 12 samples used during the pilot testing. Results of the individual grain size analyses for the 12 solids samples are given in Appendix F.2.

A statistical comparison of the distribution of particle sizes in residential solids used in the Hydro-Kleen pilot testing is given in Figure 4-27 in the form of box and whisker plots. The largest particle fraction, in terms of sample mass, is the 250 µm fraction which comprised approximately 32% of the total solids mass used in each test. Approximately 20% of the solids were contributed by particles in the 425 µm and 180 µm range each, with approximately 14% contributed by particles >2000 µm. Each of the remaining particle sizes contributed approximately 10% or less of the total mass of solids used in each test. The smallest mass of particles contained within the residential solids is in particle sizes <75 µm.

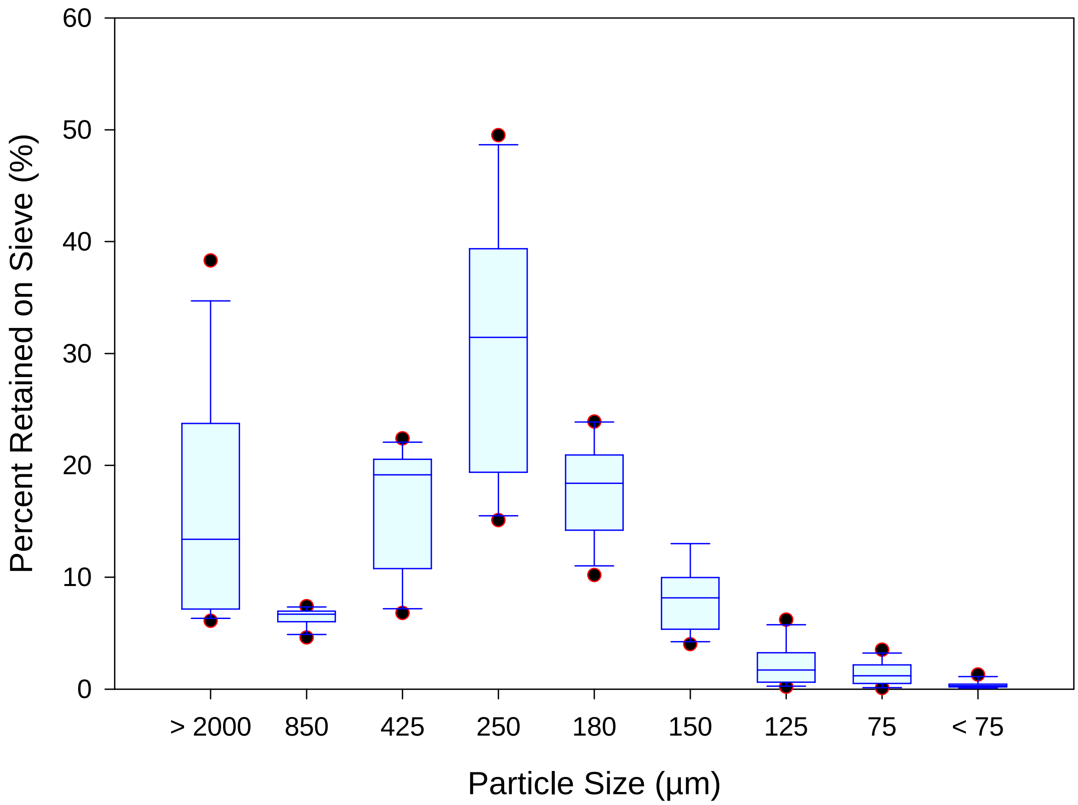


Figure 4-27. Distribution of Particle Sizes in Residential Solids Used in the Hydro-Kleen Pilot Testing.

The results of lab analyses of nitrogen and phosphorus in the residential solids used in pilot test experiments are given in Appendix F.2. Concentrations of total nitrogen by particle size in residential solids used in the Hydro-Kleen pilot testing are summarized in Figure 4-28. Although particles <75 µm in size represent the smallest mass of particles present in the residential solids, these particles contain the highest concentration of total nitrogen, with a median concentration of approximately 45,000 µg total nitrogen per gram of particle in this size range. Relatively elevated concentrations of total nitrogen were also observed in the >2000 µm and 850 µm categories, with median total nitrogen concentrations of approximately 30,000 µg/g and 35,000 µg/g, respectively. A nitrogen concentration of approximately 22,000 µg/g was also observed in the 75 µm particle range. The remaining particle sizes contained approximately 10,000 µg total nitrogen per gram of solids in each range.

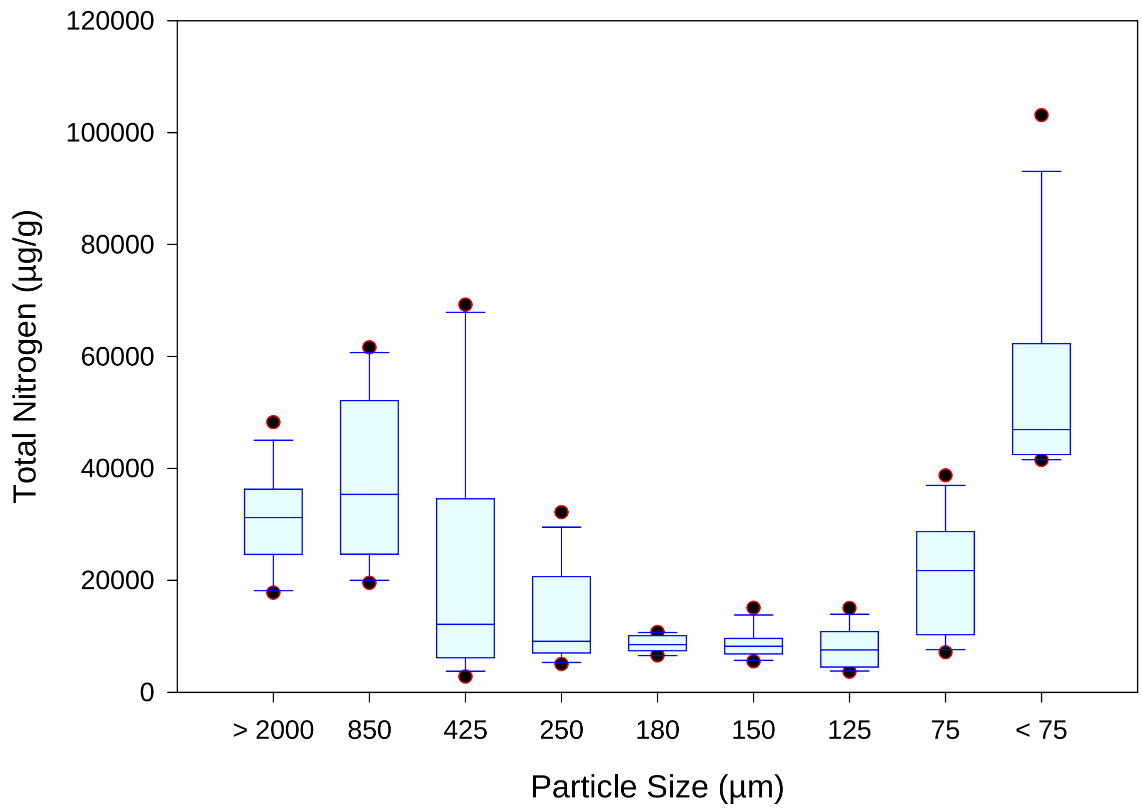


Figure 4-28. Concentrations of Total Nitrogen by Particle Size in Residential Solids Used in the Hydro-Kleen Pilot Testing.

A statistical comparison of concentrations of total phosphorus by particle size in residential solids used in the Hydro-Kleen pilot testing is given in Figure 4-29. Similar to the results obtained for total nitrogen, the highest total phosphorus concentrations were found in particles <75 µm in size, with a median concentration of approximately 16,000 µg total phosphorus per gram of particle within this range. The second highest phosphorus concentration was found in particles in the 75 µm range, with a median concentration of approximately 7000 µg total phosphorus per gram. Particles in the >2000 µm and 850 µm range were found to have total phosphorus concentrations of approximately 4000 µg/g. Phosphorus concentrations in the remaining particle sizes averaged approximately 2500 µg/g or less.

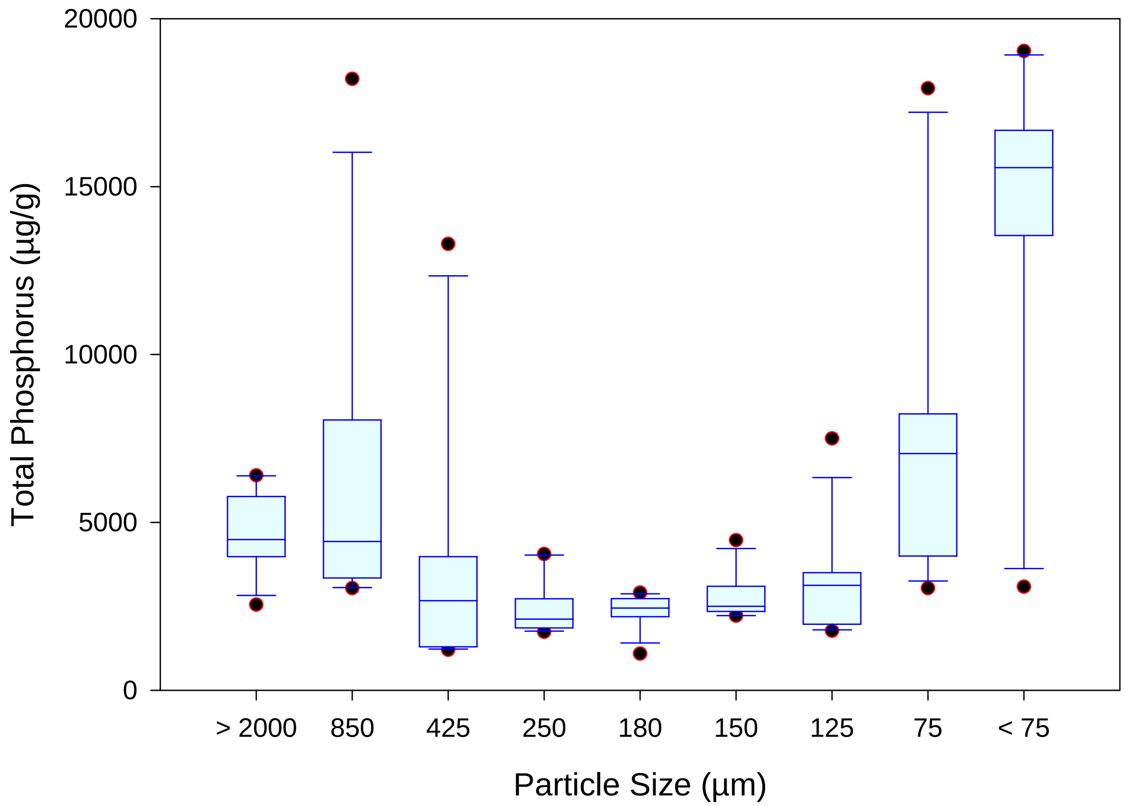


Figure 4-29. Concentrations of Total Phosphorus by Particle Size in Residential Solids Used in the Hydro-Kleen Pilot Testing.

The relative mass of total nitrogen contributed by various particle sizes in the residential solids used in the Hydro-Kleen pilot testing is given in Figure 4-30. In this comparison, the sum of the total nitrogen mass in the individual fractions is equal to the raw concentration. This figure provides a summary of the relative mass of total nitrogen contained within the solids samples which is contributed by each of the evaluated particle size fractions. The largest contribution of nitrogen mass occurs from particles >2000 µm in size. This fraction appears to contribute approximately 30% of the total nitrogen contained within the overall test sample. Approximately 15-20% of the total nitrogen is contributed by particle sizes of 250 and 425 µm. Approximately 10-15% of the total nitrogen is contributed by particle sizes of 180 and 850 µm, with relatively small contributions from particles <180 µm.

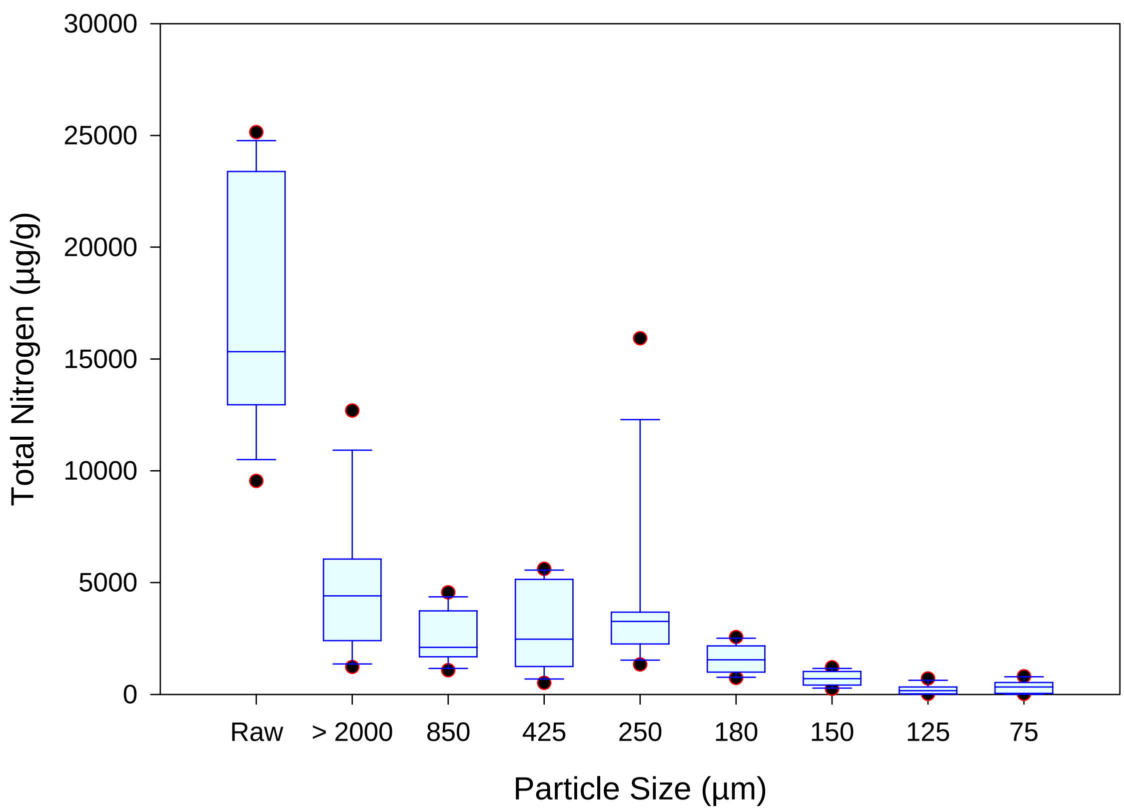


Figure 4-30. Relative Contributions of Total Nitrogen by Particle Size in Residential Solids Used in the Hydro-Kleen Pilot Testing.

Relative contributions of total phosphorus by particle size in the residential solids used in the Hydro-Kleen pilot testing are summarized in Figure 4-31. In this comparison, the sum of the total phosphorus mass in the individual fractions is equal to the raw concentration. The largest contribution of total phosphorus is provided by particles >2000 µm in size and particles in the 250 µm range. Particles in these range categories contribute approximately 20-30% of the total phosphorus present in the raw sample. Particles in the 850 and 425 µm range each contribute approximately 10-15% of the total phosphorus in the sample. Similar to the situation observed for total nitrogen, a relatively small portion of the overall total phosphorus content is contributed by particles of 180 µm or less in size, even though some of these particles contain the highest unit concentration of total phosphorus.

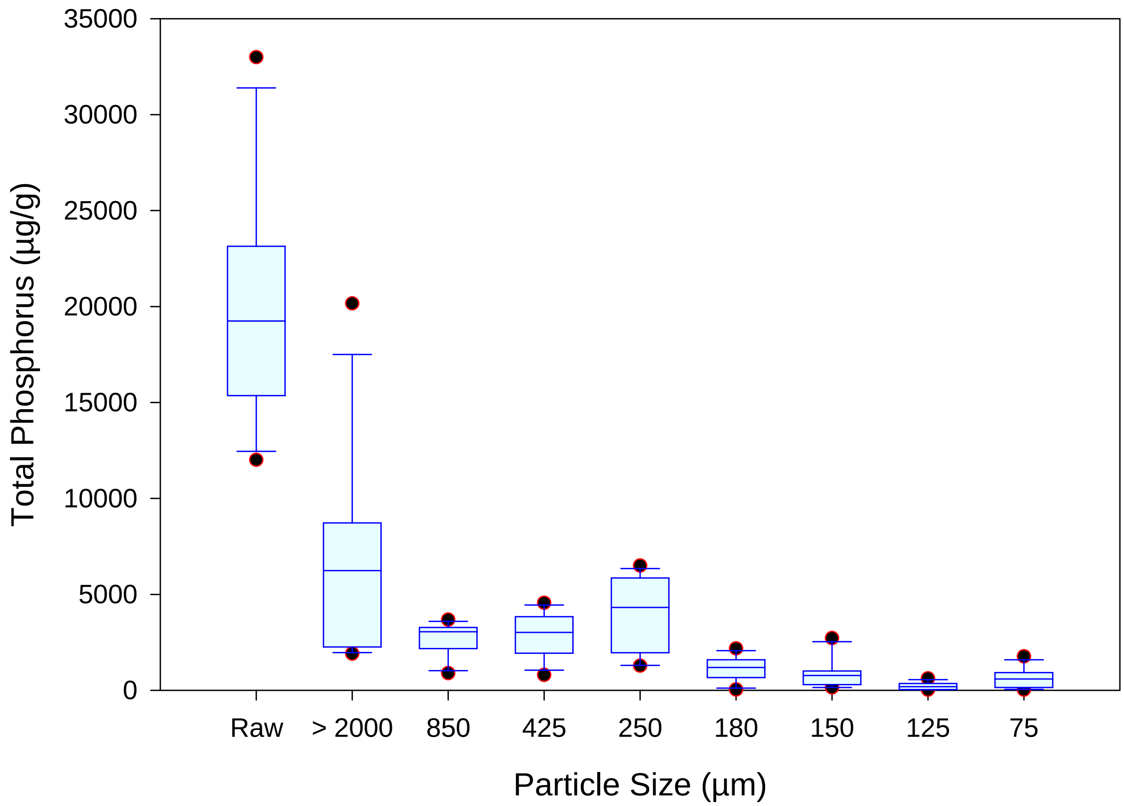


Figure 4-31. Relative Contributions of Total Phosphorus by Particle Size in Residential Solids Used in the Hydro-Kleen Pilot Testing.

4.3.2.2 Characteristics of Test Water

A summary of the physical and chemical characteristics of the test water used in pilot test experiments for the Hydro-Kleen Filter Unit is given in Table 4-20. All test water used for testing with the Hydro-Kleen Filter was obtained from Lake Conway. Two separate bulk quantities of test water were used during the Hydro-Kleen experiments. One bulk test water sample was used to conduct experiments 1-3. The second bulk test water sample was used to conduct pilot test experiments 4-12 since, as indicated in Table 4-19, very little water was used during the later pilot tests for the Hydro-Kleen Filter due to the extremely low hydraulic conductivity of the filter unit.

As seen in Table 4-20, the test water was characterized by a relatively low TSS concentration of approximately 2.5 mg/l. On an average basis, approximately 36% of the TSS was present in particles <11 μm in size. Approximately 20% of the TSS in the test water was present as particles >180 μm in size. The remaining particle size categories contributed approximately 10-15% or less of the total TSS in the test water.

A similar situation was observed for VSS concentrations in the test water. Approximately 41% of the VSS in the test sample was contributed by particles <11 μm in size, suggesting organic matter such as algal cells. The remaining particle fractions contributed approximately 10-20% of the VSS measured in the test water for each particle fraction.

The total nitrogen measured in the test water was relatively low in value, with a mean concentration of 545 μg/l. The vast majority of this, approximately 95%, was contributed by particles <11 μm in size which included algal cells as well as dissolved nitrogen constituents. The remaining particle sizes contributed approximately 2% or less of the total nitrogen measured in the raw sample.

A similar situation was observed for total phosphorus. Approximately 94% of the total phosphorus was observed in particles <11 μm in size, which includes algal cells and dissolved phosphorus compounds. The remaining particle sizes contributed approximately 2% or less of the total phosphorus measured in the test water.

TABLE 4-20

CHARACTERISTICS OF RAW WATER SAMPLES USED IN HYDRO-KLEEN FILTER PILOT TESTING

EXPERIMENT NO.	TSS CONCENTRATION (mg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.9	0.4	0.2	0.3	0.0	0.2	1.1	3.1
4-12	0.2	0.1	0.2	0.1	0.4	0.2	0.7	1.9
Mean	**0.5**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.9**	**2.5**

EXPERIMENT NO.	VSS CONCENTRATION (mg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.0	0.3	0.1	0.2	0.4	0.3	0.9	2.2
4-12	0.1	0.0	0.0	0.1	0.3	0.1	0.6	1.2
Mean	**0.1**	**0.2**	**0.1**	**0.2**	**0.4**	**0.2**	**0.7**	**1.7**

EXPERIMENT NO.	TOTAL NITROGEN CONCENTRATION (µg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	4.1	2.2	0.8	2.1	4.6	16.6	573	603
4-12	1.4	2.1	1.4	1.1	5.1	8.9	457	487
Mean	**2.7**	**2.1**	**1.1**	**1.6**	**4.8**	**12.8**	**520**	**545**

EXPERIMENT NO.	TOTAL PHOSPHORUS CONCENTRATION (µg/l)							
	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total
1-3	0.1	0.1	0.1	0.7	0.1	0.3	22.7	24
4-12	0.1	0.1	0.4	0.3	0.1	0.3	16.7	18
Mean	**0.1**	**0.1**	**0.2**	**0.5**	**0.1**	**0.3**	**19.7**	**21**

4.3.2.3 <u>Characteristics of Filter Outflow</u>

Composite samples of outflow from the Hydro-Kleen Filter were collected during each of the 12 pilot test experiments and analyzed for TSS, VSS, total nitrogen, and total phosphorus by particle size fraction. A complete listing of lab analyses for TSS, total nitrogen, and total phosphorus on outflow samples from the Hydro-Kleen Filter by particle size is given in Appendix G.2. A distribution of TSS in the outflow from the Hydro-Kleen Filter as a function of particle size during pilot testing is given in Figure 4-32. In general, low TSS concentrations in the outflow were observed for particles >180 µm and in the 140 and 100 µm ranges. More elevated TSS concentrations were observed for particle sizes of approximately 60 µm and less. The data in Figure 4-32 suggest that the Hydro-Kleen Unit is not as effective as the Ultra-Urban Filter in removing TSS particles <60 µm in size.

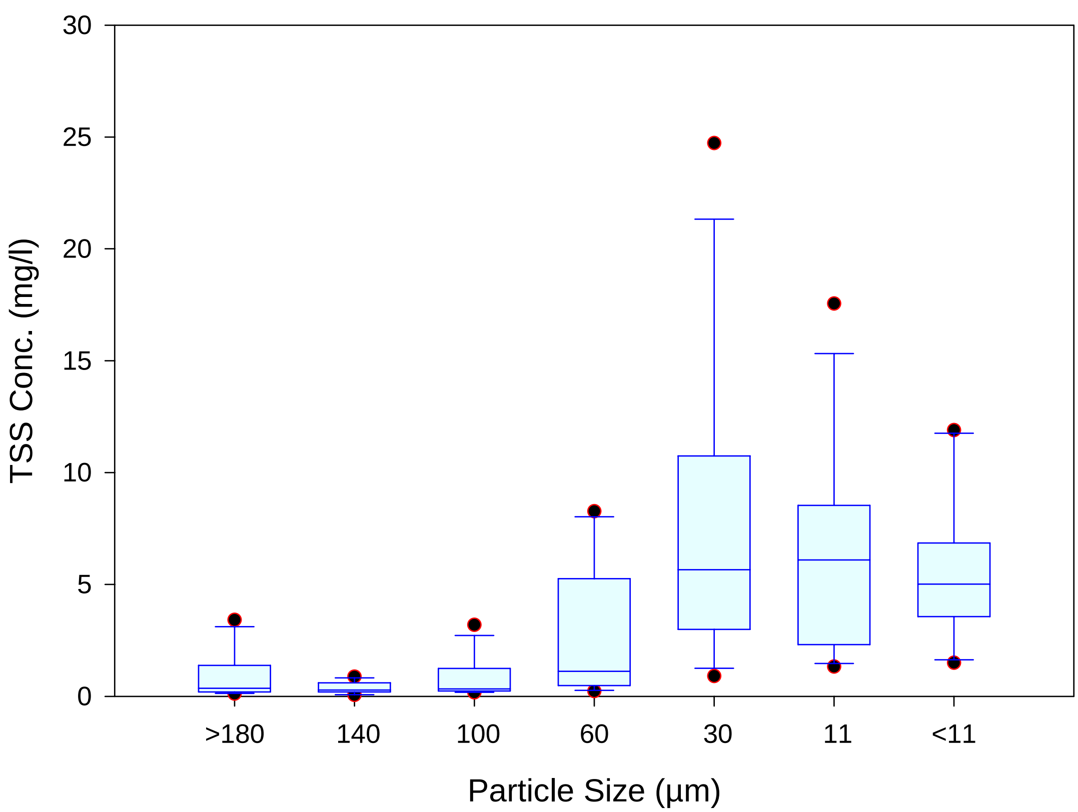


Figure 4-32. Distribution of TSS in the Outflow from the Hydro-Kleen Filter During Pilot Testing.

Distribution of VSS particles in the outflow from the Hydro-Kleen Filter during pilot testing is illustrated in Figure 4-33. In general, the distribution of VSS particles is similar to that exhibited by TSS. Low VSS concentrations were observed for particles of approximately 100 µm or greater, while somewhat larger VSS concentrations were observed for particles of approximately 60 µm or smaller. The data in Figure 4-33 suggest that the Hydro-Kleen Unit is less effective in removing VSS particles <60 µm in size than was observed for the Ultra-Urban Filter Unit.

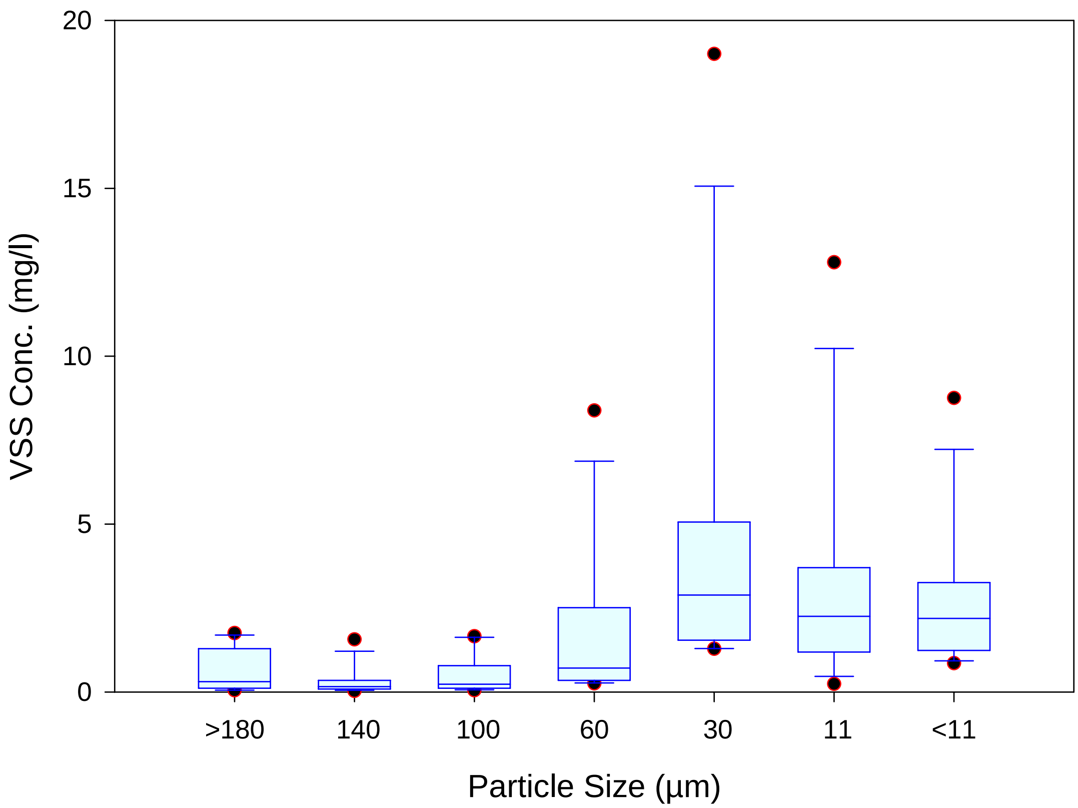


Figure 4-33. Distribution of VSS in the Outflow from the Hydro-Kleen Filter During Pilot Testing.

Distribution of total nitrogen particles in the outflow from the Hydro-Kleen Filter during pilot testing is illustrated in Figure 4-34. In general, extremely low nitrogen concentrations were measured for particle sizes of approximately 60 µm or greater. Nitrogen concentrations for particles in the 30 µm and 11 µm range appear to be slightly higher in concentration . However, for particle sizes <11 µm, a substantially elevated total nitrogen concentration was observed. This value reflects a combination of small particles which may have passed through the filter as well as dissolved nitrogen species.

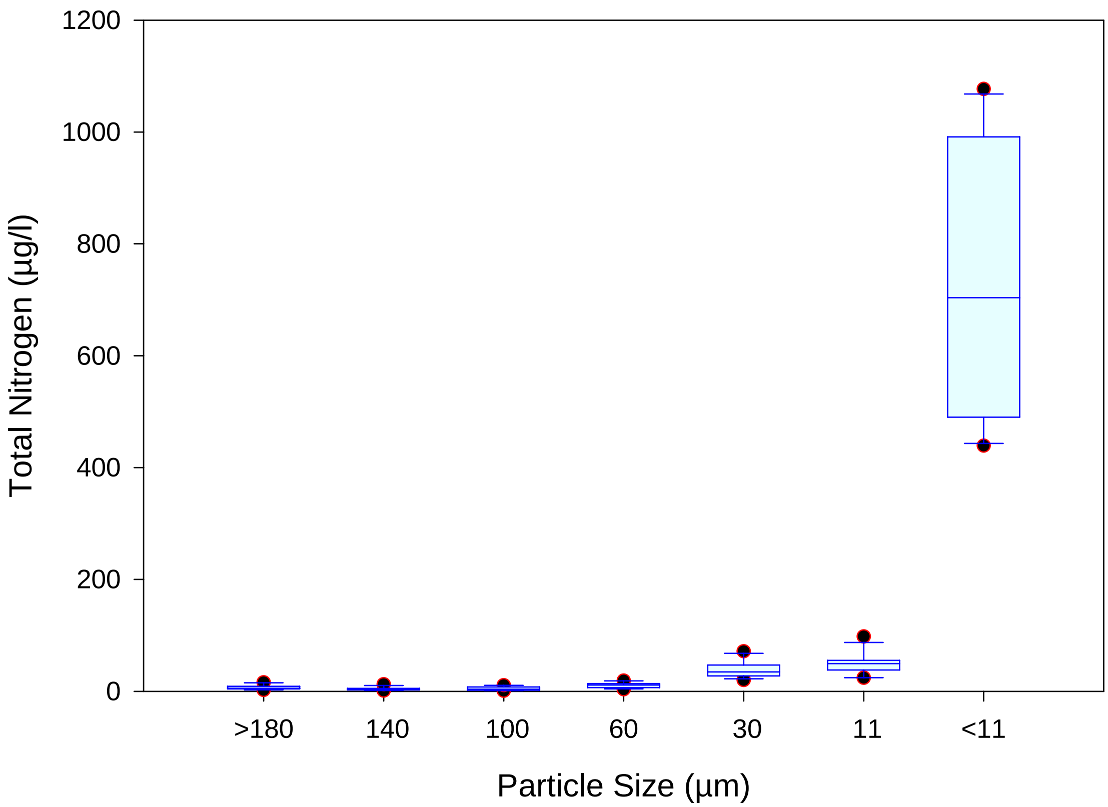


Figure 4-34. Distribution of Total Nitrogen in the Outflow from the Hydro-Kleen Filter During Pilot Testing.

A distribution of total phosphorus particles in the outflow from the Hydro-Kleen Unit during pilot testing is illustrated in Figure 4-35. Similar to the trend observed for total nitrogen, extremely low phosphorus concentrations were observed for particle sizes of approximately 60 µm in size, with slightly higher concentrations observed for particles in the 30 µm and 11 µm range. However, a substantially elevated total phosphorus concentration was observed for particles <11 µm in size which reflects a combination of small particles passing through the filter and dissolved phosphorus species.

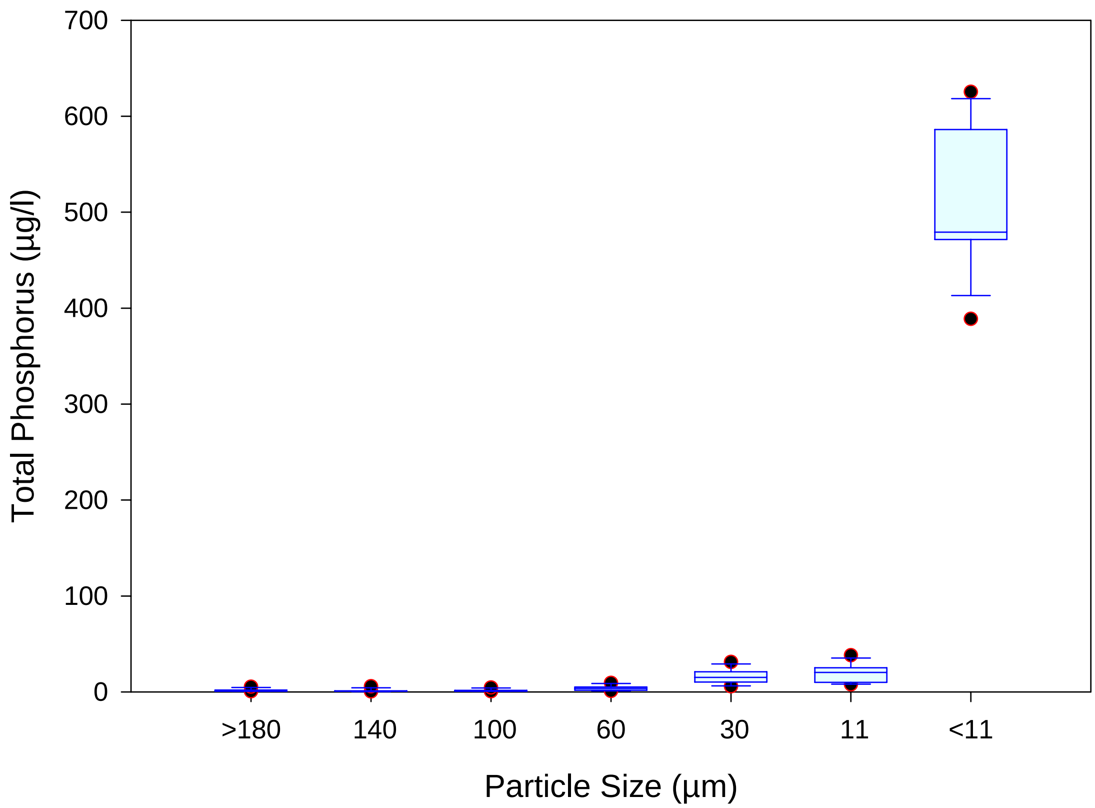


Figure 4-35. Distribution of Total Phosphorus in the Outflow from the Hydro-Kleen Filter During Pilot Testing.

4.3.2.4 Removal Effectiveness

Estimates of the mass removal effectiveness of the Hydro-Kleen Filter were calculated for TSS, total nitrogen, and total phosphorus for each of the 12 pilot test experiments. The concentrations of TSS, total nitrogen, and total phosphorus measured in each particle fraction discharging from the filter was multiplied times the volume of water used during each pilot test experiment, summarized in Table 4-15, to obtain an estimate of the total mass of suspended solids, nitrogen, and phosphorus discharging through the filter for each particle fraction. The mass associated with each particle fraction was then added together to provide an estimate of the total mass discharged from the filter. The inflow into the filter was calculated as the mass of suspended solids, total nitrogen, and total phosphorus contained in the raw solids sample as well as in the water volume used during each experiment. The difference between the inflow and outflow mass is used to calculate percent removal for each experiment.

Calculated mass removal efficiencies for the Hydro-Kleen Filter during pilot testing are summarized in Table 4-21. Removal efficiencies for TSS, total nitrogen, and total phosphorus in individual particle fractions exceeded 98% during each of the 12 pilot test experiments, with an overall TSS removal efficiency of >99.9%, a total nitrogen removal efficiency of 99.8%, and a total phosphorus removal efficiency of 99.3%. It appears that the Hydro-Kleen Filter is extremely effective in retaining particulate matter within the unit and in producing extremely high removal efficiencies for the water volume that passes through the filter.

However, as discussed previously, the hydraulic efficiency of the Hydro-Kleen Filter decreased rapidly during the pilot test experiments, with an equilibrium water acceptance rate of approximately 2 gpm. The amount of solids added during each pilot test experiment is roughly equivalent to the amount of suspended solids which would be deposited onto the Hydro-Kleen Filter during a typical 0.25-inch rain event within the contributing watershed. A hydrologic model was developed for the Hydro-Kleen Filter, similar to the hydrologic model discussed in Section 4.1.1.2 for the Stormceptor Unit, to generate estimates of runoff volumes which would reach the Hydro-Kleen Filter site during each of the measured rain events during the field

TABLE 4-21
CALCULATED MASS REMOVAL EFFECTIVENESS OF THE HYDRO-KLEEN FILTER DURING PILOT TESTING

Exp. #	Volume (gal)	Outflow TSS Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
1	12.5	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	777.78	100.0
2	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	594.34	>99.9
3	6.5	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	655.25	>99.9
4	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	792.02	>99.9
5	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	535.26	>99.9
6	4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	761.21	>99.9
7	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	637.11	>99.9
8	5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	700.97	>99.9
9	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	691.80	>99.9
10	4.75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	300.97	>99.9
11	4.25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	225.56	>99.9
12	4.25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	301.08	>99.9
	Mean	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**581.113**	**>99.9**

Exp. #	Volume (gal)	Outflow Total Nitrogen Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
13	12.5	0.001	0.000	0.001	0.001	0.002	0.002	0.051	0.057	19.60	99.7
14	8	0.000	0.000	0.000	0.001	0.002	0.002	0.032	0.037	9.63	99.6
15	6.5	0.000	0.000	0.000	0.000	0.001	0.002	0.019	0.023	8.42	99.7
16	6.5	0.000	0.000	0.000	0.000	0.001	0.001	0.025	0.027	8.38	99.7
17	7.5	0.000	0.000	0.000	0.000	0.001	0.002	0.027	0.030	10.67	99.7
18	4.5	0.000	0.000	0.000	0.000	0.000	0.001	0.012	0.014	8.67	99.8
19	4	0.000	0.000	0.000	0.000	0.001	0.001	0.009	0.011	7.27	99.9
20	5.5	0.000	0.000	0.000	0.000	0.001	0.001	0.009	0.012	9.13	99.9
21	4	0.000	0.000	0.000	0.000	0.001	0.001	0.007	0.008	8.94	99.9
22	4.75	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.014	10.07	99.9
23	4.25	0.000	0.000	0.000	0.000	0.001	0.001	0.007	0.009	7.02	99.9
24	4.25	0.000	0.000	0.000	0.000	0.000	0.001	0.010	0.012	5.39	99.8
	Mean	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**0.001**	**0.018**	**0.021**	**9.432**	**99.8**

Exp. #	Volume (gal)	Outflow Total Phosphorus Mass (g)								Inflow (g)	Percent Removal (%)
		>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11 µm	Total (g)		
13	12.5	0.000	0.000	0.000	0.000	0.001	0.001	0.024	0.026	2.89	99.1
14	8	0.000	0.000	0.000	0.000	0.001	0.001	0.019	0.021	1.77	98.8
15	6.5	0.000	0.000	0.000	0.000	0.001	0.001	0.015	0.016	2.10	99.2
16	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.014	2.41	99.4
17	7.5	0.000	0.000	0.000	0.000	0.001	0.001	0.017	0.019	1.65	98.9
18	4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.007	1.67	99.6
19	4	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.008	1.74	99.6
20	5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.011	1.85	99.4
21	4	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.008	2.16	99.6
22	4.75	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.009	1.52	99.4
23	4.25	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008	0.98	99.2
24	4.25	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008	1.40	99.4
	Mean	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.012**	**0.013**	**1.85**	**99.3**

monitoring program from September 2005-February 2006. The plot of hydraulic performance vs. time for the Hydro-Kleen Filter Unit, presented in Figure 4-25, is used to model decreases in the infiltration capacity of the filter over time. Each pilot test experiment is assumed to represent 0.25 inches of rainfall, and the infiltration capacity of the unit is assumed to decrease based on cumulative rainfall measured at the monitoring site. After a total rainfall of 2.5 inches, the flow through the Hydro-Kleen Filter is assumed to be constant at approximately 2 gpm.

The hydraulic simulation assumes that the Hydro-Kleen Filter will accept water at the equilibrium hydraulic rate during storm events, with the remainder of the runoff volume bypassing the unit and entering directly into the downstream stormsewer system. Separate removal efficiencies were calculated for final equilibrium flow rates of 2.0 gpm, which is the equilibrium acceptance rate of the Hydro-Kleen Filter Unit measured during the hydraulic testing, as summarized in Table 4-18, and for an equilibrium filter flow rate of 16.1 gpm, representing the initial hydraulic acceptance rate of the cleaned unit. Overall mass removal efficiencies are also calculated for an equilibrium filter flow rate of 6.6 gpm, a flow rate used in estimation of removal efficiencies for the Ultra-Urban Unit, for comparison purposes.

A summary of the estimated mass removal efficiency of the Hydro-Kleen Filter Unit for TSS, total nitrogen, and total phosphorus under actual field conditions is given in Table 4-22, assuming a mean removal efficiency of 99% for TSS, total nitrogen, and total phosphorus for water which migrates through the Hydro-Kleen Filter Unit. At an equilibrium flow rate of 2.0 gpm, the estimated mass removal efficiency for TSS, total nitrogen, and total phosphorus over the 170-day monitoring period would be 2.6%. If the equilibrium filter flow rate could be maintained at the initial hydraulic flow capacity of 16.1 gpm, the filter would have provided a 16.0% removal for TSS, total nitrogen, and total phosphorus. If the equilibrium filter flow rate is assumed to be 6.6 gpm, the mass treatment removal efficiency increases to 5.6%. This equilibrium flow rate was also tested in the Ultra-Urban Filter System which indicated a removal efficiency of 4.3%.

TABLE 4-22

ESTIMATED OVERALL MASS REMOVAL EFICIENCY OF THE HYDRO-KLEEN UNIT FOR TSS, TOTAL NITROGEN , AND TOTAL PHOSPHORUS UNDER ACTUAL FIELD CONDITIONS

EQUILIBRIUM FILTER FLOW RATE (gpm)	MASS TREATMENT EFFICIENCY[1] (%)
2.0	2.6
6.6	5.6
16.1	16.0

1. Assuming a mean removal of 99% for TSS, total nitrogen, and total phosphorus in the Hydro-Kleen Filter Unit

4.2.3.5 Summary

In summary, it appears that the Hydro-Kleen Filter is extremely effective in removing and retaining solids in stormwater runoff for particle sizes as low as 11 μm. Measured removal efficiencies for TSS, total nitrogen, and total phosphorus, based upon the acceptance flow rate for the filter unit, exceeds 99%. However, it appears that the hydraulic performance of the system decreases rapidly, reaching levels of approximately 10% of the initial flow capacity after only 1-2 inches of rainfall passes through the unit. Based upon the actual field conditions for the Palm Bay installation, the estimated removal for TSS, total nitrogen, and total phosphorus at the Hydro-Kleen Filter site would have been approximately 3-5% or less.

APPENDICES

APPENDIX A

PRODUCT INFORMATION FOR THE STORMCEPTOR SEPARATOR UNIT

Stormceptor

Engineers Contractors Developers

Product Specifications > Drawings > Engineers > Drawings > Contact Us > Tendering Specs

Corporate Center

- Contact Us
- About Us
- Publications
- Careers

- Sizing Tool
- Drawings
- Tendering Specs
- Installation Procedures
- Maintenance
- Design Considerations

Need a STORMCEPTOR?

➔ Tendering Specifications

SAMPLE SPECIFICATION

Oil/Sediment In-Line Separator Unit

The oil/sediment separator unit shall be a Stormceptor® model as manufactured by a licensed S affiliate, or approved equal.

The separator shall remove oil and sediment from storm water during frequent wet weather eve shall treat a minimum of 75 to 90 percent of the annual runoff volume and be capable of removi percent of the total suspended sediment load (TSS) and 60 to 95 percent of the floatable free oi must be capable of trapping silt and clay size particles in addition to large particles. The separat underground as part of the storm sewer system and be structurally designed for HS-20 (OHBDC the surface. The storage in the separator shall be vertically oriented. The separator shall be mai surface via one access point without requiring entry into the separator.

The separator shall be equipped with an internal high flow bypass that regulates the flow rate in chamber and conveys high flows directly to the outlet such that scour and/or re-suspension of m collected in the separator does not occur.

External bypasses are not acceptable. The bypass area shall be physically separated from the se prevent mixing. The separator shall be circular, and constructed from either fiberglass or precast The concrete separator shall be designed and manufactured in accordance with ASTM C-478. Th shall be oil resistance, water tight and meet the design criteria according to ASTM C-443. In the Stormceptor®, a fiberglass insert, bolted and sealed watertight to the inside of the bypass cham to normal stormwater flows into the treatment chamber. The first 16 inches (405 mm) of oil stor with fiberglass to prevent migration through the pores in the concrete.

The difference between the inlet pipe elevation to the separator and the outlet pipe elevation fr shall be 1 inch (25 mm). For a multiple inlet pipe design there is a 3-inch (75 mm) difference be inverts and the outlet pipe invert. The separator shall be able to be used as a bend structure in t system. The access cover for the separator shall clearly indicate that it is an oil/sediment separa

The separator shall be capable of containing spills of floatable substances such as free oil and n by temporary backwater conditions (i.e., trapped pollutants should not be re-suspended and sco separator during backwater conditions). The capabilities of the selected separator must be docu scientific studies and reports.

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Stormceptor 12 Madison Ave. Toronto, Ontario M5R 2S1 Canada

A MONTECO Company

Product Specifications

Contact your local Stormceptor® Manufacturer for Manufacturer Specifications in your area Conf

Inlet Unit | Single Inline Unit | Multiple Inline Unit | Series Inline Unit | Submerged Inline
Frame and Cover | Inlet / Outlet Elevation Difference | Stormceptor®Capacities
Influent and Effluent Pipe Diameter | Head Loss Through the Stormceptor® | Installation

Inlet Unit

[STC300/450 only]

- Grated opening at surface.
- Grated opening oriented directly over orifice plate/drop tee assembly.
- Outlet is oriented 180 degrees to orifice plate/drop tee assembly.
- Accommodates up to three horizontal inlet pipes.
- Useable as a bend structure.
- Minimum direction change from horizontal inlet to outlet is 90 degrees
- Minimum depth from finished grade to outlet invert (contact your local Stormceptor® Affiliate)

Single Inline Unit

[STC 750/900, 1000/1200, 1500/1800, 2000/2400, 3000/3600,4000/4800, 5000/6000, 6000/72(

- Frame and cover are orientated directly over riser pipe and oil port.
- Useable as a bend structure.
- Minimum direction change from inlet to outlet is 90 degrees

Multiple Inline Unit

[STC 750/900, 1000/1200, 1500/1800, 2000/2400, 3000/3600, 4000/4800,5000/6000, 6000/72(

- Frame and cover orientated directly over riser pipe and oil port.
- Accommodates up to two horizontal inlet pipes
- Useable as a bend structure.
- Minimum direction change from either inlet to the outlet is 90 degrees

Series Inline Unit

[STC 9000/11000, 10000/13000, 14000/16000]

- Two 2.4 m (8') diameter upper by-pass structures
- Two 3.0 m (10') or 3.7 m (12') diameter treatment chambers
- Inlets and outlet of upstream structures must be 180 degrees.
- Minimum direction change from inlet to outlet of downstream structure is 90 degrees.

- Joining weir must be installed between both units.
- Frame and covers orientated to over riser pipes and oil ports in both units.

Submerged Inline Units

- Extended weir and second drop tee height are custom designed based on tailwater elevation.
- Height of weir corresponds to the difference of outlet invert and tail water elevation.
- Weir can be extended to a maximum of 45" from the outlet elevation (including the existing weir).

Frame and Cover

Cover embossed with Stormceptor® Two 25 mm (1") square pick-holes for removal and air qual There are standard design parameters that must be provided in any storm sewer design, which i installation of a Stormceptor®.

Inlet / Outlet Elevation Difference

There is a 25.4mm (1") difference in elevation between the inlet invert and the outlet invert in a designed for one inlet. There is a 76.2mm (3") difference in elevation between the inlet invert ar in a Stormceptor® designed for multiple inlets. Storm sewer designs must take this elevation dif account. This elevation difference is constant for all Stormceptor® applications.

Stormceptor®Capacities

Model STA/STC

USA	Canada	Down Pipe Diameter / Orifice mm (inches)	Sediment Capacity L (ft3)	Oil Capacity L (USG)	Total
450	300	300 (12)**	1275 (45)	325 (85)	
900	750	150 (6)	2460 (87)	915 (242)	
1200	1000	150 (6)	3260 (115)	915 (242)	
1800	1500	150 (6)	5660 (200)	915 (242)	
2400	2000	200 (8)	6150 (217)	2945 (778)	
3600	3000	200 (8)	10415 (368)	2945 (778)	
4800	4000	250 (10)	14060 (497)	3490 (922)	
6000	5000	250 (10)	18510 (654)	3490 (922)	
7200	6000	300 (12)	23445 (828)	4150 (1096)	

* approximate flowrate without by-passing

** outlet restricted to 100 mm (4") diameter

Influent and Effluent Pipe Diameter

Flexible rubber boots are attached to the influent and effluent pipes to facilitate the installation c the Stormceptor® These boots are required for the fiberglass Stormceptor® as well as most cor certain exceptions.

The influent/effluent pipes can be grouted into the concrete Stormceptor® if desired. Pipes up t diameter can be grouted without any special preparation. Larger pipe diameters will need to be curvature of the Stormceptor® It should be noted at the time of ordering whether flexible boots

The boots that are typically used are Kor-N-Seal® Pipe Connectors. Equivalent substitute produc as long as an engineer approves them. The Kor-N-Seal® Pipe Connectors are available for pipe outside diameter (O.D.) up to 1150 mm (45") [900 mm (36") concrete I.D.]. In new developmer these pipe diameters should not be exceeded due to the source control nature of the product. Ir treatment situations, however, it may be necessary to connect a larger diameter pipe to the Stor itself. In these situations Stormceptor® should be contacted for custom manufacturing/installati design engineer should ensure that Table 1 is reviewed as well.

Head Loss Through the Stormceptor®

The measured head loss through the Stormceptor® is approximately equal to a 60° bend at a m appropriate K value to use in calculating minor losses through the storm sewer system for a Stor would be 1.3 (Minor Loss = 1.3 v2/2g).

Installation Depth

There is a minimum inlet crown (inside top of pipe) to grade elevation required to physically imp concrete Stormceptor® due to the modular construction of the structure. The minimum crown t 1m (~3'). Fiberglass units can be installed in shallow invert to grade situations. The maximum in the precast concrete Stormceptor® is 10m (~33'). The fiberglass units have been designed base depth to the bottom of the treatment chamber of 6m (~20'). The dimensions (i.e. depth of treat for various Stormceptor®units are given in Table 2.

Stormceptor® installations at depths greater than those noted above will require custom manufa

Stormceptor® should be consulted for recommendations in these instances.

Stormceptor 12 Madison Ave. Toronto, Ontario M5R 2S1 Canada

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Careers

We're looking for experts to join the Stormceptor team.

- **Regional Stormwater Specialist(s)** - technical / market stormwater expert(s)

Need a STORMCEPTOR?

Stormceptor removes oil and sediment from stormwater runoff and effectively reduces non-point source pollution from reaching receiving waters downstream.

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A MONTECO Company

Rinker MATERIALS

Stormceptor Monitoring Protocol

Please contact the Rinker Stormceptor office, with any questions regarding your monitoring program. Toll Free (800) 909-7763.

Pollutants to be Monitored

Table 1 indicates the pollutants to be monitored during the storm events and the minimum acceptable detection limit for each pollutant to be analyzed. Approved federal or state laboratory analysis methodologies are to be used for the analysis.

The optional metals indicated in Table 1 refer to the Resource Conservation Recovery Act and may be covered by a generic metals scan.

Two sediment samples are to be extracted from the monitored Stormceptor at the end of the study and analyzed for the particle size distribution and water content. A minimum of 10 particle sizes are to be used to determine the particle size distribution. Sieves to be used include the 35, 60, 100, 140, 200, 270, and 400 size. Three clay particle sizes must be analyzed to denote particle sizes between 5 and 25 μ m. The particle size distributions should be plotted on a standard grain size distribution graph.

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Table 1. Monitored Pollutants

Pollutant	Minimum Detection Limit (MDL)
Total Suspended Solids (TSS)	5 mg/l
Total Phosphorus (P)	0.02 mg/l
Total Kjeldahl Nitrogen (TKN)	0.1 mg/l
Copper (Cu)	0.001 mg/l
Cadmium (Cd)	0.005 mg/l
Lead (Pb)	0.05 mg/l
Zinc (Zn)	0.01 mg/l
Chromium (Cr)	0.01 mg/l
Total Petroleum Hydrocarbons (TPH)	1 mg/l
Conductivity	0.1 μ mho/cm
Fecal Coliform *	1 /100 ml

Additional Metals (optional)	
Arsenic (As)	0.005 mg/l
Barium (Ba)	0.01 mg/l
Mercury (Hg)	0.0005 mg/l
Selenium (Se)	0.005 mg/l
Silver (Ag)	0.01 mg/l

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Monitoring Methodology

The following monitoring protocol should be followed to ensure reasonable monitoring results and interpretation:

1. Monitoring protocols should conform to **EPA 40 CFR Part 136**.
2. The **EPA guideline of 72 hours dry period** prior to a monitoring event should be used. This will ensure that there is sufficient pollutant build-up available for wash-off during the monitored event.
3. **Flow proportional monitoring** must be conducted for the parameters indicated in Table 1. Samples should be analyzed separately for the first flush versus the remainder of the storm event. Monitoring need not extend longer than an 8-hour period after the start of the storm event (composite).
4. **Sediment sampling** (measuring the sediment depth in the unit at the beginning and end of the monitoring period) must be conducted. The water content of the sediment layer must be analyzed to determine the dry volume of suspended solids. Sediment depth sampling will indicate the rate of pollution accumulation in the unit, provide confirmation that the unit is not scouring and confirm the flow proportional monitoring results. A mass balance using the sediment sampling should be calculated to validate the flow proportional sampling.
5. **Grab sampling** (just taking samples at the inlet and outlet) is an unacceptable methodology for testing the performance of the *Stormceptor* during wet weather conditions. The oil containment area underneath the insert should be inspected via the vent pipe for dry weather spills capture once a month during the monitoring period since the flow rate of a dry weather spill may not trigger the automated samplers.
6. A tipping bucket rain gauge should be installed on-site to record the distribution of storm intensities and rainfall volume during the monitored events.
7. Results that are within the laboratory error (both inlet and outlet) or are representative of relatively clean water should be discarded. Typical concentrations of pollutants in stormwater are:

TSS	100mg/L
Total P	0.33mg/L
TKN	1.50mg/L
Total Cu	34µg/L
Total Pb	144µg/L
Total Zn	160µg/L

A threshold first flush/composite TSS value of 50 mg/L at the inlet to the *Stormceptor* should be used as the lower limit of an acceptable storm for reporting event efficiency. Monitoring results where the influent TSS concentration is less than 50 mg/L should only be used in mass load removal calculations over the entire monitoring period with other storms where the influent concentration is greater than 50 mg/L. The results should not be analyzed if the influent TSS concentrations during all monitored storms are less than 50 mg/L. Storms where the influent TSS concentration is less than 10 mg/L should be discarded from all analyses.

8. A threshold storm event volume equal to 1.5 times the storage vo lume of the Stormceptor being monitored should be used as the lower limit of an acceptable storm for monitoring.

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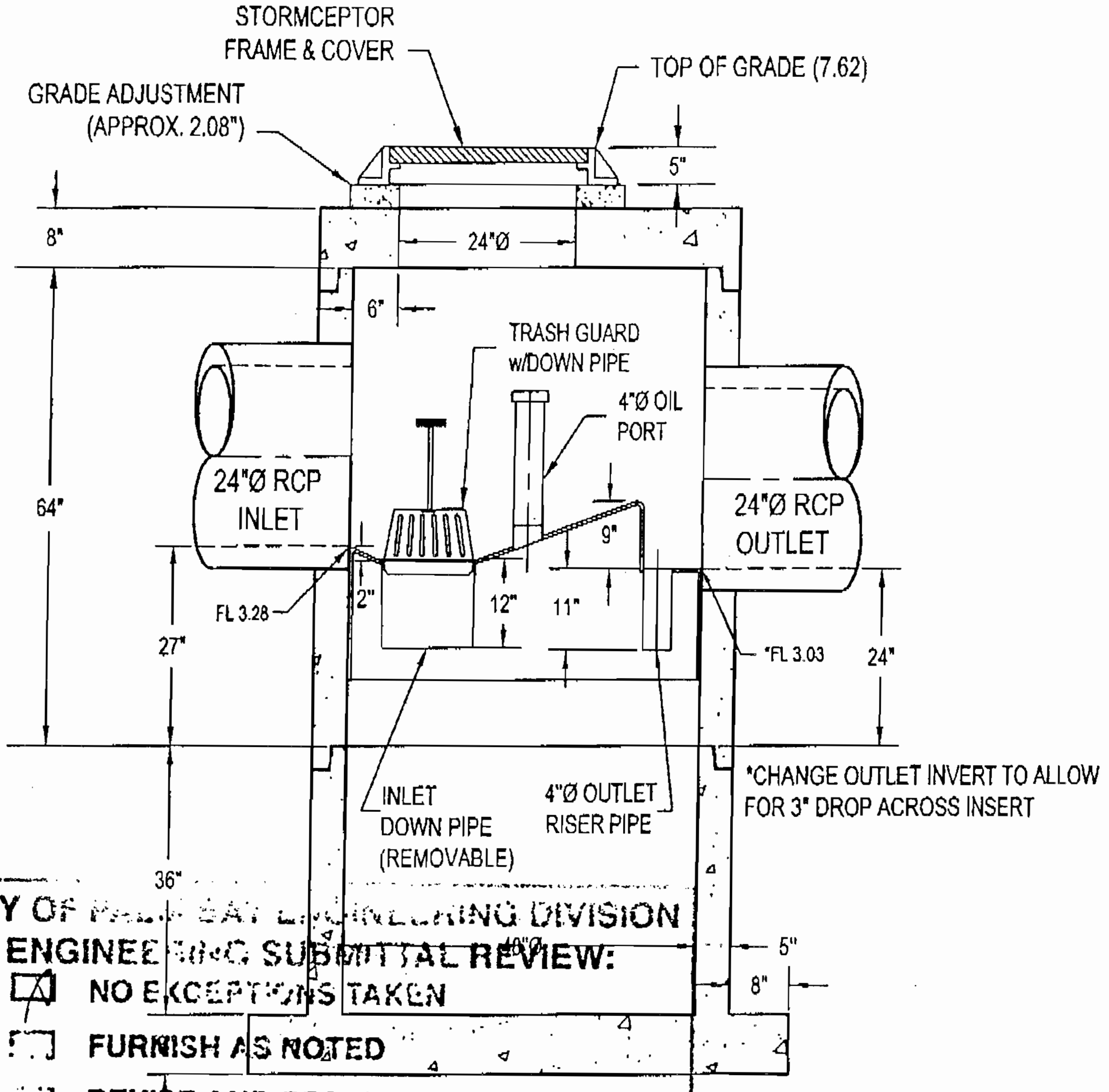
9. The perso nnel monitoring the Stormceptor should record incidental information in a log file. Information such as weather, site conditions, inspection and maintenance information, monitoring equipment failure, etc. provide valuable information that can explain anomalous results.
10. Laboratory results of monitored samples should be analyzed within 10 days of being submitted to the lab.
11. Weekly inspections of the sampling tubes, flow meter, rain gauge, and quality samplers should be conducted to ensure proper operation of the monitoring equipment. Debris and sediment that collects around the sampling intakes should be cleaned after each event.
12. During the installation of automated quality samplers, care should be exercised to ensure that representative samples will be extracted (placement of intakes, ensuring that tubing is not constricted or crimped).
13. Sampling should be conducted for a minimum of 6 storms. Ideally 15 storms should be sampled if the budget allows.

Stormceptor®	Hydro Conduit	DR. BY: E. CARRASCO
	STC 450i Precast Concrete Stormceptor (450 US Gallon Capacity)	CK. BY:
		DATE: JUNE 30, 2004
	PROJECT: TURKEY CREEK OUTFALL	SCALE: N.T.S.
	LOCATION: PALM BAY, FL	DWG.# A270-CE-243

(SHEET 1 OF 3)

MANHOLE #51



SECTION THRU CHAMBER

CITY OF PALM BAY ENGINEERING DIVISION
ENGINEERING SUBMITTAL REVIEW:

- [x] NO EXCEPTIONS TAKEN
- [ ] FURNISH AS NOTED
- [ ] REVISE AND RESUBMIT
- [ ] REJECTED

COMMENTS: ______

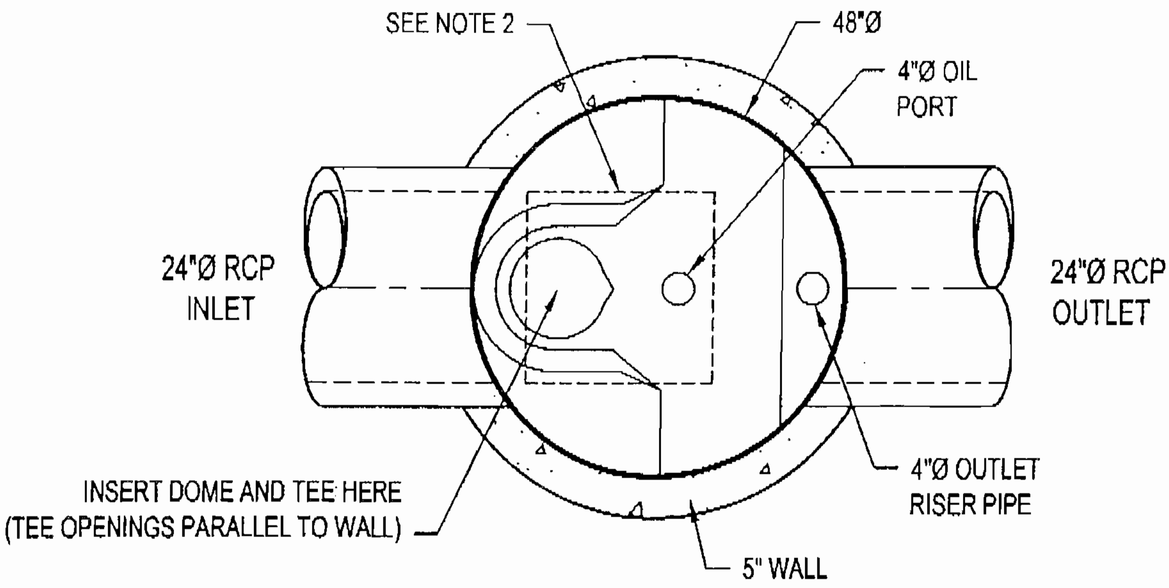
7/21/04 SIGNATURE [signature]

Jobear/Warden Construction
Submitted for Approval
Project TURKEY CREEK OUTFALL
Date 7-13-04
Submitted By ROB BEATY
Comments ______

REV.	DESCRIPTION	BY:	DATE:

Stormceptor®	Hydro Conduit	DR. BY: E. CARRASCO
		CK. BY:
	STC 450i Precast Concrete Stormceptor (450 US Gallon Capacity)	DATE: JUNE 30, 2004
	PROJECT: TURKEY CREEK OUTFALL	SCALE: N.T.S.
	LOCATION: PALM BAY, FL	DWG.# A270-CE-243

MANHOLE #51



SECTION THRU PLAN VIEW

NOTE :

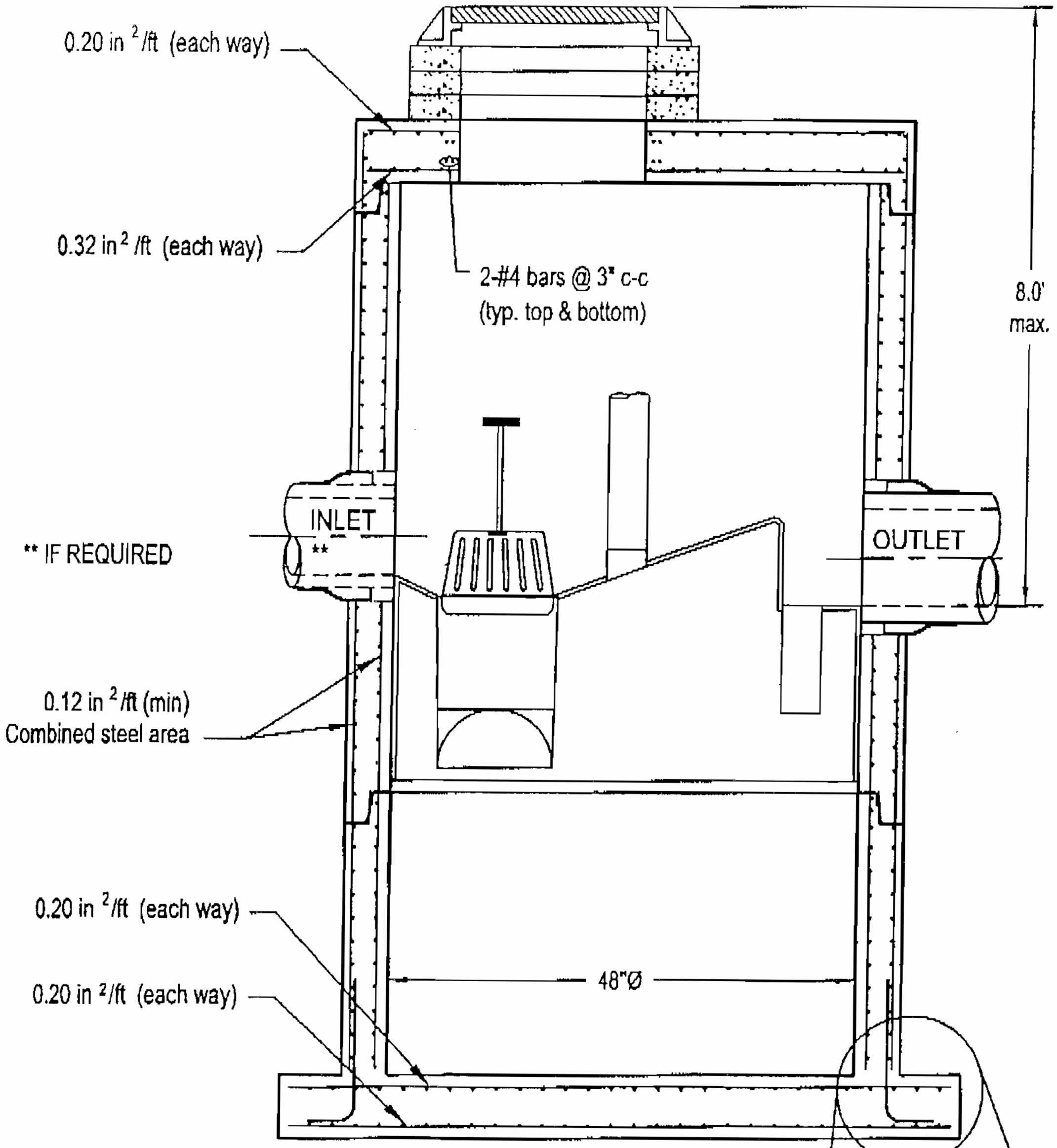
1. THE USE OF GROUTED CONNECTIONS IS RECOMMENDED AT THE INLETS AND OUTLET.
2. THE COVER SHOULD BE POSITIONED OVER THE 4"Ø OIL PORT AND THE INLET DOWN PIPE.
3. THE STORMCEPTOR SYSTEM IS PROTECTED BY ONE OR MORE OFF THE FOLLOWING U.S. PATENTS: #4985148, #5498331, #5725760, #5753115, #5849181, #6068765, & #6371690..
4. CONTRACTOR TO PROVIDE CRANE TO SET UNIT (HEAVIEST SECTION WEIGHS 2.5 TONS).

REV.	DESCRIPTION	BY:	DATE

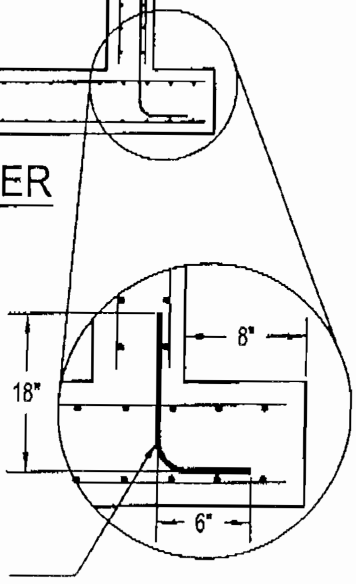
Stormceptor®	**Hydro Conduit**	DR. BY: E. CARRASCO
	STC 450i Precast Concrete Stormceptor (450 US Gallon Capacity)	CK. BY:
		DATE: JUNE 30, 2004
	PROJECT: TURKEY CREEK OUTFALL	SCALE: N.T.S.
	LOCATION: PALM BAY, FL	DWG.# A270-CE-243

(SHEET 3 OF 3)

MANHOLE #51



SECTION THRU CHAMBER



NOTES:

1. f'c = 4,000 PSI FOR ALL CONCRETE.
2. fy = 60,000 PSI FOR ALL STEEL.
3. 1" COVER OVER ALL REINFORCEMENT.
4. HS-20 LIVE LOAD
5. DESIGNED FOR MAXIMUM OUTLET INVERT DEPTH OF 8.0' BELOW GRADE.

REV.	DESCRIPTION	BY:	DATE

APPENDIX B

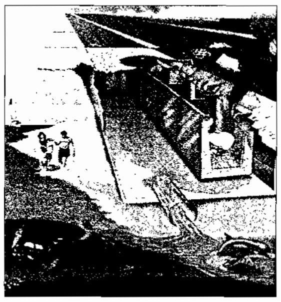
PRODUCT INFORMATION FOR THE ULTRA-URBAN FILTER SYSTEMS

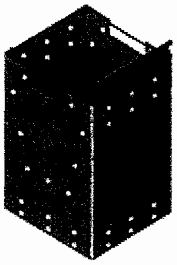
ULTRA-URBAN® FILTER WITH SMART SPONGE® & SMART SPONGE® PLUS

ULTRA-URBAN® FILTER DESCRIPTION

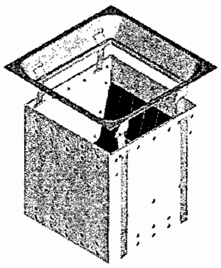
The **Ultra-Urban®** Filter with **Smart Sponge®**, developed and manufactured by AbTech Industries, is an innovative low-cost BMP that helps meet NPDES requirements with effective filtration, efficient application, and moderate maintenance. The Ultra-Urban Filter absorbs oil and grease and captures trash and sediment from Stormwater runoff before it enters the storm drain system. The Ultra-Urban Filter is ideal for municipal, industrial, and construction applications. The filter comes in two standard designs; one a modular unit geared toward curb inlet openings, and the other, a single unit designed for typical drop-in catch basin drains.

The Ultra-Urban Filter, made of a high strength corrugated recycled content plastic, is designed for use in storm drains that experience oil and grease pollution accompanied by sediment and debris. Trash and sediment accumulate in the upper basket chamber while oil and grease are absorbed in the filtration media.





CO1414 for
Curb Opening Drains
"Inlets"



DI2020 for
Drop-in Drains
"Catch Basins"

PERFORMANCE

Field and laboratory tests have confirmed the capability of the Smart Sponge to absorb, depending on the type of oil contaminant, up to five times its own weight and remove 70% to 95% of the hydrocarbons present in Stormwater runoff, typically in the range of 5 to 30 mg/liter (ppm). The captured oil is permanently bound within the Smart Sponge, eliminating leaching and allowing for easy disposal of the filtration media. Flow rates through the CO1414 filters exceed 200 gpm. Flow rates through the filters exceed 500 gpm for the DI2020 series at installation.

INSTALLATION

The Ultra-Urban Filter is easily installed. Installation time varies depending upon mounting devices selected. A single mounting bracket made of 16-gauge galvanized steel is required for the installation of the Curb Opening (CO) series. The Ultra-Urban Filter should not be installed where modules obstruct the drain pipe outlet. The size of the drain should allow room for stormwater overflow. The Drain Inlet (DI) series Ultra-Urban Filter will suspend from the drain into the catch basin through a structural plastic mount and funnel mechanism (see drawings).

MAINTENANCE

The Ultra-Urban Filter should be serviced as needed to remove sediment and debris, according to expected debris accumulation. The sediment and debris can be quickly vacuumed out of the modules through the opening of the drain with conventional maintenance equipment. For example, a curb inlet with four to five Ultra-Urban Filter modules can be typically serviced in 10 minutes or less. Under normal operating conditions the Ultra-Urban Filter should be replaced every 1-3 years.

ADVANTAGES AND BENEFITS

- Removes oil, grease, trash, sediment & debris
- Modular design accommodates most storm drains
- Smart Sponge media removes up to 95% of oil and grease in Stormwater runoff
- The only true structural catch basin insert filter
- Lightweight and easy to handle
- Quick installation, easy to maintain, can be serviced from street level
- Cost effective BMP
- Filter housing made from Recycled Content Plastic
- Recyclable through WTE

SMART SPONGE® AND SMART SPONGE® PLUS DESCRIPTION

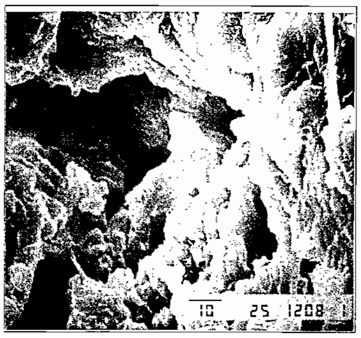


Figure A (1,000 X)

Over the past seven years, AbTech has developed the **Smart Sponge®** technology based on its proprietary blend of synthetic polymers aimed at removal of hydrocarbons and oil derivatives from surface water. AbTech's process creates a very porous structure (see Figure A) with hydrophobic and oleophilic characteristics capable of selectively removing hydrocarbons while allowing high flow through rates for water. As hydrocarbons are absorbed into its structure, the Smart Sponge® swells and maintains porosity and filtering capabilities.

Field and laboratory tests have confirmed the Smart Sponge® capability to absorb, depending on the type of oil contaminant, up to five times its own weight and remove 75% to 95% of the hydrocarbons present in Stormwater runoff, typically in the range of 5 to 30 mg/liter (ppm). The absorption is permanent and the saturated product does not leach or leak contaminants, transforming the contaminant - in most cases - into a solid waste with lower disposal costs.

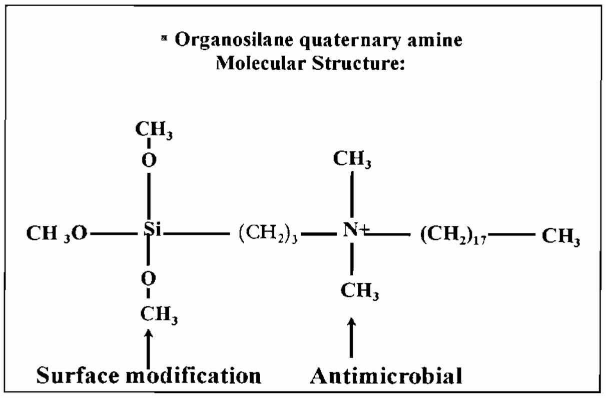


Figure B

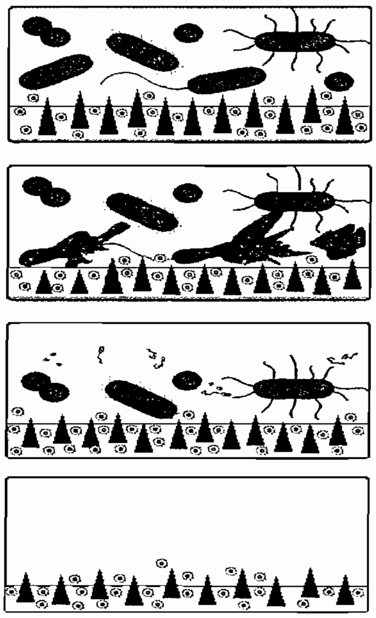
During the past couple of years, AbTech has worked on the development of an antimicrobial technology. **Smart Sponge® Plus** features a proprietary antimicrobial agent (see Figure B) chemically and permanently bound to the Smart Sponge polymer surface and therefore does not leach or leak, avoiding any downstream toxicity issues.

The antimicrobial mechanism is based on the patented agent's interaction with the microorganism cell membrane, causing the microorganism disruption (see Figure C), but no chemical or physical change in the agent.

Antimicrobial activity does not reduce the agent capability or cause its depletion and, therefore, maintains long-term effectiveness. Additionally, the hydrocarbon absorption capability is not inhibited.

Microbial reduction efficiency will vary depending on colony size, flow rates and site specific conditions.

- Consistent positive reduction in microbial concentration realized in laboratory setting and field testing sites in the United States.
- Larger scaled field deployment and data generation projects are ongoing.



1. Active agent attached permanently to the surface of the Smart Sponge.
2. Microorganisms contact the surface and are destroyed.
3. Further growth of microorganisms is inhibited.
4. Left behind is a Clean Surface

Figure C

TARGETED MICROORGANISMS

- Enterococcus
- Coliforms
  - Fecal coliform
  - Escherichia Coli

AbTech INDUSTRIES

Surface Water Quality Solutions for Clean Water Today *and* Tomorrow

UUF FEATURES

CATCH BASIN MODEL	TRASH & DEBRIS CAPACITY	FLOW RATE Q (approx.)	GROSS WEIGHT (approx.) For New UUF
DI1414 N	1.5 ft^3	200 gpm = 0.44 cfs	20 lbs
CO1414N	1.5 ft^3	200 gpm = 0.44 cfs	20 lbs
DI1414H	0.8 ft^3	171 gpm = 0.39 cfs	13 lbs
CO1414H	0.8 ft^3	171 gpm = 0.39 cfs	13 lbs
DI1420N	2.1 ft^3	307 gpm = 0.70 cfs	23 lbs
DI1420H	1.1 ft^3	307 gpm = 0.70 cfs	14 lbs
DI1616N	1.6 ft^3	240 gpm = 0.55 cfs	24 lbs
DI2020N	3.0 ft^3	500 gpm = 1.11 cfs	30 lbs
DI2020H	1.7 ft^3	500 gpm = 1.11 cfs	22 lbs

Jobear/Warden Construction
Submitted for Approval

Project Turkey Creek Outfall

Date 7-13-04

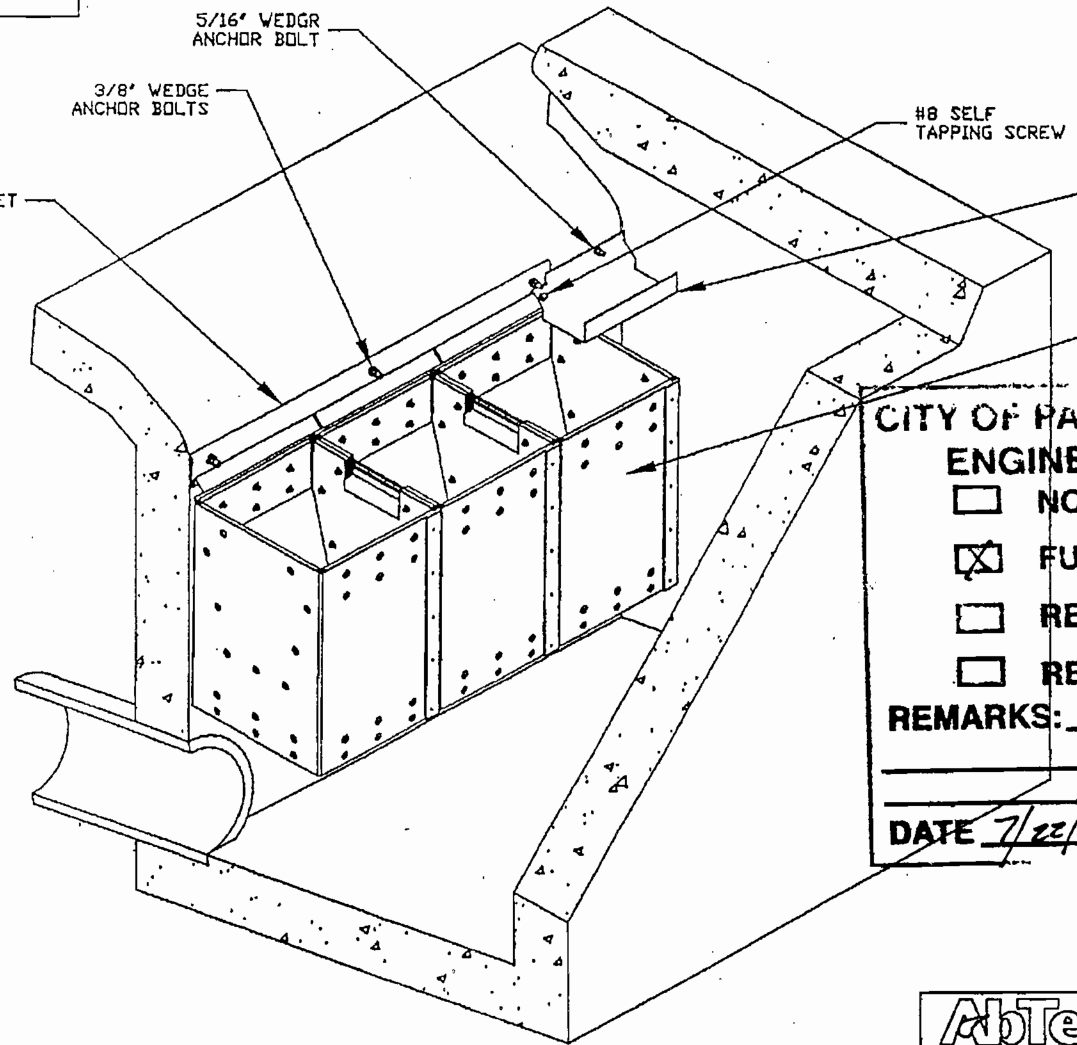
Submitted By Rob Beatty

Comments

ULTRA-URBAN® FILTER CURB OPENING SERIES "CO"

DESCRIPTION	ILLUSTRATION OF CURB OPENING INSTALLATION
FINISH N/A	STD. TOLERANCE UNLESS OTHERWISE NOTED x ±1 .xx ±.03 .xxx ±.031 FRAC ±1/32 ANG ±.5°
MATERIAL SPECIFIED N/A	APPLICATION
QTY. / ITEM NO. / PART NO.	DESCRIPTION

DRAWING TYPE REF.



CITY OF PALM BAY ENGINEERING DIVISION
ENGINEERING SUBMITTAL REVIEW:

- [ ] NO EXCEPTIONS TAKEN
- [x] FURNISH AS NOTED
- [ ] REVISE AND RESUBMIT
- [ ] REJECTED

REMARKS: Furnish & Install Model CO1414 H 13" DEEP

DATE 7/22/04 SIGNATURE [signature]

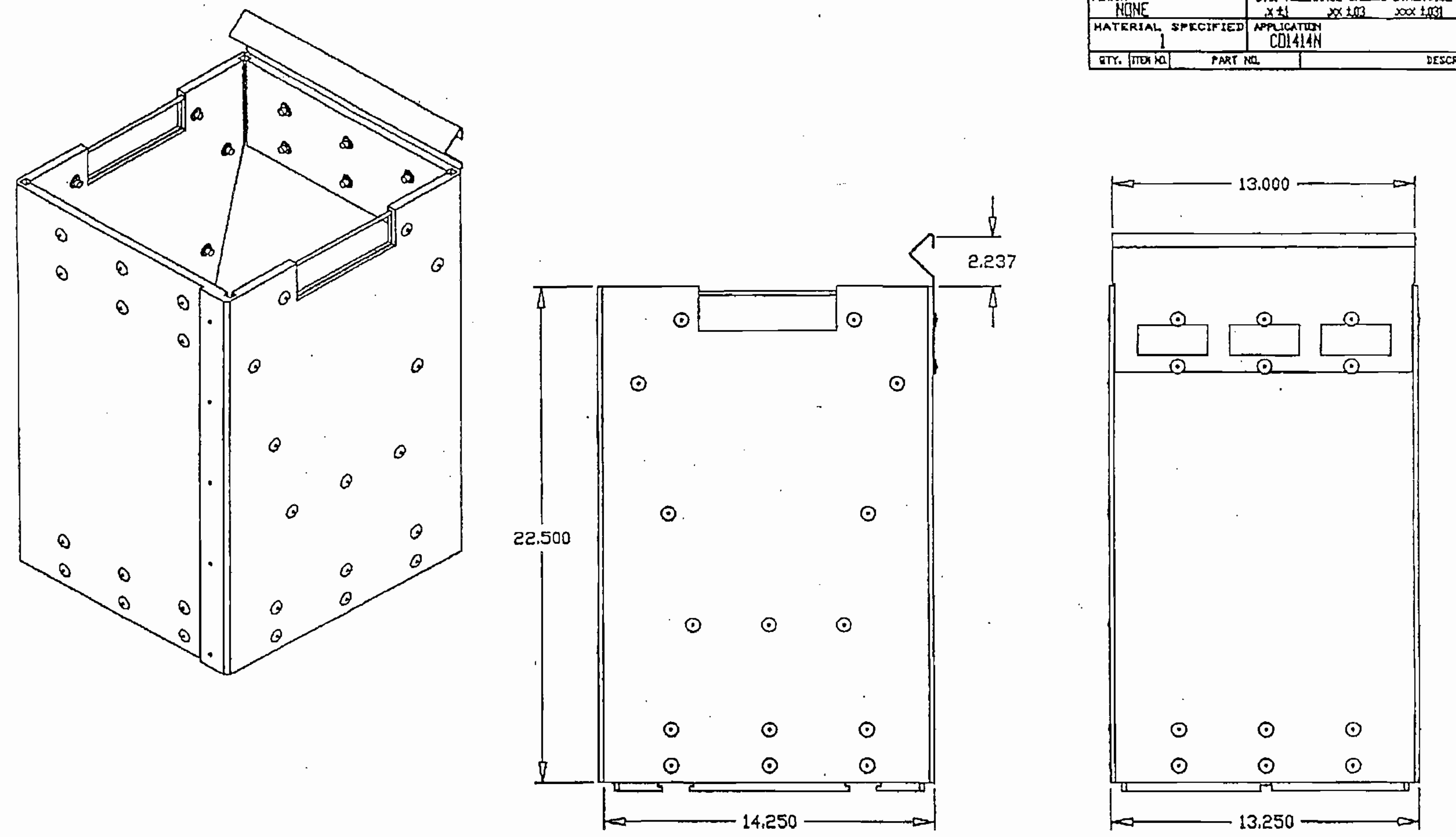
NOTE: ~~FOR INSTRUCTION ON HOW TO INSTALL UUF BOXES PLEASE REFER TO OUR INSTALLATION~~ INTRUCTIONS, PROCEDURE EP-03

AbTech INDUSTRIES SCOTTSDALE ARIZONA	REV.	BY	DATE	DESCR.
THIS DRAWING IS DRAWN TO A SCALE OF 1=1, THE BORDER IS SCALED UP 1 TIMES TO FIT	DRAWN BY DATE 08/01	DWG# -08T01		

CO1414N

DRAWING TYPE PART

DESCRIPTION 13" X 14" X 22.5" UUF COMPLETE ASSEMBLY	
FINISH NONE	STD. TOLERANCE UNLESS OTHERWISE NOTED .X ±1 .XX ±.03 .XXX ±.031 FRAC. ±1/32 ANG. ±.5°
MATERIAL SPECIFIED 1	APPLICATION CO1414N
QTY. ITEM NO. PART NO.	DESCRIPTION



AbTech INDUSTRIES SCOTTSDALE ARIZONA

REV.	BY	DATE	DESCR.

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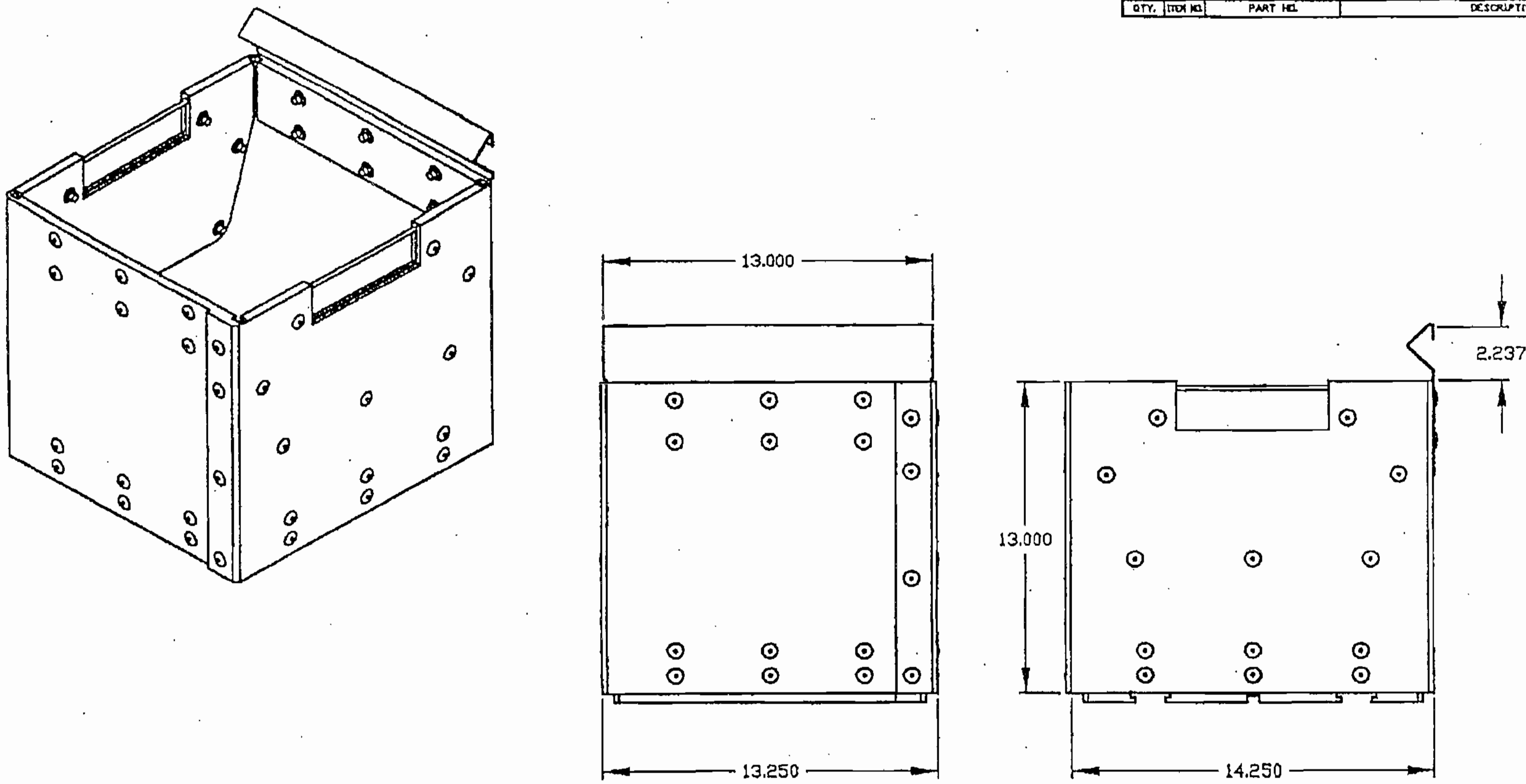
CO1414H

DRAWING TYPE REF.

DESCRIPTION 13" X 14" X 13" UUF	
FINISH NONE	STD. TOLERANCE UNLESS OTHERWISE NOTED .X ±.1 .XX ±.03 .XXX ±.031 FRAC ±1/32 ANG ±.5°
MATERIAL SPECIFIED N/A	APPLICATION CO1414H

QTY.	ITEM NO.	PART NO.	DESCRIPTION



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REV.	BY	DATE	DESCR.

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DRAWN PMV DATE 7/01

DWG.# 00606T01

AbTech CO1414 Ultra Urban Filter Installation Instructions

1. Installation of the Mounting Bracket

The location and number of Ultra Urban Filter (UUF) box(es) in each catch basin should be determined by the end user, based on actual flow rates and characteristics of the drain.

- Measure width of the drain opening and the depth of the drain inlet.
- Determine the number of UUF boxes to be installed.
- Determine the length of the bracket, number and location of the holes. Table 1 is meant to provide suggestions.
- Users should follow their own safety protocols and confined space entry procedures.
- Setup the appropriate barriers and traffic control equipment. Remove the drain inlet cover. Make sure the drain is clean and clear of debris.

SUGGESTED LENGTH OF MOUNTING BRACKET AND LOCATION OF HOLES

Number of Boxes	1 to 2	3 to 5	6-7	8 to 10
Length of Bracket	Number of boxes times 12.75"	Number of boxes times 13.00"	Number of boxes times 13.125"	Number of boxes times 13.125"
Number of Anch. Bolts	2	3	4	5
Location of Anch. Bolts	3' from the edges	6" from the edges + one in the middle	6" and 30" from the edges	12" and 36" from the edges + 1 (middle)

Table 1.

- Use gloves when handling or installing mounting bracket, sharp edges can cause injuries.

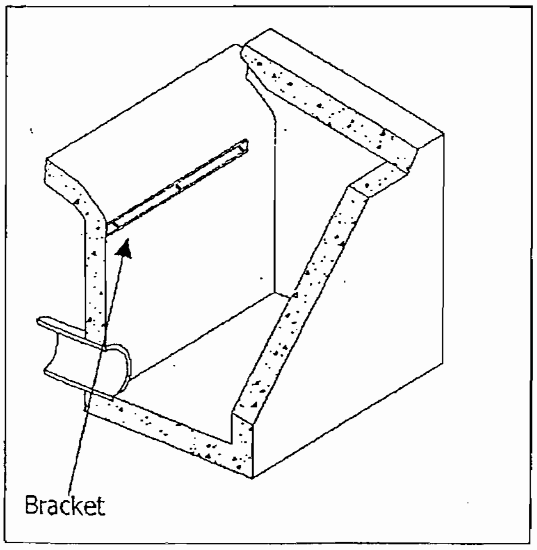


Figure 1.

- Cross-sectional view shown in Figure 2 gives the suggested elevation of anchor bolts and the interference between the bracket's flange and the inlet radius.

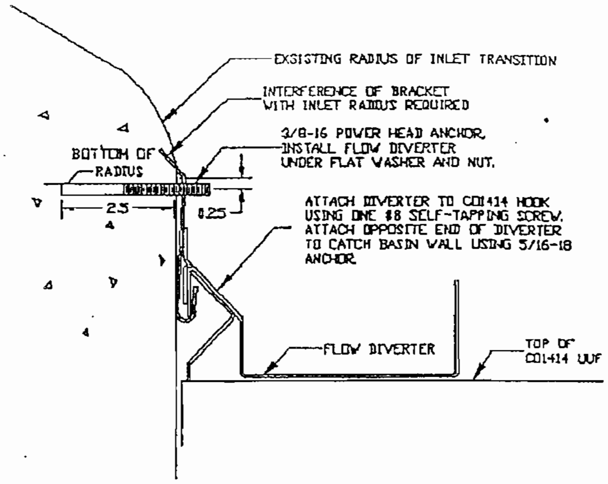


Figure 2.

- UUF Box(es) should be installed so that there is approx. 2"-3" clearance between the bottom of the catch basin and the bottom of the box.
- Use 3/8-16 wedge anchor bolts, 2.25" long, to attach Mounting Bracket to catch basin wall.

2. Installation of the UUF Boxes

- UUF boxes should be installed so that the flow through inlet-outlet pipes is not affected.
- Prior installation, remove necessary Over-Flow Cut-Outs to provide openings for lateral overflow between boxes.

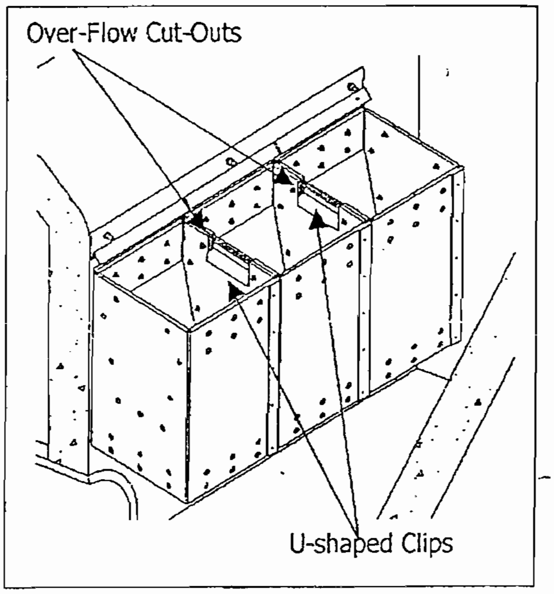


Figure 3.

- Install U-shaped Clips over the Over-Flow Cut-Outs as shown in figure 3.

3. Installation of the Flow Diverter (FD)

- When determining the length of the Flow Diverter, an additional 2" must be added to the length to allow over-flow the UUF box.
- Table 2 is intended to provide suggested number and location for the anchor bolts.
- Users are encouraged to develop and follow their own procedures and safety protocols.
- At approximately 1.5" from the overhanging edge, vertically cut the higher side of the Flow Diverter to approximately 3/16" below the first bend.

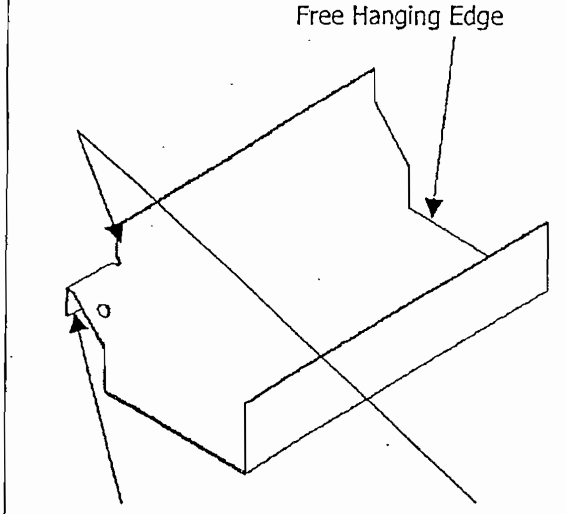


Figure 4.

- Use gloves when handling and installing the Flow Diverter, sharp edges can cause injuries.
- Bend down the cut portion of the flange, as shown in figure 4.
- The bent down flange of the Flow Diverter should engage the bracket and sit on top of the hook of the UUF box as shown in figures 2 and 5.
- Use 1/4-20 Wedge Anchor bolts, 2.25" long to secure the Flow Diverter to the catch basin wall.

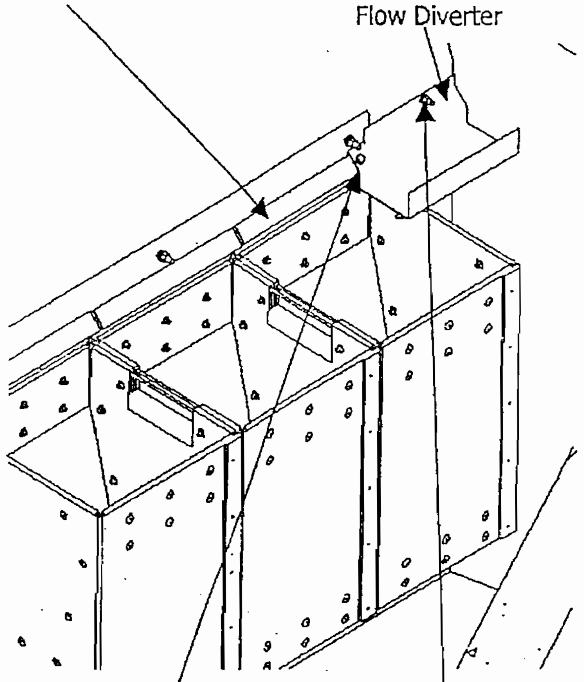


Figure 5.

- Secure Flow Diverter to CO1414 Hook using one #8 Self-Tapping screw as shown in figure 5; drilling 3/16" clearance hole may be required.
- Clean up the area and make sure that tools and debris have been removed from the catch basin. Replace the cover to the drain and secure as needed.

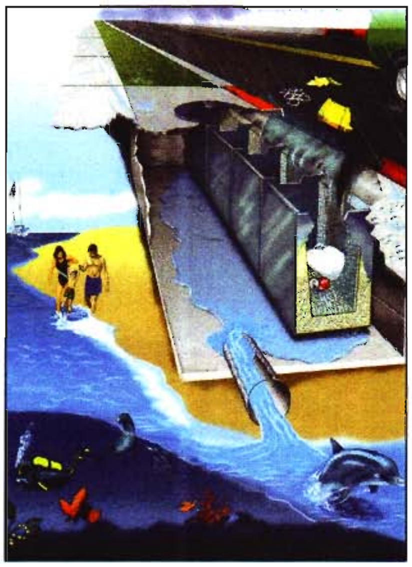
SUGGESTED LOCATION OF THE HOLES FOR FLOW DIVERTERS (FD)

FD Length	Less than 3'	3' to 5'	5' to 7'	7' to 11'
Number of Anch. Bolts	1	2	2 - 3	3 - 4
Location of Anch. Bolts	At 3" from the free hanging edge (FH)	At 3" from the (FH) edge and one in the middle	At 3" from the (FH) edge and approx. every 3'	At 3" from the (FH) edge and approx. every 3'

Table 2.

The Ultra-Urban® Filter Technical Specifications

DESCRIPTION



The **Ultra-Urban® Filter** with Smart Sponge® developed and manufactured by AbTech Industries, is an innovative low-cost BMP that helps meet NPDES requirements with effective filtration, efficient application, and moderate maintenance. The Ultra-Urban Filter absorbs oil and grease and captures trash and sediment from Stormwater runoff before it enters the storm drain system. The Ultra-Urban Filter is ideal for municipal, industrial, and construction applications. The filter comes in two standard designs; one a modular unit geared toward curb inlet openings, and the other, a single unit designed for typical drop-in catch basin drains.
The Ultra-Urban Filter, made of a high strength corrugated recycled content plastic, is designed for use in storm drains that experience oil and grease pollution accompanied by sediment and debris. Trash and sediment accumulate in the upper basket chamber while oil and grease are absorbed in the filtration media.

PERFORMANCE

Field and laboratory tests have confirmed the capability of the Smart Sponge to absorb, depending on the type of oil contaminant, up to five times its own weight and remove 70% to 95% of the hydrocarbons present in Stormwater runoff, typically in the range of 5 to 30 mg/liter (ppm). The captured oil is permanently bound within the Smart Sponge, eliminating leaching and allowing for easy disposal of the filtration media. Flow rates through the CO1414 filters exceed 200 gpm. Flow rates through the filters exceed 500 gpm for the DI2020 series at installation.

INSTALLATION

The Ultra-Urban Filter is easily installed. Installation time varies depending upon mounting devices selected. A single mounting bracket made of 16-gauge galvanized steel is required for the installation of the Curb Opening (CO) series. The Ultra-Urban Filter should not be installed where modules obstruct the drain pipe outlet. The size of the drain should allow room for stormwater overflow. The Drain Inlet (DI) series Ultra-Urban Filter will suspend from the drain into the catch basin through a structural plastic mount and funnel mechanism (see drawings).

MAINTENANCE

The Ultra-Urban Filter should be serviced as needed to remove sediment and debris, according to expected debris accumulation. The sediment and debris can be quickly vacuumed out of the modules through the opening of the drain with conventional maintenance equipment. For example, a curb inlet with four to five Ultra-Urban Filter modules can be typically serviced in 10 minutes or less. Under normal operating conditions the Ultra-Urban Filter should be replaced every 1-3 years.

smart sponge DESCRIPTION

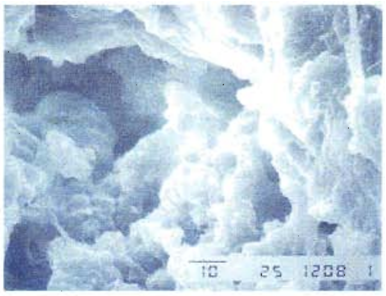


Figure A (1,000 X)

AbTech developed the Smart Sponge technology based on its proprietary blend of synthetic polymers aimed at removal of hydrocarbons and oil derivatives from surface water. AbTech's process creates a very porous structure (see Figure A) with hydrophobic and oleophilic characteristics capable of selectively removing hydrocarbons while allowing high flow through rates for water. As hydrocarbons are absorbed into its structure, the Smart Sponge® swells and maintains porosity and filtering capabilities.

Field and laboratory tests have confirmed the Smart Sponge capability to absorb, depending on the type of oil contaminant, up to five times its own weight and remove 75% to 95% of the hydrocarbons present in Stormwater runoff, typically in the range of 5 to 30 mg/liter (ppm). The absorption is permanent and the saturated product does not leach or leak contaminants, transforming the contaminant – in most cases – into a solid waste with lower disposal costs.

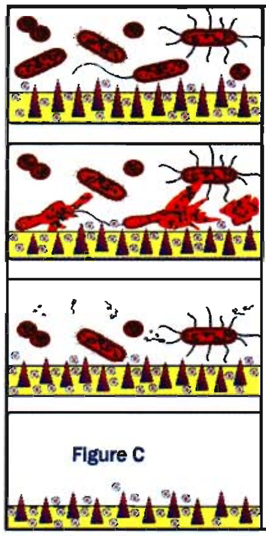


Figure C

- Active agent attached permanently to the surface of the Smart Sponge.
- Microorganisms contact the surface and are destroyed.
- Further growth of microorganisms is inhibited.
- Left behind is a Clean Surface

During the past couple of years, AbTech has worked on the development of an antimicrobial technology. Smart Sponge **Plus** features a proprietary antimicrobial agent chemically and permanently bound to the Smart Sponge polymer surface and therefore does not leach or leak, avoiding any downstream toxicity issues. The antimicrobial mechanism is based on the patented agent's interaction with the microorganism cell membrane, causing the microorganism disruption (see Figure C), but no chemical or physical change in the agent. Antimicrobial activity does not reduce the agent capability or cause its depletion and, therefore, maintains long-term effectiveness. Additionally, the hydrocarbon absorption capability is not inhibited.

- Microbial reduction efficiency will vary depending on colony size, flow rates and site specific conditions.
- Consistent positive reduction in microbial concentration realized in laboratory setting and field testing sites in the United States.

Larger scaled field deployment and data generation projects are ongoing.

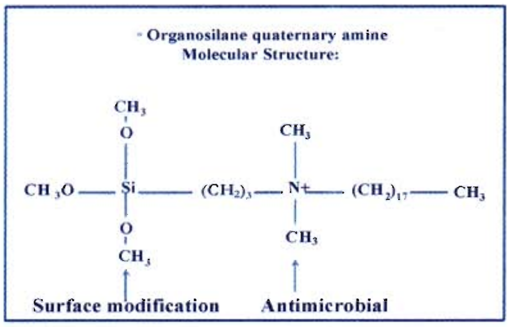


Figure B

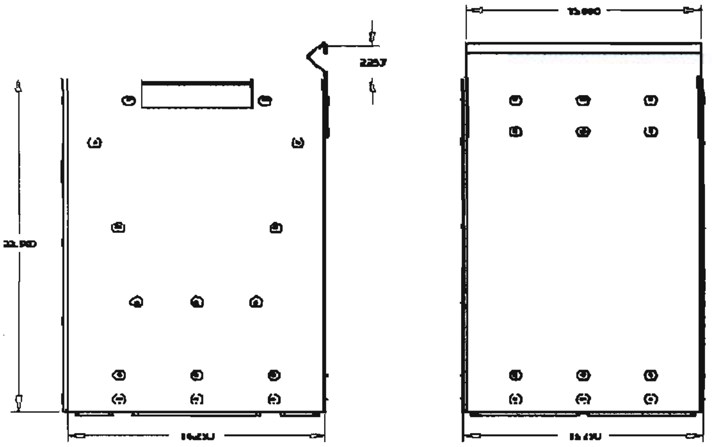
TARGETED

Enterococcus

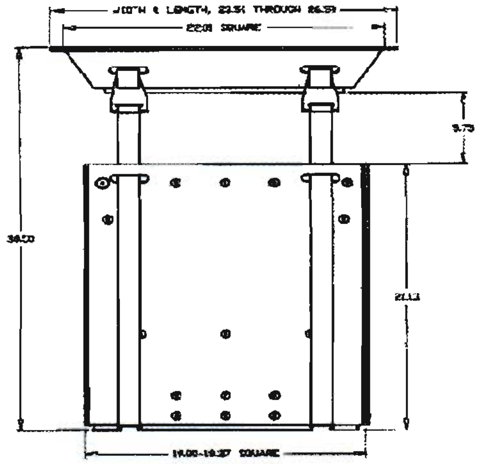
Coliforms
- Fecal coliform
  - Escherichia Coli

ULTRA-URBAN® FILTER DRAWINGS

Complete product drawings for each model available from AbTech in CAD or PDF format.



CO1414N Side & Front View



DI2020N

ULTRA-URBAN® FILTER KEY FEATURES

Part #	Description	Dimensions	Gross Weight (approx.) With Smart Sponge®	Gross Weight (approx.) Trash & Debris Only	Flow Rate Q (approx.)	Trash & Debris Capacity
Curb Opening Module:						
CO1414N	UUF, Normal size	13¼ ″ x 14¼″ x 22½″	20 lbs.	5.5 lbs.	200 gpm = 0.44 cfs	1.5 ft^3
CO1414H	UUF, Half size	13¼″ x 14¼″ x 13″	13 lbs.	4.5 lbs.	170 gpm = 0.39 cfs	0.8 ft^3
Drain Insert Module:						
DI1414N	UUF, Normal size	13¼″ x 14¼″ x 21 1/8 ″	20 lbs.	5.6 lbs.	200 gpm = 0.44 cfs	1.5 ft^3
DI1414H	UUF, Half size	13¼″ x 14¼″ x 13″	13 lbs.	4.5 lbs.	170 gpm = 0.39 cfs	0.8 ft^3
DI1420N	UUF, Normal size	14″ x 19¼″ x 21 1/8″	24 lbs.	6.5 lbs.	300 gpm = 0.70 cfs	2.1 ft^3
DI1420H	UUF, Half size	14″ x 19¼″ x 13 3/8″	18 lbs.	5.0 lbs.	300 gpm = 0.70 cfs	1.1 ft^3
DI1616N	UUF, Normal size	16″ x 16″ x 21 1/8″	24 lbs.	6.5 lbs.	240 gpm = 0.55 cfs	1.8 ft^3
DI1616H	UUF, Half size	16″ x 16″ x 13 3/8″	18 lbs.	5.0 lbs.	240 gpm = 0.55 cfs	1.0 ft^3
DI2020N	UUF, Normal size	19¼″ x 19¼″ x 21 1/8″	30 lbs.	7.5 lbs.	500 gpm = 1.11 cfs	3.0 ft^3
DI2020H	UUF, Half size	19¼″ x 19¼″ x 13 3/8″	22 lbs.	6.0 lbs.	500 gpm = 1.11 cfs	1.7 ft^3

Each of the above available with Smart Sponge®, Smart Sponge® Plus, or Trash & Debris

DISPOSAL OPTIONS

AbTech's Smart Sponge technology transforms liquid hydrocarbons into a stable solid[1]. The handling and disposal of this solid waste is less expensive and less problematic than that of other plastic and organic solvents which leach and leak hydrocarbons back into the environment. The following waste disposal and resource recovery industries will accept spent Smart Sponge for disposal and/or recycling.

- **Waste-to-Energy Facilities** - A specialized segment of the solid waste industry will use spent Smart Sponge as an alternative fuel in the production of electricity.
  - WTE is acknowledged at the federal level as a renewable energy source under the Federal Power Act, Title IV of the Clean Air Act.
  - WTE is a participant in the Department of Energy's National Renewable Energy Program.
- **Cement Kilns** - This industry will use the spent Smart Sponge as an alternative fuel in the production process of Portland Cement. This process is considered a beneficial reuse of waste products. The BTU value of spent Smart Sponge is consistently above the average acceptable levels set for this high temperature.
- **Landfills** - The ability of Smart Sponge to transform liquid hydrocarbons into a solid waste makes for less expensive and easy disposal. Spent Smart Sponge generated from the AbTech laboratories have been classified as a solid waste and are acceptable at Subtitle D Landfills[2].

[1] Generators of spent Smart Sponge will need to have their waste analyzed, tested, and classified to determine the generator's particular waste. According to testing performed for AbTech Industries, spent Smart Sponge soaked with petroleum hydrocarbons are transformed into solid wastes. AbTech does not take any responsibility for the generator's waste classification for handling, transport and the ultimate disposal or recycling of the waste. The generator must always classify and characterize its own waste.

[2] Spent Smart Sponge generated from the AbTech laboratories with a multitude of liquid petroleum hydrocarbons have passed the EPA Toxicity Characteristic Leachate Procedures and Paint Filter Test. These tests are used in determining the amount of liquid waste and any free liquids present that may be released into the landfill environment.

APPENDIX C

PRODUCT INFORMATION FOR THE HYDRO-KLEEN FILTRATION SYSTEM

APPLICATION PROFILE

The Hydro-Kleen™ Storm Water Filtration System is a patented multi-media filtration design combined with pre-settling sedimentation containment and overflow by-pass protection. Units are placed into drains under the grate cover. Water flow is directed into the pre-settling sedimentation chamber that collects heavy sediments and debris. Water then passes through a transition inlet into the filtration chamber.

Units are designed to trap contaminants contained in the "first flush" from storm events while allowing overflow protection to eliminate flooding during heavy wet weather events. To accomplish this, the filtration chamber is designed to handle up to 40 gpm through the media chamber, effectively treating up to ½" of rain per hour. Higher flows from high intensity wet weather events are diverted to by-pass outlets that are designed to handle whatever flow enters the drain. This prevents flooding or ponding on the surface while capturing the majority of hydrocarbon, metals, and sediment loadings from urban 'hot spot' surfaces.

A properly maintained unit will achieve substantial reductions of contaminants from entering into surface waters. Units strategically placed downstream from impervious surfaces such as gas stations, parking lots, industrial and commercial sites that contain higher contaminate loading, give municipalities and businesses an effective tool for reducing storm water pollutants.

With new storm water rules directed at smaller municipalities and businesses, and an increased emphasis on watershed protection at the local, state and federal levels, the Hydro-Kleen™ Storm Water Filtration System provides an effective and low-cost technology for reducing urban pollutants in storm runoff, human generated flows, or from other non-point sources.

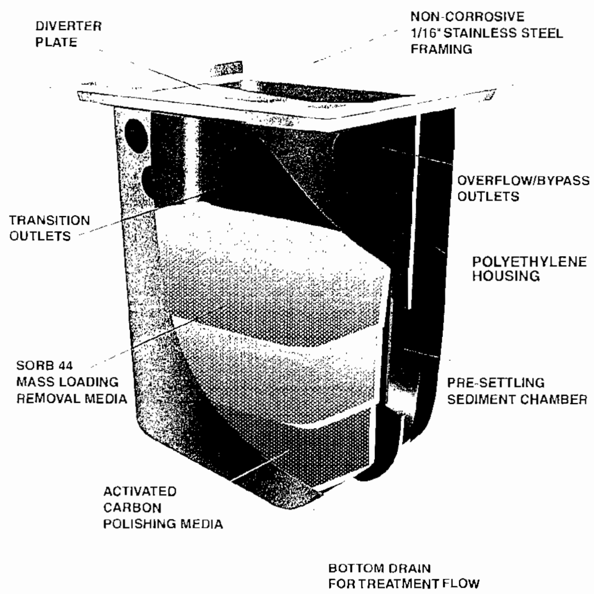
HYDRO-KLEEN™

STORM WATER
FILTRATION SYSTEMS

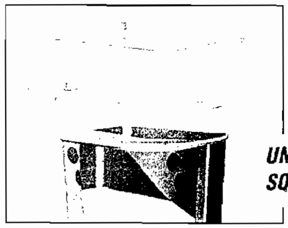
Simple

Efficient

Cost-Effective



UNIT COMPONANTS



UNITS AVAILABLE FOR ROUND OR SQUARE CATCH BASIN GRATES

TECHNOLOGY VERIFICATION PROGRAM

Hydro Compliance recognizes that storm water professionals need to have assurances that proprietary technologies actually perform within the claims that are made by manufacturers. To this end, we have been, and continue to be, involved in a multitude of studies to verify our claims as an effective tool for 'hot spot' applications. These include studies in the Port of Seattle, municipal testing in Michigan, Washington, and other states, as well as commercial studies. Most importantly, we are a current participant in EPA's Environmental Technology Verification Program (ETV). The Hydro-Kleen is being tested for dual verification in the Source Water Protection Program for In-Drain Treatment Devices as well as the Wet Weather Flow Technologies program.

HCM is careful not to make claims about the Hydro-Kleen that are not appropriate. Current data confirms that we have consistently removed a high percentage of hydrocarbons, metals and sediment loadings. These are the primary constituents of concern in industrial, commercial and other urban hot spot applications. There are many different Best Management Practice (BMP) technologies and designs, and we believe that each has its place in the treatment train of a well drafted storm water management plan.

For further information about BMP applications and our continuing efforts to supplement our data base, feel free to contact us at any time. You can also visit our website for more complete details about storm water regulatory requirements and related BMPs.

ETV PARTICIPANT

EPA's Environmental Technology Verification Program

Municipal or Private Sector Financing and/or Leasing Options Available

FEATURES AND BENEFITS

- Removes hydrocarbons, organically bound metals, sediments and other organic chemicals from wet weather industrial runoff.
- Utilizes pre-settling sediment chamber.
- Patented dual media filtration system provides consistent removal efficiencies between change-outs.
- By-pass system prevents flooding or ponding during high flow storm events.
- Units custom built for retrofit or new sites.
- Excellent post construction control for 'Hot Spot' applications.
- Pre-treatment device for groundwater protection and infiltration practices.

EXAMPLES OF CURRENT APPLICATIONS

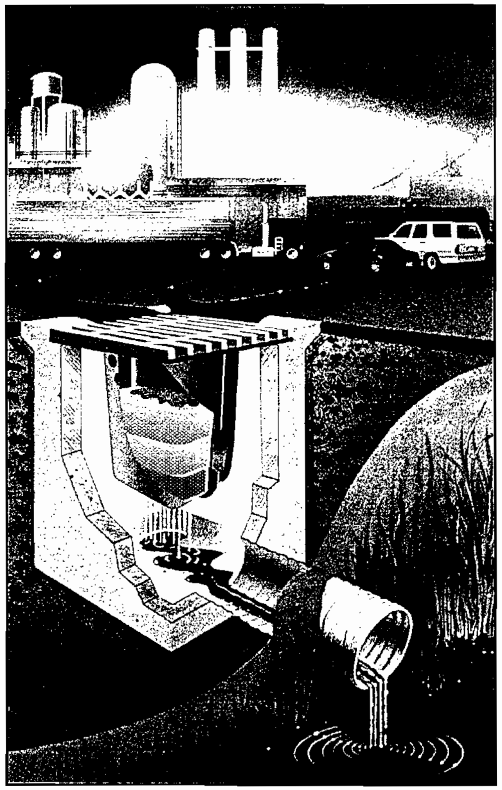
- American Airlines
- Alcoa
- BP Amoco
- Federal Express
- Ford Motor Company
- General Motors
- US Steel
- Port of Seattle Terminals
- Kroger
- Mills Corporation - Malls
- Seven Eleven
- US Air Force
- US Army
- Various Municipalities
- Multiple Scrap Yards

HYDRO COMPLIANCE MANAGEMENT, INC.
ANN ARBOR • SEATTLE

Phone: 800-526-9629
Fax: 734-332-7972
Hydro-Kleen.com

HYDRO-KLEEN™
STORM WATER
FILTRATION SYSTEMS

In-Drain Systems for Urban 'Hot Spots' Applications



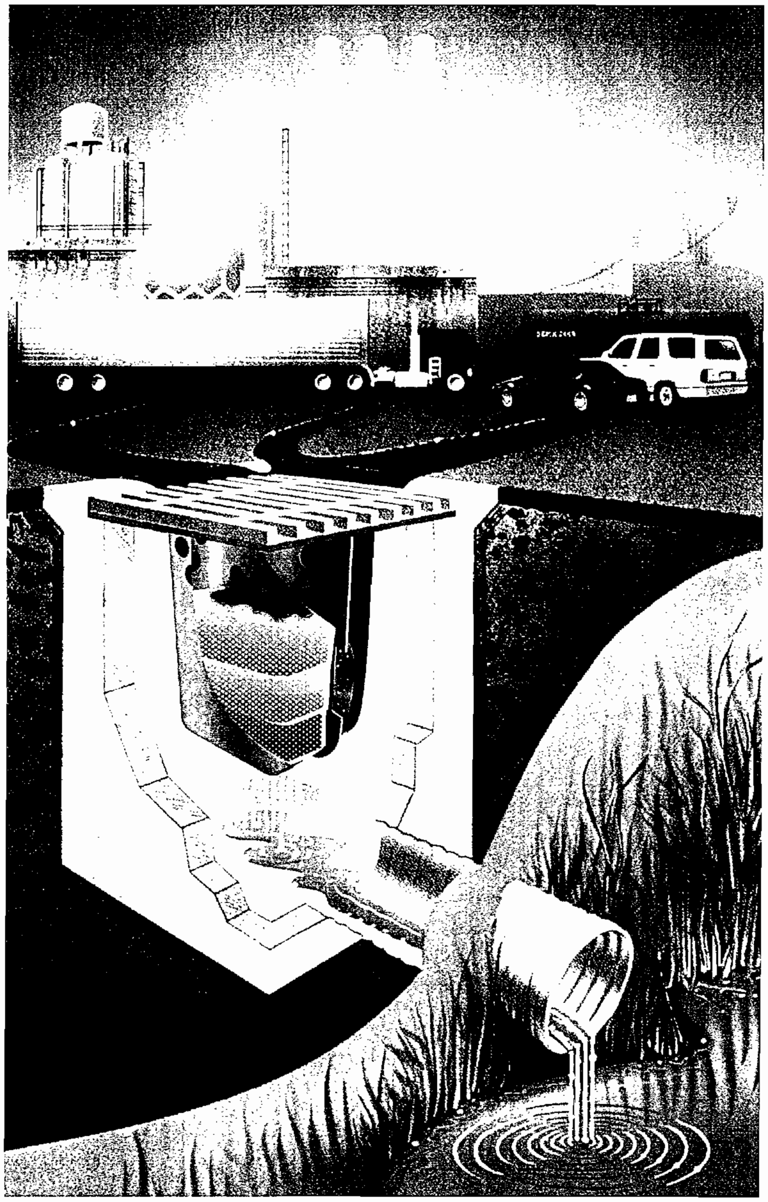
WORKING TO CLEAN OUR WATERWAYS...

Hydro-Kleen™

Storm Water Filtration System

In-drain treatment for 'Hot Spot' applications.
Recongnized as a Best Management Practice for meeting regulatory requirements.

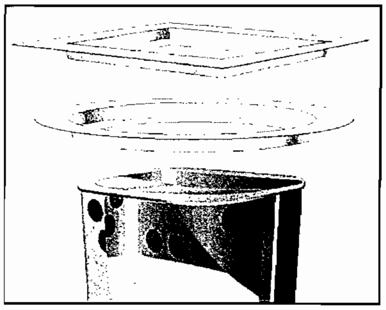
Simple
Efficient
Cost-Effective



What a BMP should be

- ***Removes hydrocarbons, metals, sediments, and other organic chemical compounds from wet weather flows and industrial runoff***
- ***Utilizes pre-settling sediment chamber prior to treatment chamber***
- ***Patented dual media filtration system provides consistent removal efficiencies between change-outs***
- ***By-pass system prevents flooding or ponding during high flow storm events***
- ***Unit custom built for retrofit or new sites***
- ***Excellent post construction control for hot spot applications***
- ***Pre-treatment device for groundwater protection and infiltration practices***

UNITS AVAILABLE FOR ROUND OR SQUARE CATCH BASIN GRATES



ETV PARTICIPANT
EPA's Environmental Technology Verification Program

Municipal or Private Sector Financing and/or Leasing Options Available

HYDRO COMPLIANCE MANAGEMENT, INC.
ANN ARBOR • SEATTLE
For more information, please call: (800) 526-9629 or visit us at our web site at: www.Hydro-Kleen.com

HYDRO-KLEEN™ Filtration Systems Specification

The storm water runoff filtration system shall consist of a unit or units to be installed in existing or designed catch basins.

The water runoff filtration units shall be properly sized for the catch basin opening and predicted run-off.

The water runoff filtration system shall contain a pre-settling sediment chamber and a contaminant filtration chamber.

The media within the filtration chamber shall be a layered dual media system.

The first or primary filtration media shall consist of 8" in two or more mesh bags. This primary media shall be a non-leaching absorbent cellulose material that will attach hydrocarbons.

The second filter media shall consist of 4" of specially textured activated carbon to achieve a final polishing effect on the hydrocarbons in the discharge water as well as removing other organics, metals, and other contaminants.

Run-off water entering the unit shall be first diverted into the sediment chamber and from there shall flow into the filtering chamber through a transition inlet.

The units shall have sufficient overflow capacity to prevent ponding or flooding on the surface.

Filtration systems effectiveness shall be verified through third party testing.

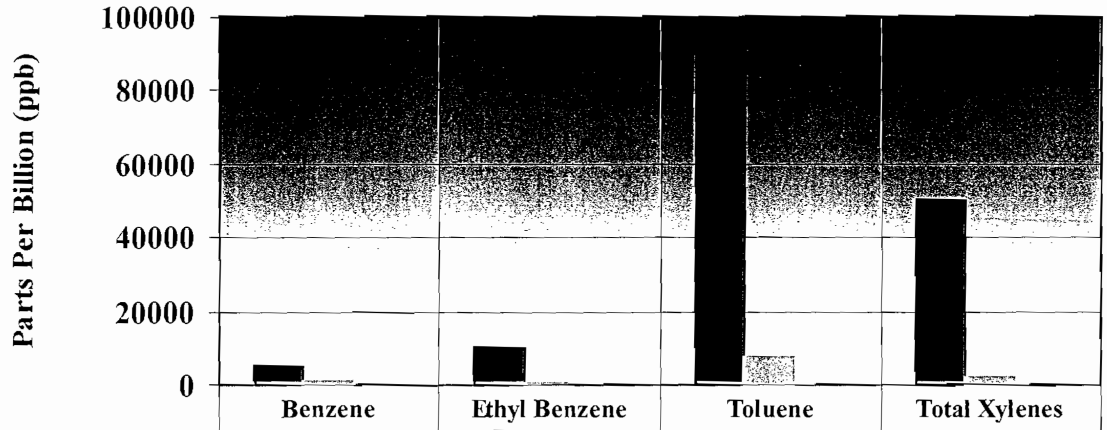
The filtration system shall be the Hydro-Kleen™ Filtration System or equivalent.

Hydro Compliance Management, Inc.
912 North Main Street
Ann Arbor, Michigan 48104

Office: 800-526-9629 or (734) 332-7300
Fax: 734-332-7972
www.Hydrocompliance.com

Third Party Analytical Test of the Hydro-Kleen™ Filtration System

Hydrocarbon Removal Efficiency (BTEX)



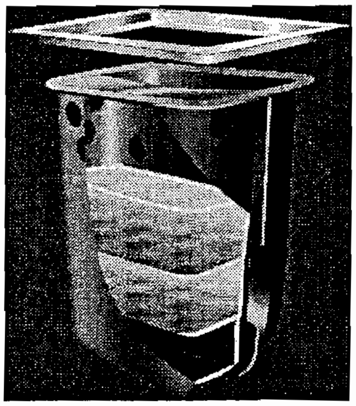
	Benzene	Ethyl Benzene	Toluene	Total Xylenes
Pre-Filter	5100	10000	91000	50000
Post-Filter	840	540	7800	2400
% Removal	83.5%	94.6%	91.4%	95.2%

Total Suspended Solids (TSS) Efficiency

Upstream	1800
DownStream	570
% Removal	0.683333333

Total Suspended Solids Removal>0.45microns

HYDRO-KLEEN™ FILTRATION SYSTEM



Application Profile

The Hydro-Kleen™ Filtration System is a patented multi-media filtration design combined with pre-settling sedimentation containment and overflow by-pass protection. Each unit is custom manufactured for retrofit or specification to fit your specific catch basin or drain invert size. Units are placed into drains by removing the grate/cover, inserting the unit onto the grate lip, and replacing the cover. Water flow enters the unit and is directed into a pre-settling sedimentation chamber that collects heavy sediments and debris passing through the grate. Water then passes through transition inlets at the top of the sediment chamber into the filtration chamber. The primary media, Sorb-44, traps hydrocarbons through adsorption to a hydrophobic cellulose material. The secondary media is a special blend of activated carbon (AC-10) that removes any remaining hydrocarbons as well as a variety of other organics, and metals and other contaminants from the runoff. Water then passes through the of the bottom treatment chamber into the catch basin.

A properly maintained unit will achieve substantial reductions of contaminants from entering surface waters. Units are designed to trap contaminants contained in the "first flush" from storm events while allowing overflow protection to eliminate flooding during heavy wet weather events. To accomplish this, the filtration chamber is designed to handle 40 – 50 gpm through the media chamber, effectively handling up to ½" of rain per hour in a properly designed drain. Higher flows from high intensity wet weather events are diverted to by-pass outlets that are designed to move whatever flows the drain is designed to handle. This prevents flooding or ponding on the surface while capturing the majority of contaminant loadings from impervious surfaces. Units strategically placed downstream from "hot spots" such as gas stations, parking lots and other industrial/commercial sites containing higher contaminate loadings, give municipalities and businesses an effective tool for reducing pollutants.

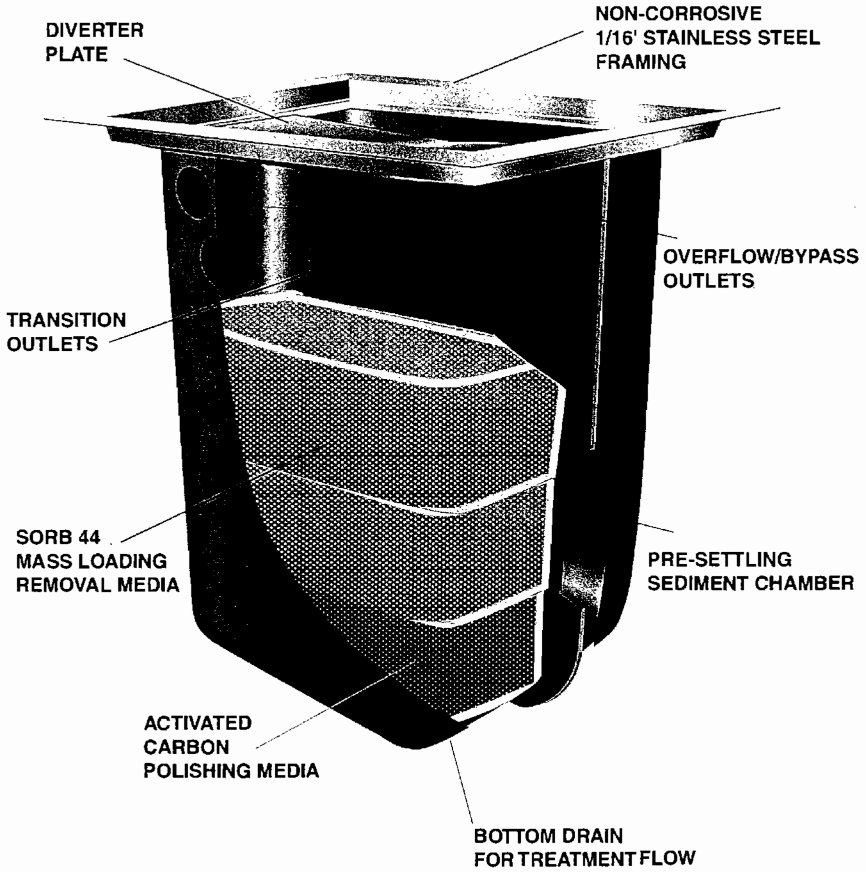
Hydro-Kleen™ Filtration Systems are cost-effective and can be installed at a fraction of the cost of a conventional oil-water separator and other BMP's. A typical unit will cost under $2,000. Moreover, this system does not require expensive installation as it can be retrofitted into existing storm drains as well as specified into new or re-development projects.

Hydro-Kleen™ Filtration System is also an effective pre-treatment device when used in conjunction with groundwater infiltration systems, detention facilities, water retention systems and oil/grit separators. It can also be utilized as a post-treatment device in wet pond risers. The application of a Hydro-Kleen™ Filtration System for compact project sites is ideal for eliminating the need to set aside land for detention basins or for using traditional, expensive oil-water separators, where land use is minimal such as in urban settings.

As with any system, the unit must be maintained on a regular schedule to prevent saturation of the filter media by contaminants and blockage from sedimentation and debris buildup. Maintenance is simple and can be accomplished in minutes by merely vacuuming sediment loadings from the sedimentation chamber and replacing the filters. With surface access there is no confined space entry. There is also no pump and haul issues as there is no free product or liquid hydrocarbons to dispose of. It is recommended that filters be changed every 4 to 6 months depending on the application. Disposal of the spent media in a typical application may be accomplished through placement into lined landfills, as the filter media is non-leaching. Always ensure compliance with all local regulations prior to disposal.

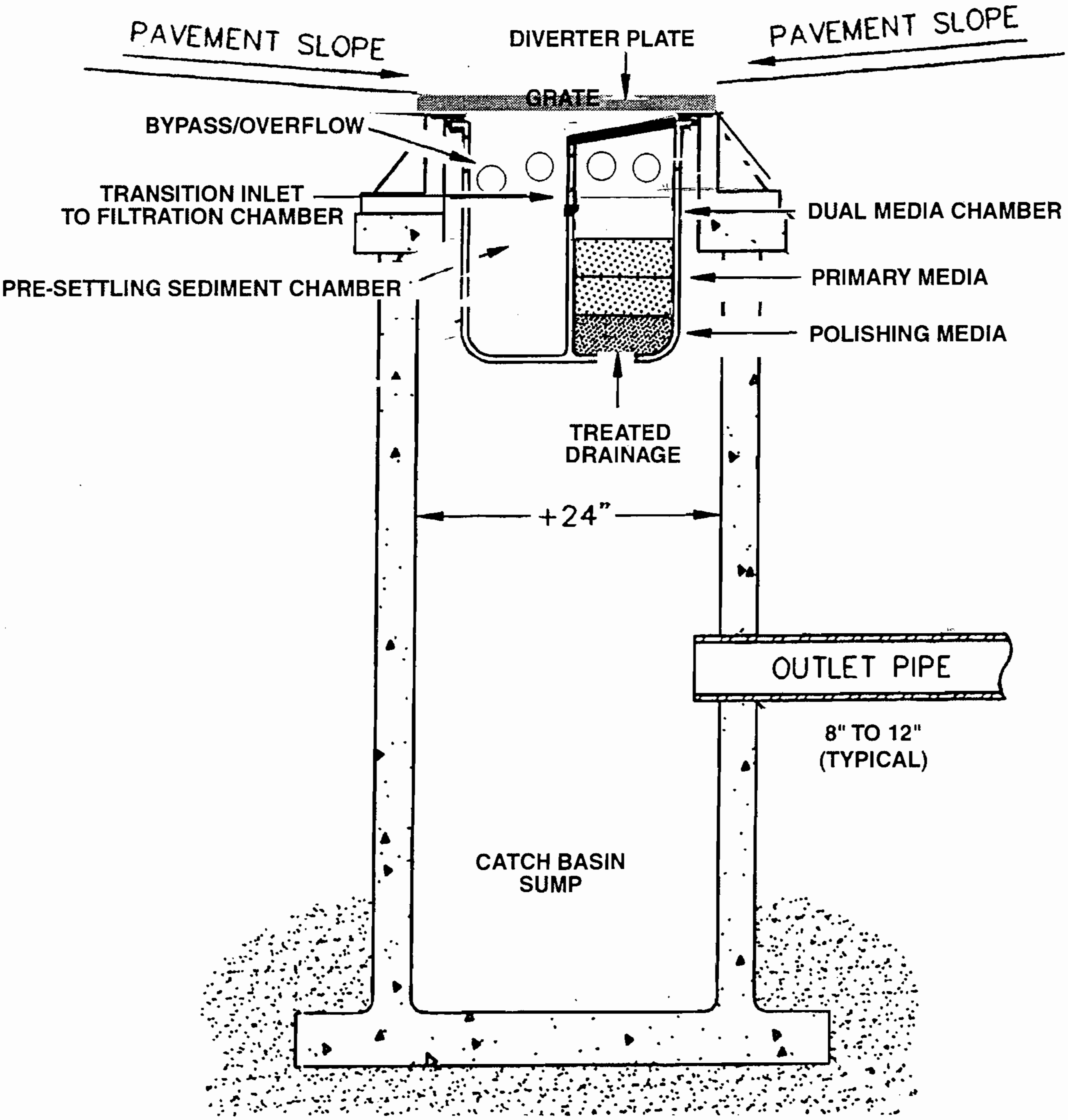
With new storm water rules directed at smaller municipalities and businesses and an increased emphasis on watershed protection at the local, state and federal levels, the Hydro-Kleen™ Filtration System provides an effective, low-cost technology for reducing pollutants from storm runoff, human generated flows, and other non-point sources.

HYDRO-KLEEN™ FILTRATION SYSTEM



HYDRO-KLEEN™ FILTRATION SYSTEM

SPECIFICATION



1. UNIT SHIPPED READY TO INSTALL WITH ONE EXTRA SET OF REPLACEMENT MEDIA.
2. UNIT DOES NOT INCLUDE CATCH BASIN OR GRATE FRAME.
3. PRINT SHOULD DESIGINATE HYDRO-KLEEN FILTRATION SYSTEM (HKFS) NEXT TO DESIGNATED CATCH BASIN.

912 North Main St Suite 100
Ann Arbor, Michigan 48104
(800) 526-9629

Installation and Maintenance

Hydro-Kleen Filtration System

Installation Instructions

1. Secure and place proper traffic safety barriers around site to prevent unauthorized traffic in work area.
2. Use proper safety equipment and procedures when removing and replacing grates and installing and servicing filters.
3. Clear work area and remove grate.
4. Confirm measurements of filter and catch basin.
5. Clean catch basin if necessary.
6. Place filtration unit in the catch basin.
7. Caulk with food grade silicone around metal frame to prevent water from bypassing system.
8. Install Media in filter housing.
9. Record data of system/filter installationin log.
10. Replace grate
11. On curb inlets, install deflector devices.

General

Timely change-out of the filter media is necessary to keep the media from becoming saturated. Upon saturation, pollutants will freely pass through the filter system. The following information is provided for the user to establish an maintenance program. Depending on site specific needs, units may require more frequent change outs.

There are two types of systems, one with sediment chambers and one without sediment chambers.

A site that does not have moving sediments, leaves or debris, or are too small for sediment chambers are candidates for standard flow-through units.

For outside locations, sediment chambers are highly recommended.

Unit maintenance consists of the following two activities:

1) Removal of trapped solids, debris and foreign matter is necessary to prevent flow restrictions and blockage.
2) Media replacement prior to saturation by pollutants.

Flow Restrictions & Blockage

Filter flow rates are reduced when, sediments such as silt and sand, collesct without maintenance in the treatment chamber. Blockage may also occur when leaves and debris enter the filter chamber.

Sediment Removal

Sediment chambers may be vacuumed clean with an 8" or smaller hose. This should be performed when the sediment levels approach the transition flow ports or the meadia chamber accumilates sediement on the filters.

Debris Removal

Debris screens prevent leaves, grass clippings, etc. from entering the filtration and sedimentation chambers. These screens should be cleaned as required to keep an unobstructed flow through the filtration media.

Media Replacement

Media should be changed twice annually for typical applications.
Use one of the following methods to determine when to replace your filter media.

Water Sampling

Water sampling is the most positive indicator of media performance. Change the media when effluent contaminant levels approach regulatory and/or predetermined concentration discharge limits.

Visual Inspection

As the media becomes saturated with hydrocarbons, the Sorb-44 media changes to a dark greyish color . The absorbent bags may be removed and inspected for color change.

Calendar Based

Filter saturation is dependent on the volume of contaminants removed. For normal road and parking lot applications, changing media every 6 months should be satisfactory.

Electronic Monitoring

Certain pollutants may be monitored electronically. Electronic monitors may be tied to alarm centers, such as an EBW or EMCO Electronics sensor monitor.

When filter discharges exceed alarm threshold settings the media should be changed.

Third Party Testing Results for the Hydro-Kleen Filtration System

Containment	Initial Concentration	After Filtration*	MDL/PQL
EPA 8015/8020/8021			
Gasoline	100,000 ppb	N.D.*	50 ppb
Toluene	46,000 ppb	N.D.*	5 ppb
2-Methylpentane	9,000 ppb	N.D.*	5 ppb
2-Methylheptane	8000 ppb	N.D.*	3 ppb
Benzene	28,000 ppb	N.D.*	10 ppb
Xylene	66,000 ppb	N.D.*	16 ppb
2-Methylhexane	1500 ppb	N.D.*	10 ppb
Trimethylhexane	4700 ppb	N.D.*	15 ppb
EPA 8270			
Diesel	100,000 ppb	N.D.*	50 ppb
EPA 413/418/1664			
Oil and Grease	100,000 ppb	N.D.*	.02 ppb
EPA 601			
1,1-Dichloroethane	17,000 ppb	5 ppb	3 ppb
Chloromenthane	20,000 ppb	N.D.*	2 ppb
EPA 603			
Acrylonitrile	11,000 ppb	4 ppb	3 ppb
Anthracene	15,000 ppb	N.D.*	20 ppb
EPA 608			
PCB's	50,000 ppb	5 ppb	20 ppb
Chlordane	20,000 ppb	N.D.*	25 ppb
Aldrin	20,000 ppb	N.D.*	20 ppb
Endrin	20,000 ppb	N.D.*	10 ppb
Heptachlor	20,000 ppb	N.D.*	5 ppb
EPA 610			
Phenanthrene	6,000 ppb	N.D.*	7 ppb
Benzo(a)pyrene	12,000 ppb	N.D.*	40 ppb
Chrysane	7,000 ppb	N.D.*	30 ppb
EPA 613			
Dioxins (2,3,7,8-TCDD)	10,000 ppb	4 ppm	

***N.D.**
("non detect"at or below method detection limits)

Comments:
The results indicate that the two media used in

tandem, under ideal conditions, can be extremely efficient at moving a wide range of hydrocarbons, petroleum distillates, and related organic compounds from an aqueous matrix.

Note:
Methods from EPA, 40CFR Part 136: SW846 (Test Methods for Evaluating Solid Wastes): and EPA 600/4-79-020 (Methods for Chemical Analysis of waters and Wastes)

Evaluation of the Hydro-Kleen

Results are based on tests performed by laboratories certified by the Department of Health Services, State of California, for Environmental Testing. Testing was conducted on a scale-model of the Hydro-Kleen Storm Drain System. The scale-model had a top chamber about 10"X10" and a bottom chamber about 8"X 8" with approximately 10" depth of filter medium in each chamber. The top chamber contained a cellulose material called Sorb 44 and the lower chamber a special activated carbon called AC-10. The unit was tested for its ability to remove hydrocarbons and related organics from water. Both pre- and post filtered water was tested by GC (gas chromatography) to determine levels of hydrocarbons present. The fuels and oils used in these tests contained hydrocarbons varying from C3 to C22 (i.e., propane, docosane, etc.) .

The first test involved contaminating water with items such as gas, diesel fuel, and oil, in a 100-1000 ppm range. This contaminated water was drained through the filter unit. Concentrations as high as 100 ppm initial total petroleum hydrocarbon (TPH) were reduced to 1-3 ppm under a flow rate of 5-10 gpm. Concentration as high as 1000 ppm are highly unusual, yet were reduced with the Hydro Kleen filtration system to the 5-10 ppm TPH range even under the highest flow rates.

We also tested running water contaminated with automobile drain oil at approximately 1,100 ppm in a closed loop, through the system and into a tank of live fish. A reservoir filled with contaminated water was set over the filtration system and drained into a 40-gallon tank holding 12 fish. The water was recirculated by way of a pump up through the contaminating reservoir and drained through the filter unit back into the fish tank for three consecutive days at 3-4 gpm.

After three days of continuous operation there were still absolutely no signs of toxicity. The fish were still quite healthy. The GC was down in the 20-30 ppb range. Even though flow rates were lower than in the first set of tests, this is still a dramatic demonstration of the systems effectiveness. In conclusion, our testing found your Hydro Kleen filtration system to be 95-99% effective under conditions of our tests in removing hydrocarbon substances from water.

Greg S. Conrad,Ph.D.

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HOME

APPENDIX D

RESULTS OF PARTICLE FRACTIONATION ANALYSES ON INFLOW AND OUTFLOW WATER SAMPLES FOR THE STORMCEPTOR UNIT

Results of Particle Fractionation on Palm Bay Stromceptor Inflow Water Samples

Collected on September 09, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	26.3	19.0	34.5	80.4	62.4	45.0	1285.4	1553.0
Total P	µg/l	6.3	4.2	9.3	24.2	14.9	11.5	385.6	456.0
TSS	mg/l	5.0	1.9	4.9	9.0	5.7	3.1	0.5	30.2
VSS	mg/l	1.3	0.5	1.0	2.1	1.3	0.7	0.1	7.0

Collected on September 29, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	14.9	10.6	14.2	25.3	29.0	19.8	1293.3	1407.0
Total P	µg/l	3.3	2.6	3.3	7.9	5.8	2.0	207.1	232.0
TSS	mg/l	0.5	0.4	0.4	1.3	1.0	0.3	4.1	8.0
VSS	mg/l	0.3	0.3	0.2	0.6	0.5	0.1	2.2	4.3

Collected on October 05, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	5.0	2.9	3.7	12.4	8.5	14.8	888.7	936.0
Total P	µg/l	0.5	0.1	0.3	2.7	1.4	1.5	174.5	181.0
TSS	mg/l	0.6	0.4	0.5	0.8	0.4	0.7	5.4	8.8
VSS	mg/l	0.2	0.1	0.3	0.4	0.1	0.3	2.7	4.2

Collected on October 14, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	11.1	2.6	2.7	6.7	10.1	18.1	545.7	597.0
Total P	µg/l	3.0	0.7	0.5	0.9	1.8	3.0	65.1	75.0
TSS	mg/l	1.0	0.1	0.2	0.3	0.4	0.3	6.1	8.4
VSS	mg/l	2.1	0.0	0.4	0.6	0.5	0.1	1.5	5.4

Collected on October 20, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	100.1	18.6	25.2	49.1	92.1	75.1	1429.7	1790.0
Total P	µg/l	22.7	3.2	4.5	10.2	21.9	13.9	233.5	310.0
TSS	mg/l	12.2	2.3	2.5	2.7	5.1	2.8	3.7	31.2
VSS	mg/l	9.7	1.9	2.3	1.9	3.2	1.6	2.9	23.4

Collected on October 27, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	133.1	13.2	18.5	34.5	55.4	64.0	1751.4	2070.0
Total P	µg/l	32.4	2.2	3.6	7.1	13.7	14.9	396.1	470.0
TSS	mg/l	15.6	2.3	2.2	1.9	3.9	3.1	1.3	30.2
VSS	mg/l	9.1	0.4	0.7	1.1	2.0	1.6	0.6	15.6

Results of Particle Fractionation on Palm Bay Stromceptor Inflow Water Samples

Collected on November 04, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	214.0	35.9	17.3	24.4	38.2	59.0	1953.2	2342.0
Total P	µg/l	69.6	0.1	5.4	7.3	11.7	16.4	526.5	637.0
TSS	mg/l	13.4	2.1	1.3	1.3	2.0	3.0	3.5	26.5
VSS	mg/l	11.4	1.9	1.3	1.3	1.7	2.2	3.4	23.2

Collected on November 11, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	74.9	13.1	13.2	17.9	14.4	37.5	427.0	598.0
Total P	µg/l	8.7	1.5	1.8	2.9	1.7	3.7	74.7	95.0
TSS	mg/l	0.4	0.1	0.1	0.1	0.1	0.2	0.3	1.3
VSS	mg/l	0.3	0.1	0.0	0.1	0.1	0.1	0.2	1.0

Collected on November 22, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	101.0	32.7	47.4	135.2	239.2	328.0	2186.4	3070.0
Total P	µg/l	37.4	5.3	8.7	48.1	77.2	85.0	572.3	834.0
TSS	mg/l	5.3	0.7	1.2	4.8	7.0	6.5	4.1	29.6
VSS	mg/l	2.8	0.4	0.6	2.1	3.0	2.7	1.5	13.1

Collected on December 16, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	339.4	114.0	58.3	98.6	296.1	292.5	828.1	2027.0
Total P	µg/l	95.3	24.0	11.9	20.9	78.2	81.0	340.8	652.0
TSS	mg/l	15.1	15.2	2.9	1.7	6.2	7.8	8.8	57.8
VSS	mg/l	3.9	0.7	1.3	0.8	2.7	3.2	4.4	17.0

Collected on December 20, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	171.5	69.0	76.8	49.5	164.2	226.5	2423.4	3181.0
Total P	µg/l	31.5	12.8	14.1	11.8	22.4	22.6	465.8	581.0
TSS	mg/l	19.3	1.8	2.9	4.4	9.8	9.0	21.4	68.6
VSS	mg/l	6.5	0.6	0.5	1.5	2.8	2.6	5.7	20.2

Collected on January 25, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	1341.6	23.4	8.2	55.4	56.5	141.4	1386.5	3013.0
Total P	µg/l	279.6	3.8	1.3	9.7	8.4	19.8	744.5	1067.0
TSS	mg/l	31.4	1.4	0.5	4.9	4.3	8.1	4.4	55.0
VSS	mg/l	22.4	1.0	0.4	3.3	2.7	4.6	2.8	37.2

Results of Particle Fractionation on Palm Bay Stromceptor Inflow Water Samples

Collected on February 10, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	573.0	67.2	43.0	33.2	97.1	69.0	1755.5	2638.0
Total P	µg/l	100.4	13.6	7.7	6.7	14.4	10.7	843.4	997.0
TSS	mg/l	40.5	3.7	2.3	1.7	4.5	3.1	27.2	83.0
VSS	mg/l	24.5	2.4	1.6	1.7	2.6	1.6	17.2	51.5

Collected on February 17, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	499.5	57.5	74.3	179.2	311.3	149.7	1682.4	2954.0
Total P	µg/l	93.9	9.3	12.4	36.5	59.4	24.9	575.6	812.0
TSS	mg/l	19.8	2.5	4.2	10.4	17.1	6.7	7.5	68.2
VSS	mg/l	15.3	1.8	3.0	7.0	15.5	0.8	5.1	48.4

Results of Particle Fractionation on Palm Bay Stromceptor Outfall Water Samples

Collected on September 09, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	96.1	28.2	16.8	48.9	78.5	236.3	442.1	947.0
Total P	µg/l	10.8	2.6	1.7	5.3	13.6	35.7	135.3	205.0
TSS	mg/l	3.5	0.7	0.6	1.8	3.4	6.9	3.2	20.1
VSS	mg/l	2.0	0.5	0.4	1.1	1.9	5.5	0.2	11.6

Collected on September 29, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	55.8	53.9	56.8	78.7	81.6	67.1	3049.1	3443.0
Total P	µg/l	7.6	5.3	5.0	4.3	11.7	11.2	275.9	321.0
TSS	mg/l	0.7	0.6	0.5	0.9	0.3	1.7	1.8	6.4
VSS	mg/l	0.2	0.3	0.1	0.3	0.1	0.6	0.4	2.0

Collected on October 05, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	48.8	26.3	13.1	18.5	45.1	35.6	1269.6	1457.0
Total P	µg/l	13.4	4.2	5.8	4.0	14.0	8.1	310.5	360.0
TSS	mg/l	7.4	2.3	2.3	2.8	7.4	5.6	6.5	34.3
VSS	mg/l	6.7	1.8	1.8	2.3	6.3	5.1	5.9	30.0

Collected on October 14, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	13.7	1.1	0.9	3.9	9.8	13.7	633.0	676.0
Total P	µg/l	1.5	0.1	0.1	0.5	1.3	1.6	69.9	75.0
TSS	mg/l	0.5	0.2	0.1	0.3	0.3	0.5	0.3	2.2
VSS	mg/l	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.4

Collected on October 20, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	133.6	43.8	105.5	144.0	144.3	179.3	1416.5	2167.0
Total P	µg/l	19.1	3.1	7.4	16.4	22.9	29.5	458.5	557.0
TSS	mg/l	13.2	1.0	1.6	3.5	6.1	6.8	2.0	34.2
VSS	mg/l	12.2	1.0	1.3	2.8	4.7	5.1	1.4	28.5

Collected on October 27, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	6.3	27.7	25.3	40.0	87.5	70.6	2048.6	2306.0
Total P	µg/l	1.7	6.6	5.6	8.8	22.1	16.2	487.0	548.0
TSS	mg/l	0.2	0.6	0.6	0.8	2.2	1.3	1.1	6.8
VSS	mg/l	0.1	0.3	0.3	0.4	0.8	0.5	0.4	2.7

Results of Particle Fractionation on Palm Bay Stromceptor Outfall Water Samples

Collected on November 04, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	106.5	18.7	30.0	49.7	45.7	164.6	823.8	1239.0
Total P	µg/l	14.1	3.1	6.3	13.1	10.1	45.5	342.8	435.0
TSS	mg/l	0.4	0.6	1.3	3.3	2.2	9.6	4.5	21.9
VSS	mg/l	0.4	0.6	1.0	2.5	1.0	3.5	2.9	11.7

Collected on November 11, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	9.1	8.2	8.4	5.6	17.5	39.4	423.8	512.0
Total P	µg/l	1.4	1.6	1.6	0.8	3.6	3.9	51.2	64.0
TSS	mg/l	0.2	0.1	0.2	0.0	0.2	0.3	8.1	9.1
VSS	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	2.6	3.2

Collected on November 22, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	97.4	9.0	26.7	35.0	96.1	59.7	2635.1	2959.0
Total P	µg/l	21.3	1.2	5.8	7.6	16.9	33.8	450.4	537.0
TSS	mg/l	4.3	0.6	1.1	2.0	3.8	5.6	12.4	29.8
VSS	mg/l	4.8	0.4	1.1	0.9	3.2	4.5	7.9	22.8

Collected on December 16, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	25.0	17.4	39.1	6.1	27.0	45.4	753.1	913.0
Total P	µg/l	6.6	4.0	8.9	1.0	4.0	11.0	342.4	378.0
TSS	mg/l	1.3	0.7	1.2	0.9	0.5	0.7	4.0	9.4
VSS	mg/l	0.7	0.5	0.8	0.5	0.3	0.4	3.3	6.4

Collected on December 20, 2005

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	34.4	25.9	23.9	27.9	62.6	160.0	2545.2	2880.0
Total P	µg/l	4.9	2.8	2.1	3.4	8.5	14.3	447.1	483.0
TSS	mg/l	2.3	1.5	1.4	1.8	1.7	2.8	20.6	32.1
VSS	mg/l	2.1	1.0	1.0	1.4	1.3	1.8	9.9	18.5

Collected on January 25, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	508.5	47.4	128.3	99.5	267.6	194.1	2856.6	4102.0
Total P	µg/l	99.1	7.6	20.9	17.3	54.9	33.1	1439.2	1672.0
TSS	mg/l	5.7	0.6	1.2	1.8	2.9	1.9	26.2	40.3
VSS	mg/l	5.5	0.6	1.3	1.8	2.6	1.6	14.1	27.4

Results of Particle Fractionation on Palm Bay Stromceptor Outfall Water Samples

Collected on February 10, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	89.5	16.8	15.8	23.2	48.9	37.3	2344.5	2576.0
Total P	µg/l	18.0	3.2	3.2	4.9	9.7	7.0	594.1	640.0
TSS	mg/l	6.0	1.5	1.1	1.4	8.3	2.0	3.6	23.9
VSS	mg/l	4.9	1.2	1.1	0.6	4.6	1.7	2.9	17.0

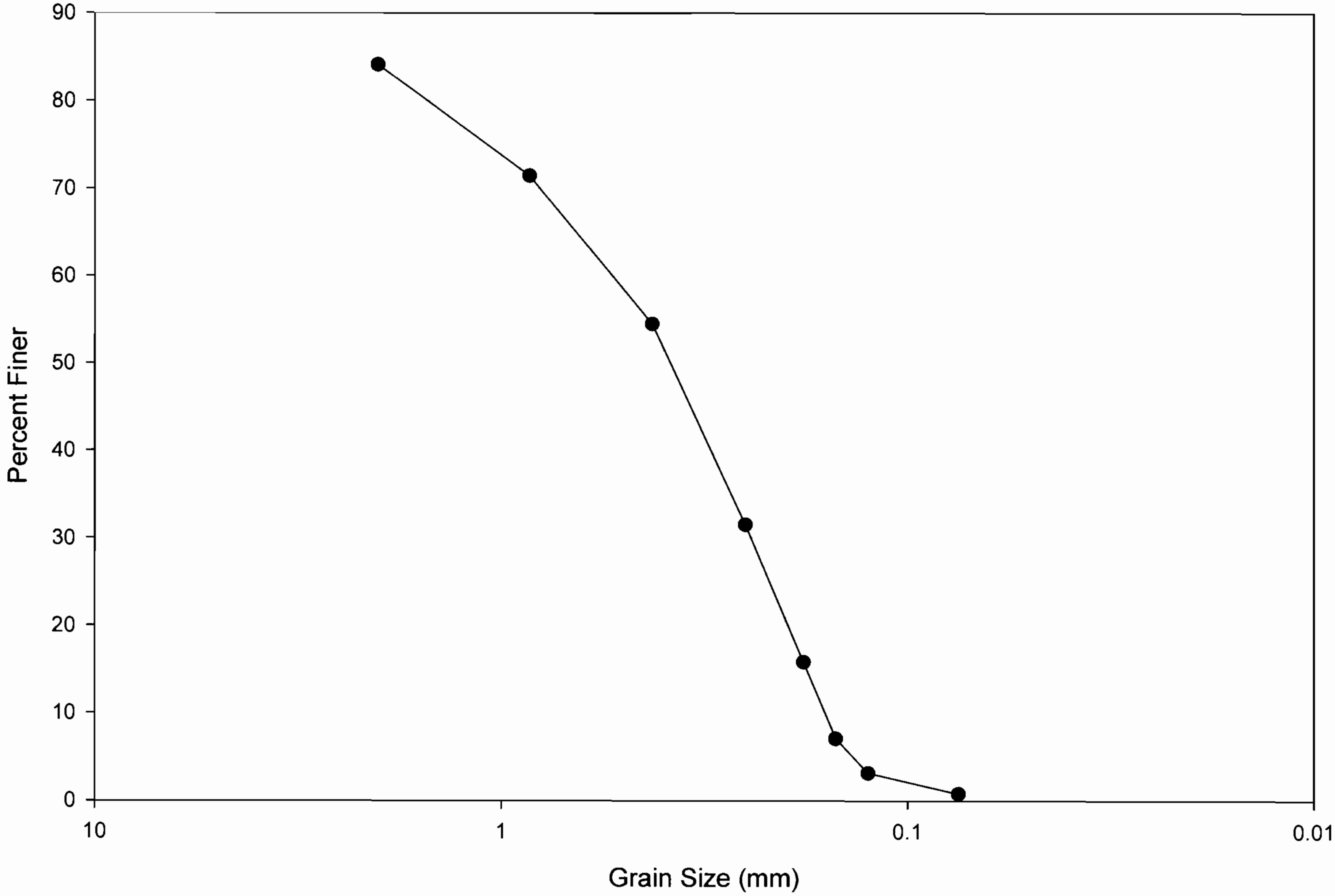
Collected on February 17, 2006

Parameter	Units	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Total N	µg/l	24.7	8.7	7.3	22.5	102.4	49.1	3889.4	4104.0
Total P	µg/l	4.2	1.5	1.5	5.7	25.7	13.1	435.3	487.0
TSS	mg/l	3.1	0.6	0.7	3.0	7.8	3.9	6.8	25.9
VSS	mg/l	2.4	0.2	0.7	1.8	5.2	2.1	4.5	16.9

APPENDIX E

GRAIN SIZE ANALYSES FOR SOLIDS REMOVED FROM THE STORMCEPTOR SUMP

Palm Bay
Grain Size Distribution Curve
Stormceptor Sump Solids



Palm Bay
Stormceptor Sump Solids

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.52	641.98	167.5	15.9	15.9	84.1
20	0.85	445.20	578.52	133.3	12.7	28.6	71.4
40	0.425	422.79	601.08	178.3	16.9	45.5	54.5
60	0.25	393.29	635.24	242.0	23.0	68.5	31.5
80	0.18	390.63	555.94	165.3	15.7	84.2	15.8
100	0.15	380.61	472.42	91.8	8.7	92.9	7.1
120	0.125	364.10	405.39	41.3	3.9	96.8	3.2
200	0.075	375.69	400.47	24.8	2.4	99.2	0.8
PAN	<0.075	369.04	377.49	8.4	0.8	100.0	0.0
	Total			1052.7	100.0		
						D10=	0.16
						D30=	0.24
						D60=	0.54

Uniformity Coefficient= 3.38
Coefficient of Gradiation= 0.67

APPENDIX F

ANALYSES ON RESIDENTIAL SOLIDS USED FOR TESTING OF THE ULTRA-URBAN AND HYDRO-KLEEN FILTER UNITS

1. **Grain Size Analyses**
2. **Nutrient Content**

1. GRAIN SIZE ANALYSES

Palm Bay
Residential Solids - Sample A

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	832.90	1185.96	353.1	11.0	11.0	89.0
20	0.85	445.27	636.47	191.2	6.0	17.0	83.0
40	0.425	422.61	1076.60	654.0	20.4	37.4	62.6
60	0.25	393.17	1806.25	1413.1	44.1	81.5	18.5
80	0.18	390.59	871.42	480.8	15.0	96.5	3.5
100	0.15	380.70	478.43	97.7	3.0	99.5	0.5
120	0.125	364.13	367.06	2.9	0.1	99.6	0.4
200	0.075	375.76	384.37	8.6	0.3	99.9	0.1
PAN	<0.075	369.24	373.56	4.3	0.1	100.0	0.0
	Total			3205.8	100.0		
						D10=	0.21
						D30=	0.28
						D60=	0.41

Uniformity Coefficient= 1.95
Coefficient of Gradiation= 0.91

Palm Bay
Residential Solids - Sample B

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	833.08	1161.16	328.1	10.0	10.0	90.0
20	0.85	445.89	642.10	196.2	6.0	15.9	84.1
40	0.425	423.63	965.84	542.2	16.5	32.4	67.6
60	0.25	396.35	2175.55	1779.2	54.1	86.5	13.5
80	0.18	392.12	740.40	348.3	10.6	97.1	2.9
100	0.15	381.56	434.75	53.2	1.6	98.7	1.3
120	0.125	364.19	370.89	6.7	0.2	98.9	1.1
200	0.075	375.77	391.35	15.6	0.5	99.4	0.6
PAN	<0.075	369.25	388.22	19.0	0.6	100.0	0.0
	Total			3288.4	100.0		
						D10=	0.22
						D30=	0.29
						D60=	0.40

Uniformity Coefficient= 1.82
Coefficient of Gradiation= 0.96

Palm Bay
Residential Solids - Sample C

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	833.04	1199.66	366.6	8.8	8.8	91.2
20	0.85	446.93	672.28	225.4	5.4	14.1	85.9
40	0.425	424.34	1659.20	1234.9	29.5	43.6	56.4
60	0.25	396.35	2427.30	2031.0	48.5	92.1	7.9
80	0.18	392.46	649.72	257.3	6.1	98.3	1.7
100	0.15	381.74	441.35	59.6	1.4	99.7	0.3
120	0.125	364.25	371.22	7.0	0.2	99.9	0.1
200	0.075	375.83	378.92	3.1	0.1	99.9	0.1
PAN	<0.075	369.20	371.46	2.3	0.1	100.0	0.0
	Total			4187.0	100.0		
						D10=	0.25
						D30=	0.32
						D60=	0.47

Uniformity Coefficient= 1.88
Coefficient of Gradiation= 0.87

Palm Bay
Residential Solids - Sample D

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.51	569.45	94.9	9.6	9.6	90.4
20	0.85	445.52	496.53	51.0	5.2	14.8	85.2
40	0.425	425.17	572.80	147.6	15.0	29.8	70.2
60	0.25	396.48	1024.50	628.0	63.8	93.6	6.4
80	0.18	391.60	403.66	12.1	1.2	94.8	5.2
100	0.15	380.90	399.29	18.4	1.9	96.7	3.3
120	0.125	364.13	371.92	7.8	0.8	97.5	2.5
200	0.075	375.73	391.98	16.3	1.6	99.1	0.9
PAN	<0.075	369.14	377.95	8.8	0.9	100.0	0.0
	Total			984.9	100.0		
						D10=	0.26
						D30=	0.31
						D60=	0.39

Uniformity Coefficient= 1.50
Coefficient of Gradiation= 0.95

Palm Bay
Residential Solids - Sample E

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.59	559.01	84.4	9.2	9.2	90.8
20	0.85	445.73	492.05	46.3	5.1	14.3	85.7
40	0.425	424.52	544.57	120.1	13.1	27.5	72.5
60	0.25	396.47	780.78	384.3	42.1	69.6	30.4
80	0.18	391.49	490.88	99.4	10.9	80.4	19.6
100	0.15	380.99	464.52	83.5	9.1	89.6	10.4
120	0.125	364.19	388.83	24.6	2.7	92.3	7.7
200	0.075	375.77	423.87	48.1	5.3	97.6	2.4
PAN	<0.075	369.25	391.57	22.3	2.4	100.0	0.0
	Total			913.1	100.0		

D10=	0.15
D30=	0.25
D60=	0.36

Uniformity Coefficient=	2.40
Coefficient of Gradiation=	1.16

Palm Bay
Residential Solids - Sample F

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.61	560.75	86.1	8.5	8.5	91.5
20	0.85	445.83	498.85	53.0	5.3	13.8	86.2
40	0.425	424.91	562.05	137.1	13.6	27.4	72.6
60	0.25	396.50	981.14	584.6	57.9	85.3	14.7
80	0.18	391.59	441.68	50.1	5.0	90.2	9.8
100	0.15	381.00	435.78	54.8	5.4	95.6	4.4
120	0.125	364.20	379.37	15.2	1.5	97.1	2.9
200	0.075	375.78	391.19	15.4	1.5	98.7	1.3
PAN	<0.075	369.16	382.58	13.4	1.3	100.0	0.0
	Total			1009.8	100.0		

D10=	0.18
D30=	0.28
D60=	0.38

Uniformity Coefficient=	2.11
Coefficient of Gradiation=	1.15

Palm Bay
Residential Solids - Sample G

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.50	623.34	148.8	41.0	41.0	59.0
20	0.85	445.52	476.81	31.3	8.6	49.7	50.3
40	0.425	422.75	466.12	43.4	12.0	61.6	38.4
60	0.25	393.81	439.90	46.1	12.7	74.3	25.7
80	0.18	390.56	421.32	30.8	8.5	82.8	17.2
100	0.15	350.98	396.01	45.0	12.4	95.3	4.7
120	0.125	364.11	371.34	7.2	2.0	97.2	2.8
200	0.075	375.71	383.81	8.1	2.2	99.5	0.5
PAN	<0.075	369.12	371.01	1.9	0.5	100.0	0.0
	Total			362.6	100.0		
						D10=	0.16
						D30=	0.30
						D60=	NA

Uniformity Coefficient= NA
Coefficient of Gradiation= NA

Palm Bay
Residential Solids - Sample H

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.68	603.20	128.5	41.4	41.4	58.6
20	0.85	445.74	477.81	32.1	10.3	51.8	48.2
40	0.425	423.23	464.58	41.4	13.3	65.1	34.9
60	0.25	395.10	439.11	44.0	14.2	79.3	20.7
80	0.18	391.27	421.05	29.8	9.6	88.9	11.1
100	0.15	381.14	397.38	16.2	5.2	94.1	5.9
120	0.125	364.24	371.20	7.0	2.2	96.4	3.6
200	0.075	375.75	384.41	8.7	2.8	99.2	0.8
PAN	<0.075	369.12	371.74	2.6	0.8	100.0	0.0
	Total			310.2	100.0		
						D10=	0.17
						D30=	0.36
						D60=	NA

Uniformity Coefficient= NA
Coefficient of Gradiation= NA

Palm Bay
Residential Solids - Sample I

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.55	585.58	111.0	34.2	34.2	65.8
20	0.85	445.68	477.95	32.3	9.9	44.1	55.9
40	0.425	423.31	471.50	48.2	14.8	58.9	41.1
60	0.25	394.76	450.29	55.5	17.1	76.0	24.0
80	0.18	391.04	427.08	36.0	11.1	87.1	12.9
100	0.15	381.07	402.39	21.3	6.6	93.6	6.4
120	0.125	364.22	371.46	7.2	2.2	95.9	4.1
200	0.075	375.77	386.17	10.4	3.2	99.1	0.9
PAN	<0.075	369.14	372.20	3.1	0.9	100.0	0.0
	Total			325.1	100.0		
						D10=	0.17
						D30=	0.30
						D60=	1.25

Uniformity Coefficient= 7.35
Coefficient of Gradiation= 0.42

Palm Bay
Residential Solids - Sample J

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.59	601.48	126.9	31.1	31.1	68.9
20	0.85	445.62	486.79	41.2	10.1	41.1	58.9
40	0.425	423.65	488.85	65.2	16.0	57.1	42.9
60	0.25	394.90	477.70	82.8	20.3	77.4	22.6
80	0.18	391.14	441.22	50.1	12.3	89.6	10.4
100	0.15	381.31	405.63	24.3	6.0	95.6	4.4
120	0.125	364.26	370.31	6.1	1.5	97.1	2.9
200	0.075	375.78	384.85	9.1	2.2	99.3	0.7
PAN	<0.075	369.14	372.05	2.9	0.7	100.0	0.0
	Total			408.5	100.0		
						D10=	0.18
						D30=	0.31
						D60=	0.94

Uniformity Coefficient= 5.22
Coefficient of Gradiation= 0.57

Palm Bay
Residential Solids - Sample K

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.53	606.54	132.0	40.9	40.9	59.1
20	0.85	445.62	478.67	33.1	10.3	51.2	48.8
40	0.425	423.58	468.22	44.6	13.8	65.0	35.0
60	0.25	393.97	439.96	46.0	14.3	79.3	20.7
80	0.18	391.09	422.51	31.4	9.7	89.0	11.0
100	0.15	381.20	396.64	15.4	4.8	93.8	6.2
120	0.125	364.20	372.21	8.0	2.5	96.3	3.7
200	0.075	375.76	384.67	8.9	2.8	99.1	0.9
PAN	<0.075	369.16	372.11	2.9	0.9	100.0	0.0
	Total			322.4	100.0		
						D10=	0.17
						D30=	0.36
						D60=	NA

Uniformity Coefficient= NA
Coefficient of Gradiation= NA

Palm Bay
Residential Solids - Sample L

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.61	607.16	132.6	36.7	36.7	63.3
20	0.85	445.59	480.55	35.0	9.7	46.4	53.6
40	0.425	423.39	475.21	51.8	14.3	60.7	39.3
60	0.25	394.39	453.38	59.0	16.3	77.0	23.0
80	0.18	391.08	430.74	39.7	11.0	88.0	12.0
100	0.15	381.24	401.88	20.6	5.7	93.7	6.3
120	0.125	364.25	372.90	8.6	2.4	96.1	3.9
200	0.075	375.76	386.47	10.7	3.0	99.1	0.9
PAN	<0.075	369.14	372.51	3.4	0.9	100.0	0.0
	Total			361.4	100.0		
						D10=	0.17
						D30=	0.32
						D60=	1.50

Uniformity Coefficient= 8.82
Coefficient of Gradiation= 0.40

Palm Bay
Residential Solids - Sample M

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.44	540.60	66.2	7.8	7.8	92.2
20	0.85	445.37	492.26	46.9	5.5	13.4	86.6
40	0.425	422.71	611.80	189.1	22.4	35.8	64.2
60	0.25	393.13	811.68	418.6	49.5	85.3	14.7
80	0.18	390.49	476.49	86.0	10.2	95.5	4.5
100	0.15	380.53	414.23	33.7	4.0	99.4	0.6
120	0.125	364.10	366.12	2.0	0.2	99.7	0.3
200	0.075	375.69	377.49	1.8	0.2	99.9	0.1
PAN	<0.075	369.06	369.94	0.9	0.1	100.0	0.0
	Total			845.1	100.0		

D10=	0.22
D30=	0.29
D60=	0.41

Uniformity Coefficient=	1.86
Coefficient of Gradiation=	0.93

Palm Bay
Residential Solids - Sample N

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.62	566.02	91.4	14.1	14.1	85.9
20	0.85	445.78	483.88	38.1	5.9	20.0	80.0
40	0.425	423.41	545.21	121.8	18.8	38.8	61.2
60	0.25	393.53	638.32	244.8	37.8	76.6	23.4
80	0.18	390.56	484.71	94.2	14.5	91.1	8.9
100	0.15	380.59	428.11	47.5	7.3	98.4	1.6
120	0.125	364.09	366.69	2.6	0.4	98.8	1.2
200	0.075	375.69	381.09	5.4	0.8	99.7	0.3
PAN	<0.075	369.11	371.25	2.1	0.3	100.0	0.0
	Total			647.9	100.0		

D10=	0.18
D30=	0.27
D60=	0.41

Uniformity Coefficient=	2.28
Coefficient of Gradiation=	0.99

Palm Bay
Residential Solids - Sample O

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.55	577.26	102.7	14.6	14.6	85.4
20	0.85	445.99	490.96	45.0	6.4	20.9	79.1
40	0.425	422.83	553.41	130.6	18.5	39.5	60.5
60	0.25	393.32	650.42	257.1	36.5	75.9	24.1
80	0.18	390.70	503.07	112.4	15.9	91.9	8.1
100	0.15	380.92	426.12	45.2	6.4	98.3	1.7
120	0.125	364.14	369.26	5.1	0.7	99.0	1.0
200	0.075	375.70	381.01	5.3	0.8	99.8	0.2
PAN	<0.075	369.11	370.77	1.7	0.2	100.0	0.0
	Total			705.0	100.0		
						D10=	0.19
						D30=	0.26
						D60=	0.42

Uniformity Coefficient= 2.21
Coefficient of Gradiation= 0.85

Palm Bay
Residential Solids - Sample P

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.52	580.41	105.9	12.7	12.7	87.3
20	0.85	445.37	500.73	55.4	6.7	19.4	80.6
40	0.425	422.83	592.37	169.5	20.4	39.8	60.2
60	0.25	393.18	725.22	332.0	39.9	79.7	20.3
80	0.18	390.53	507.46	116.9	14.1	93.7	6.3
100	0.15	380.60	422.22	41.6	5.0	98.7	1.3
120	0.125	364.12	370.01	5.9	0.7	99.4	0.6
200	0.075	375.71	379.27	3.6	0.4	99.8	0.2
PAN	<0.075	369.08	370.33	1.3	0.2	100.0	0.0
	Total			832.1	100.0		
						D10=	0.19
						D30=	0.28
						D60=	0.43

Uniformity Coefficient= 2.26
Coefficient of Gradiation= 0.96

Palm Bay
Residential Solids - Sample Q

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.62	589.27	114.7	20.0	20.0	80.0
20	0.85	445.49	483.70	38.2	6.7	26.7	73.3
40	0.425	422.85	525.23	102.4	17.9	44.5	55.5
60	0.25	393.26	534.87	141.6	24.7	69.3	30.7
80	0.18	390.55	488.66	98.1	17.1	86.4	13.6
100	0.15	380.60	427.28	46.7	8.1	94.5	5.5
120	0.125	364.11	376.70	12.6	2.2	96.7	3.3
200	0.075	375.69	390.68	15.0	2.6	99.3	0.7
PAN	<0.075	369.10	372.94	3.8	0.7	100.0	0.0
	Total			573.1	100.0		

D10= 0.16
D30= 0.25
D60= 0.51

Uniformity Coefficient= 3.19
Coefficient of Gradiation= 0.77

Palm Bay
Residential Solids - Sample R

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.58	530.15	55.6	6.9	6.9	93.1
20	0.85	445.29	498.24	53.0	6.6	13.6	86.4
40	0.425	422.82	593.41	170.6	21.3	34.9	65.1
60	0.25	393.23	766.82	373.6	46.7	81.5	18.5
80	0.18	390.56	493.55	103.0	12.9	94.4	5.6
100	0.15	380.61	418.98	38.4	4.8	99.2	0.8
120	0.125	364.12	369.02	4.9	0.6	99.8	0.2
200	0.075	375.70	376.64	0.9	0.1	99.9	0.1
PAN	<0.075	369.07	369.56	0.5	0.1	100.0	0.0
	Total			800.4	100.0		

D10= 0.20
D30= 0.28
D60= 0.41

Uniformity Coefficient= 2.05
Coefficient of Gradiation= 0.96

Palm Bay
Residential Solids - Sample S

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.56	524.23	49.7	7.3	7.3	92.7
20	0.85	445.29	492.88	47.6	7.0	14.4	85.6
40	0.425	422.76	554.79	132.0	19.5	33.9	66.1
60	0.25	393.30	596.78	203.5	30.1	64.0	36.0
80	0.18	390.59	532.72	142.1	21.0	85.0	15.0
100	0.15	380.63	449.00	68.4	10.1	95.1	4.9
120	0.125	364.12	379.51	15.4	2.3	97.4	2.6
200	0.075	375.69	389.88	14.2	2.1	99.5	0.5
PAN	<0.075	369.07	372.78	3.7	0.5	100.0	0.0
	Total			676.6	100.0		

D10=	0.16
D30=	0.23
D60=	0.38

Uniformity Coefficient=	2.38
Coefficient of Gradiation=	0.87

Palm Bay
Residential Solids - Sample T

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.57	527.16	52.6	7.1	7.1	92.9
20	0.85	445.33	496.14	50.8	6.9	13.9	86.1
40	0.425	422.83	575.23	152.4	20.6	34.5	65.5
60	0.25	393.24	636.48	243.2	32.8	67.3	32.7
80	0.18	390.60	543.77	153.2	20.7	87.9	12.1
100	0.15	380.76	452.18	71.4	9.6	97.6	2.4
120	0.125	364.13	372.75	8.6	1.2	98.7	1.3
200	0.075	375.69	382.79	7.1	1.0	99.7	0.3
PAN	<0.075	369.06	371.30	2.2	0.3	100.0	0.0
	Total			741.6	100.0		

D10=	0.17
D30=	0.24
D60=	0.39

Uniformity Coefficient=	2.29
Coefficient of Gradiation=	0.87

Palm Bay
Residential Solids - Sample U

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.55	519.84	45.3	6.1	6.1	93.9
20	0.85	445.40	496.61	51.2	6.9	13.0	87.0
40	0.425	422.84	570.69	147.9	19.9	32.9	67.1
60	0.25	393.24	589.63	196.4	26.5	59.4	40.6
80	0.18	390.63	543.16	152.5	20.6	79.9	20.1
100	0.15	380.74	447.48	66.7	9.0	88.9	11.1
120	0.125	364.13	410.33	46.2	6.2	95.2	4.8
200	0.075	375.75	402.01	26.3	3.5	98.7	1.3
PAN	<0.075	369.08	378.81	9.7	1.3	100.0	0.0
	Total			742.2	100.0		
						D10=	0.14
						D30=	0.22
						D60=	0.38

Uniformity Coefficient= 2.71
Coefficient of Gradiation= 0.91

Palm Bay
Residential Solids - Sample V

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.53	562.53	88.0	26.3	26.3	73.7
20	0.85	445.60	469.68	24.1	7.2	33.5	66.5
40	0.425	422.97	451.05	28.1	8.4	41.9	58.1
60	0.25	393.40	448.40	55.0	16.4	58.3	41.7
80	0.18	390.83	470.87	80.0	23.9	82.2	17.8
100	0.15	380.77	424.32	43.6	13.0	95.2	4.8
120	0.125	364.16	374.45	10.3	3.1	98.3	1.7
200	0.075	375.73	380.30	4.6	1.4	99.7	0.3
PAN	<0.075	369.15	370.24	1.1	0.3	100.0	0.0
	Total			334.7	100.0		
						D10=	0.16
						D30=	0.22
						D60=	0.49

Uniformity Coefficient= 3.06
Coefficient of Gradiation= 0.62

Palm Bay
Residential Solids - Sample W

Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.52	572.67	98.2	38.3	38.3	61.7
20	0.85	445.37	457.22	11.9	4.6	42.9	57.1
40	0.425	422.96	440.30	17.3	6.8	49.6	50.4
60	0.25	393.49	432.28	38.8	15.1	64.8	35.2
80	0.18	390.75	441.40	50.7	19.7	84.5	15.5
100	0.15	380.65	401.61	21.0	8.2	92.7	7.3
120	0.125	364.15	376.32	12.2	4.7	97.4	2.6
200	0.075	375.69	381.46	5.8	2.2	99.7	0.3
PAN	<0.075	369.09	369.97	0.9	0.3	100.0	0.0
	Total			256.6	100.0		
						D10=	0.16
						D30=	0.23
						D60=	1.40

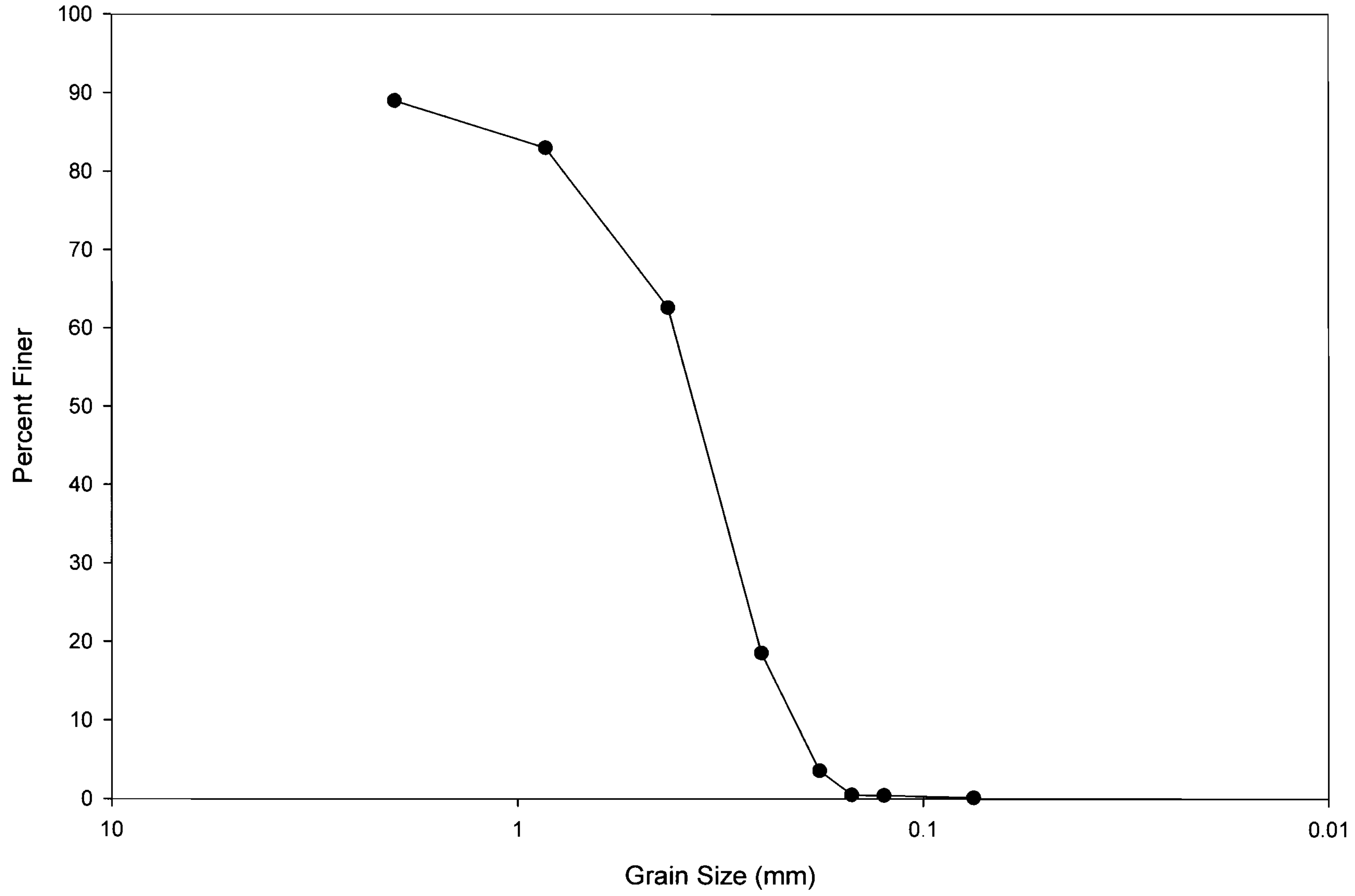
Uniformity Coefficient= 8.75
Coefficient of Gradiation= 0.24

Palm Bay
Residential Solids - Sample X

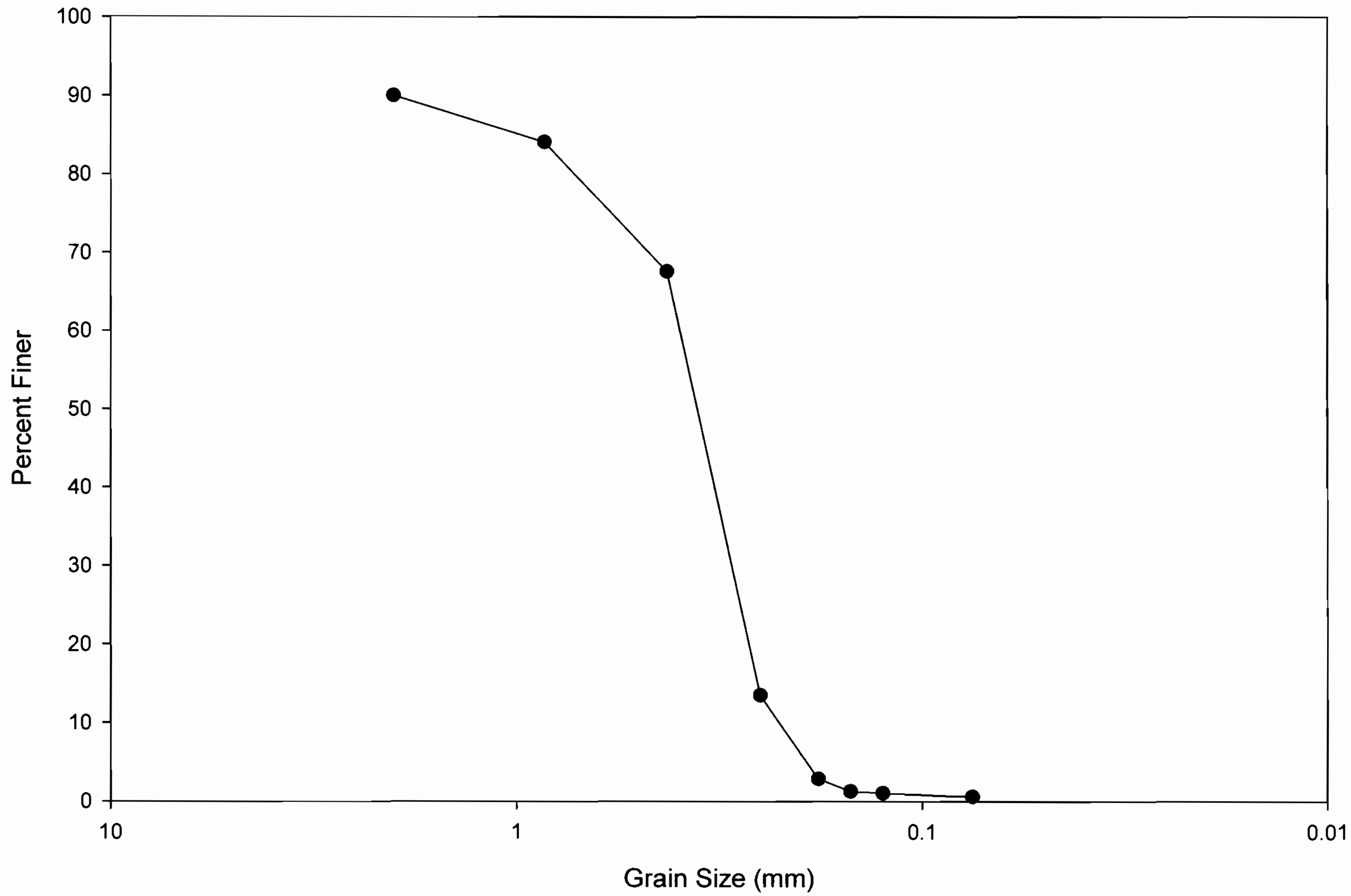
Seive Number	Grain Size (mm)	Weight of Seive	Weight Seive + Sed	Weight of Sed	Percent Retained on Seive	Cummulative Percent Retained	Percent Finer
10	>2	474.52	558.36	83.8	25.0	25.0	75.0
20	0.85	445.29	470.19	24.9	7.4	32.4	67.6
40	0.425	422.85	450.05	27.2	8.1	40.5	59.5
60	0.25	393.29	452.46	59.2	17.6	58.1	41.9
80	0.18	390.63	470.61	80.0	23.8	82.0	18.0
100	0.15	380.59	424.21	43.6	13.0	95.0	5.0
120	0.125	364.12	375.05	10.9	3.3	98.2	1.8
200	0.075	375.68	380.56	4.9	1.5	99.7	0.3
PAN	<0.075	369.07	370.13	1.1	0.3	100.0	0.0
	Total			335.6	100.0		
						D10=	0.16
						D30=	0.22
						D60=	0.43

Uniformity Coefficient= 2.69
Coefficient of Gradiation= 0.70

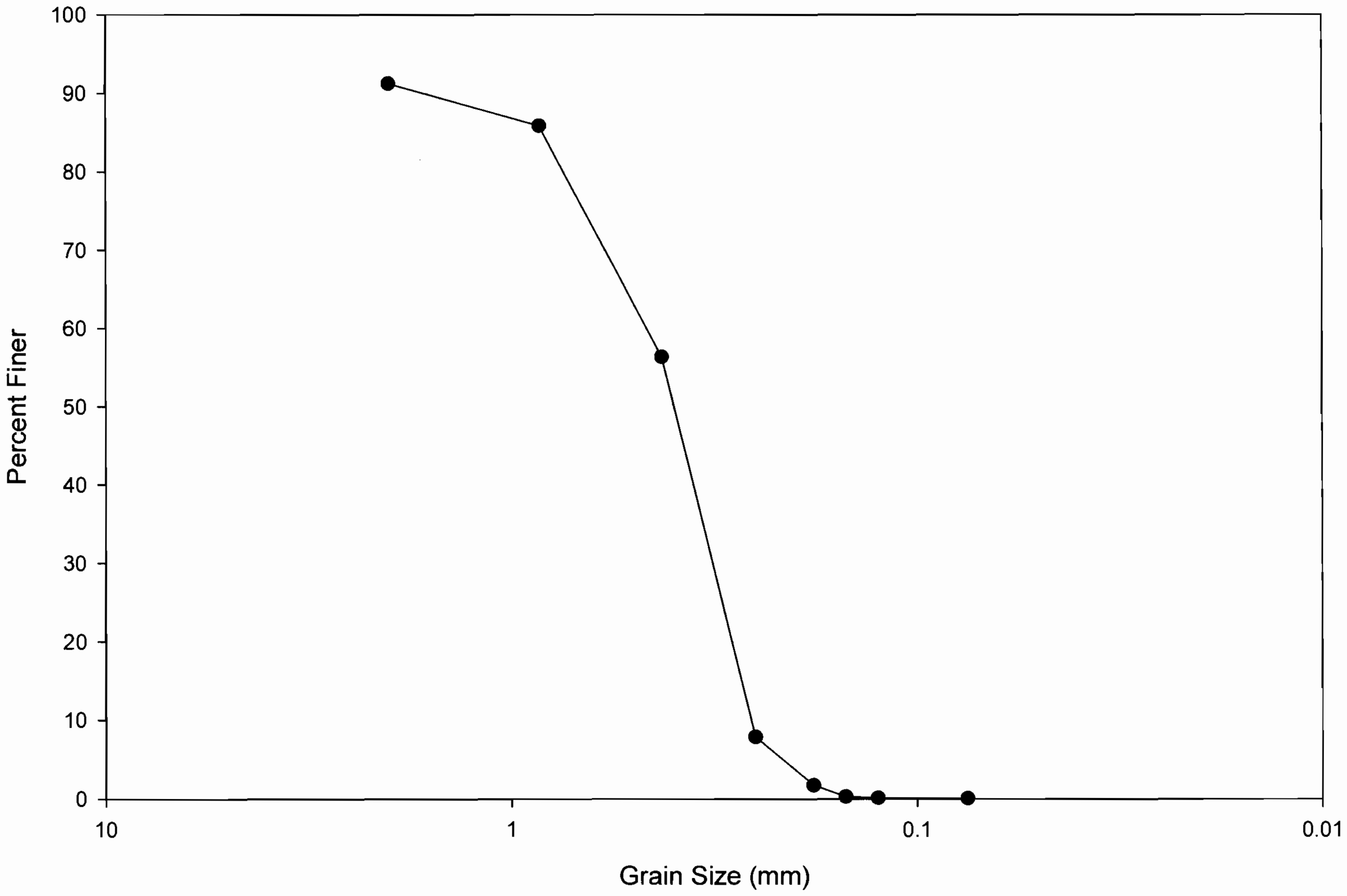
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample A



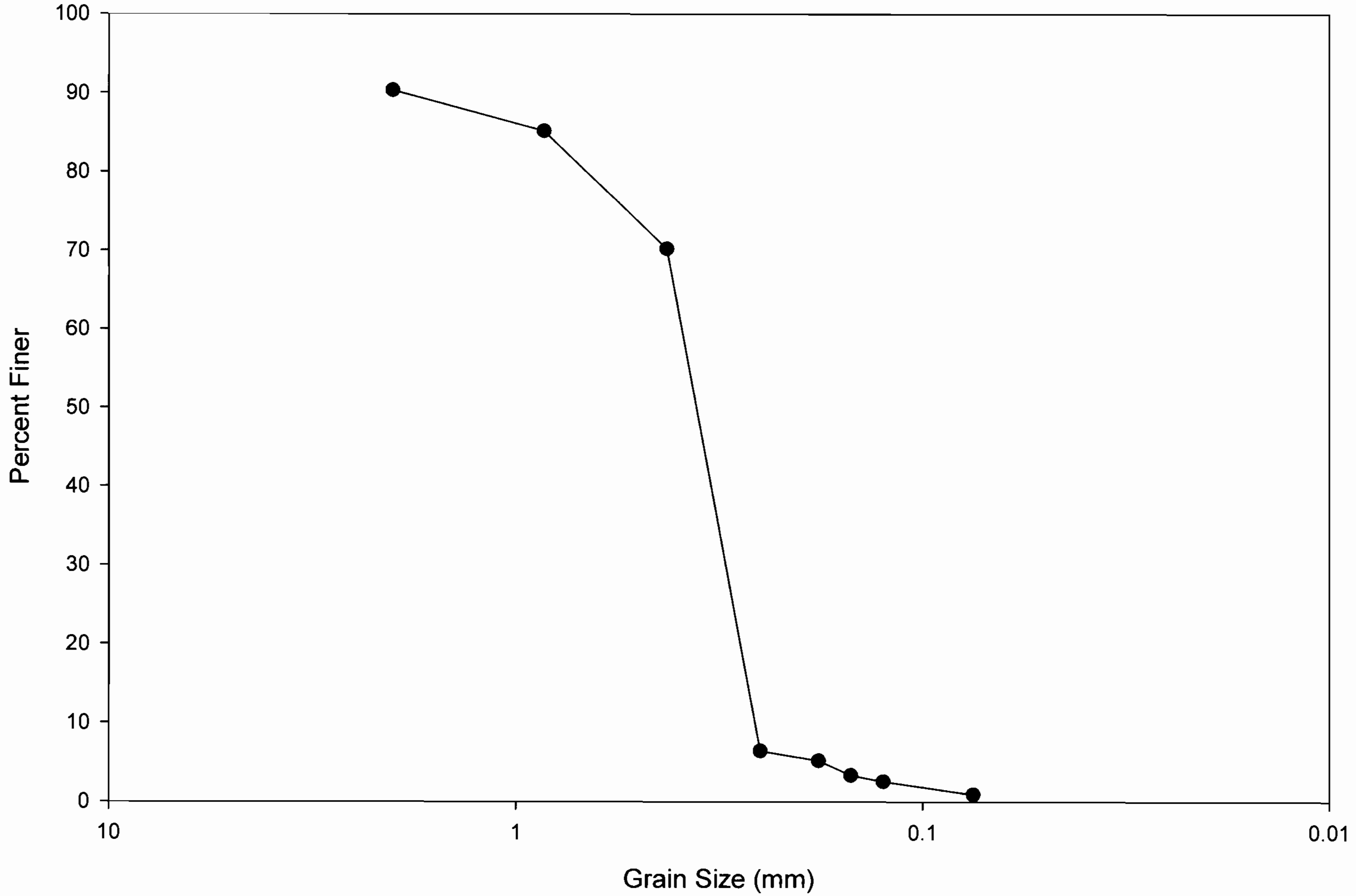
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample B



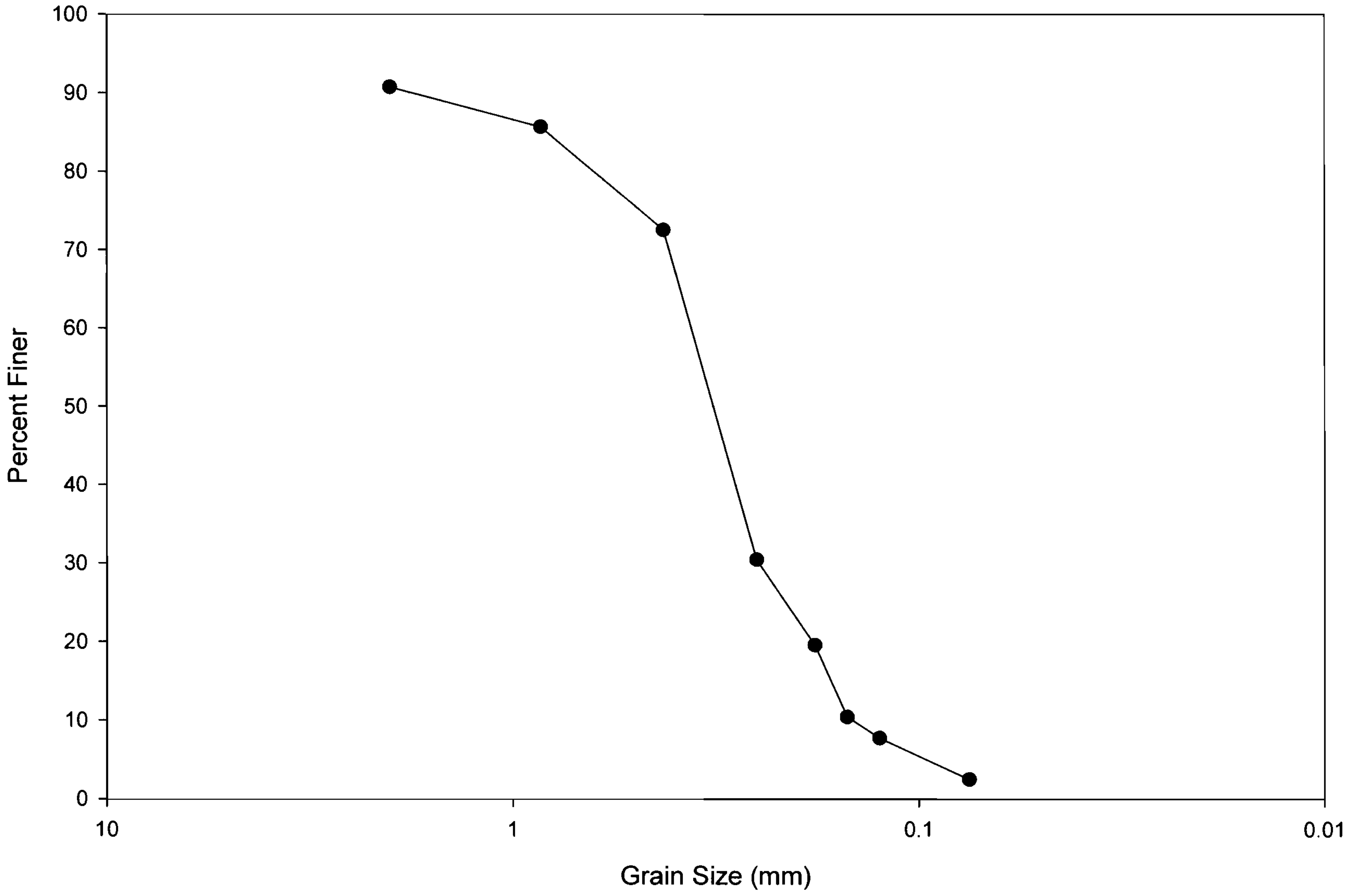
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample C



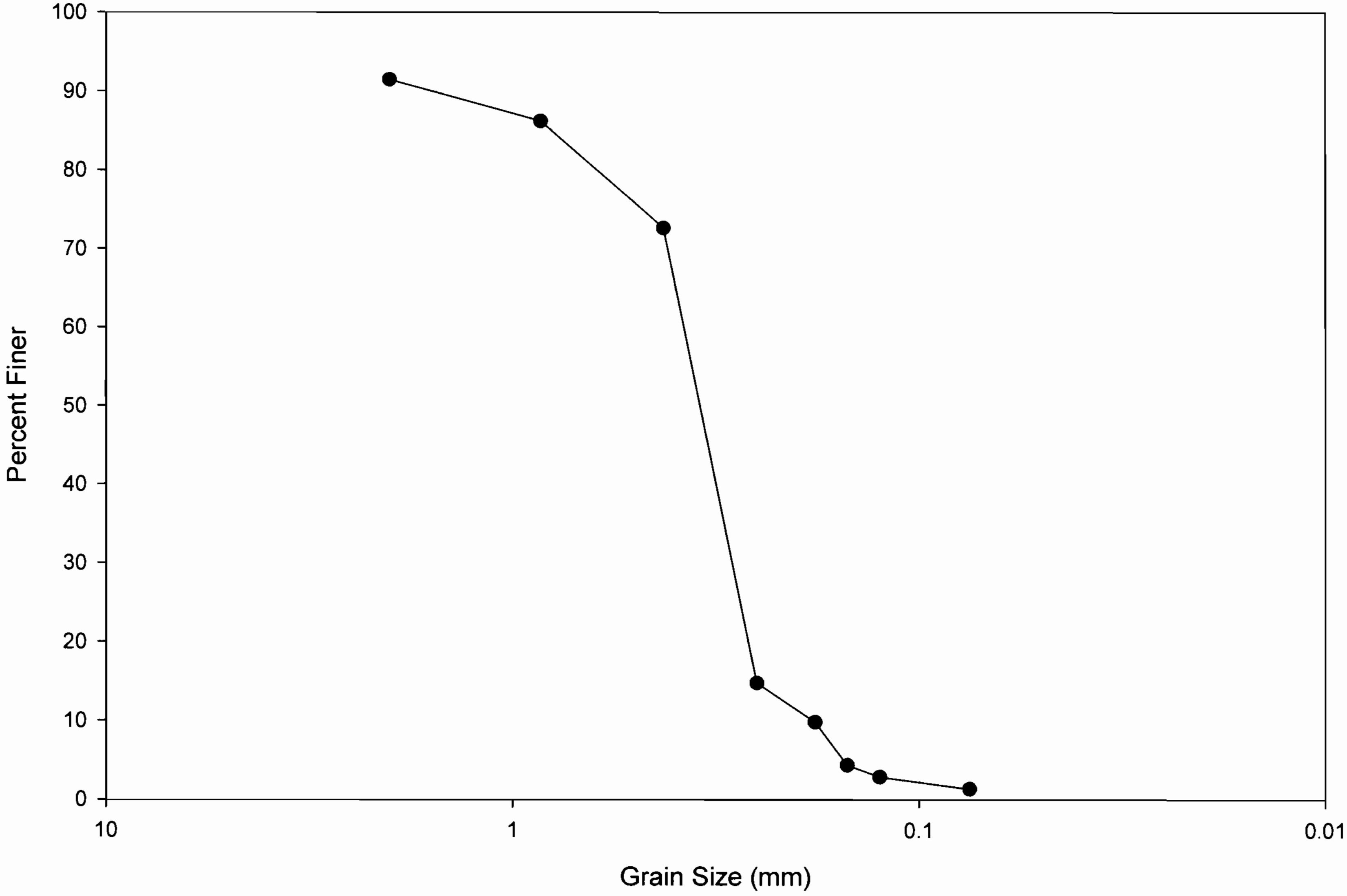
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample D



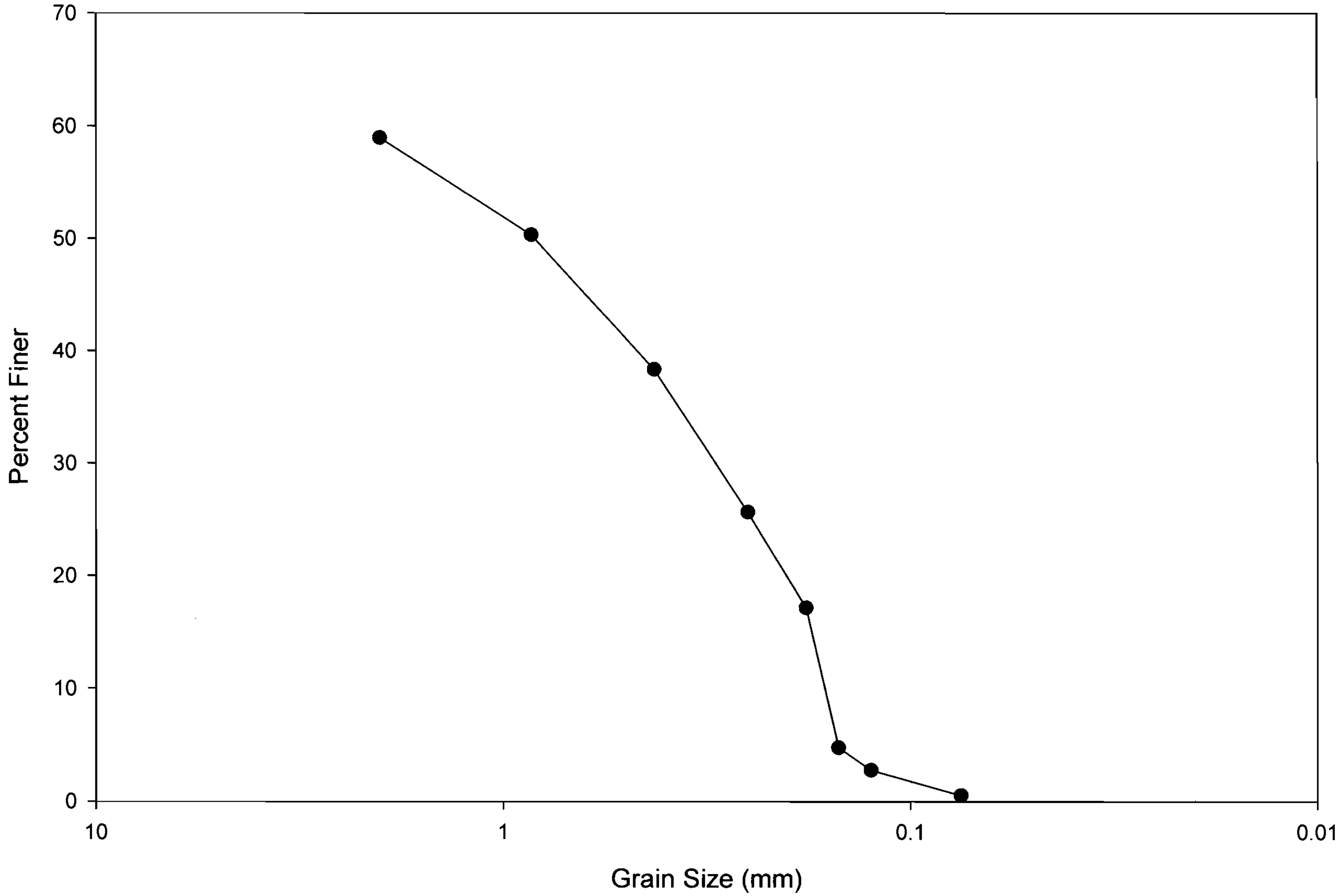
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample E

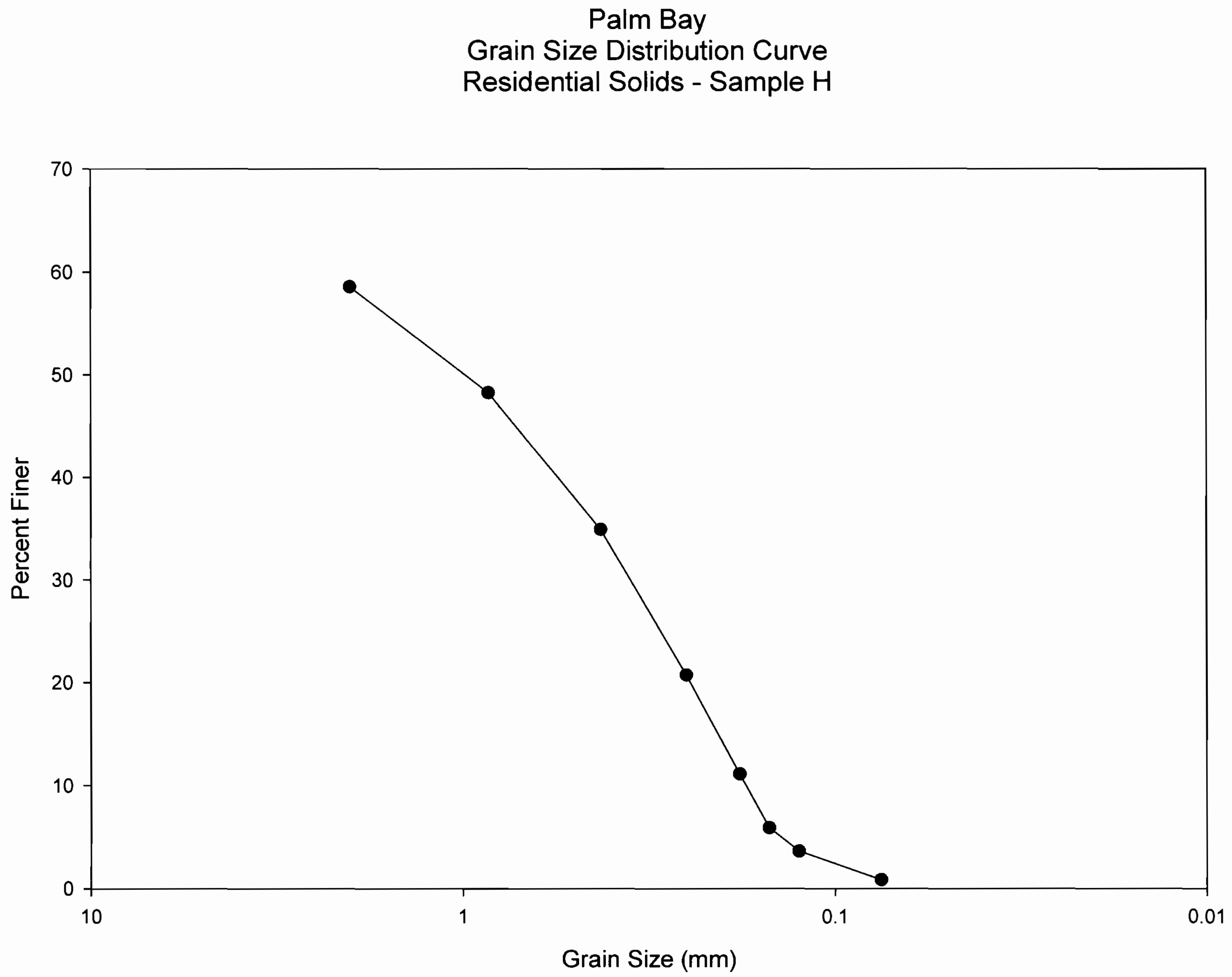


Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample F



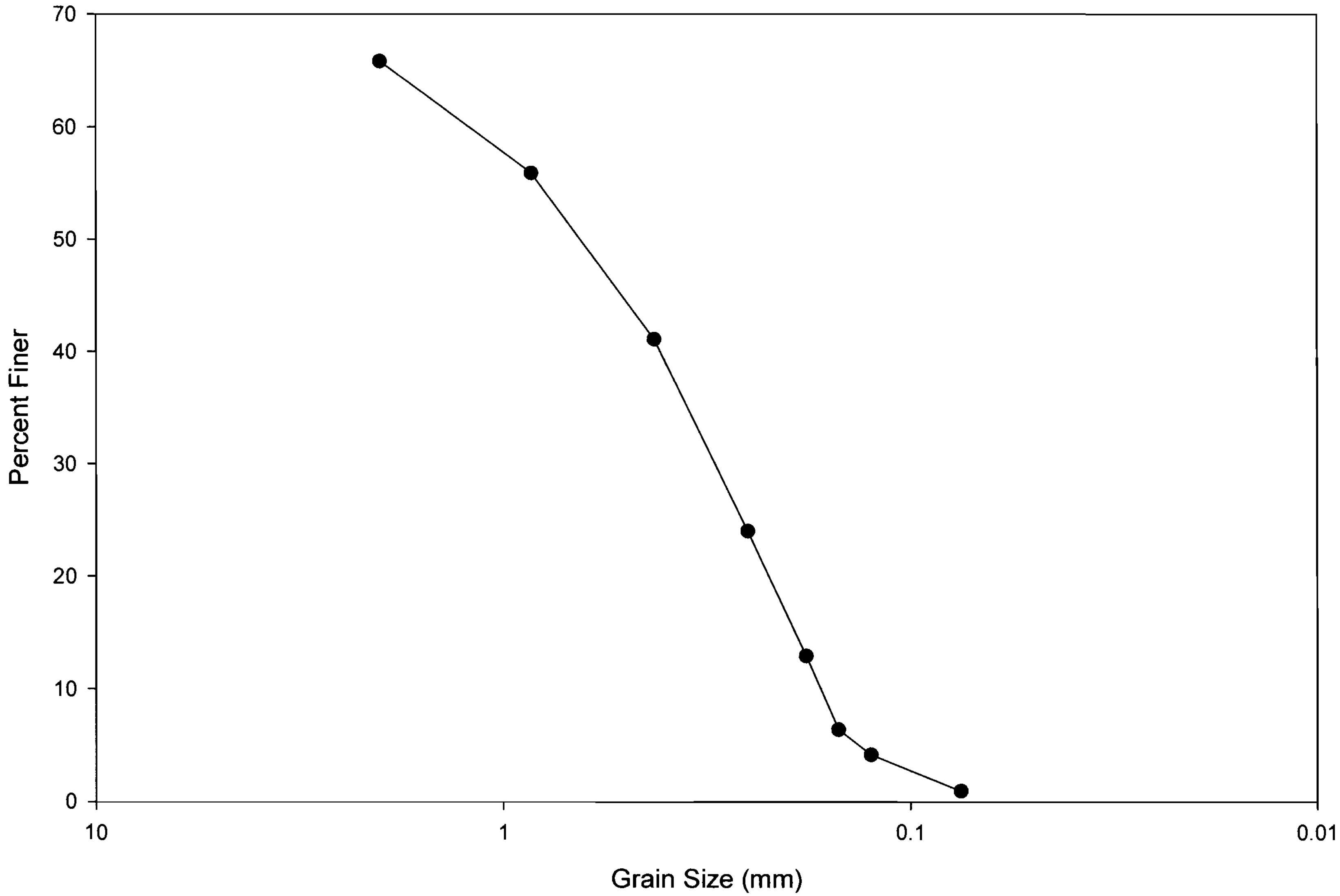
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample G



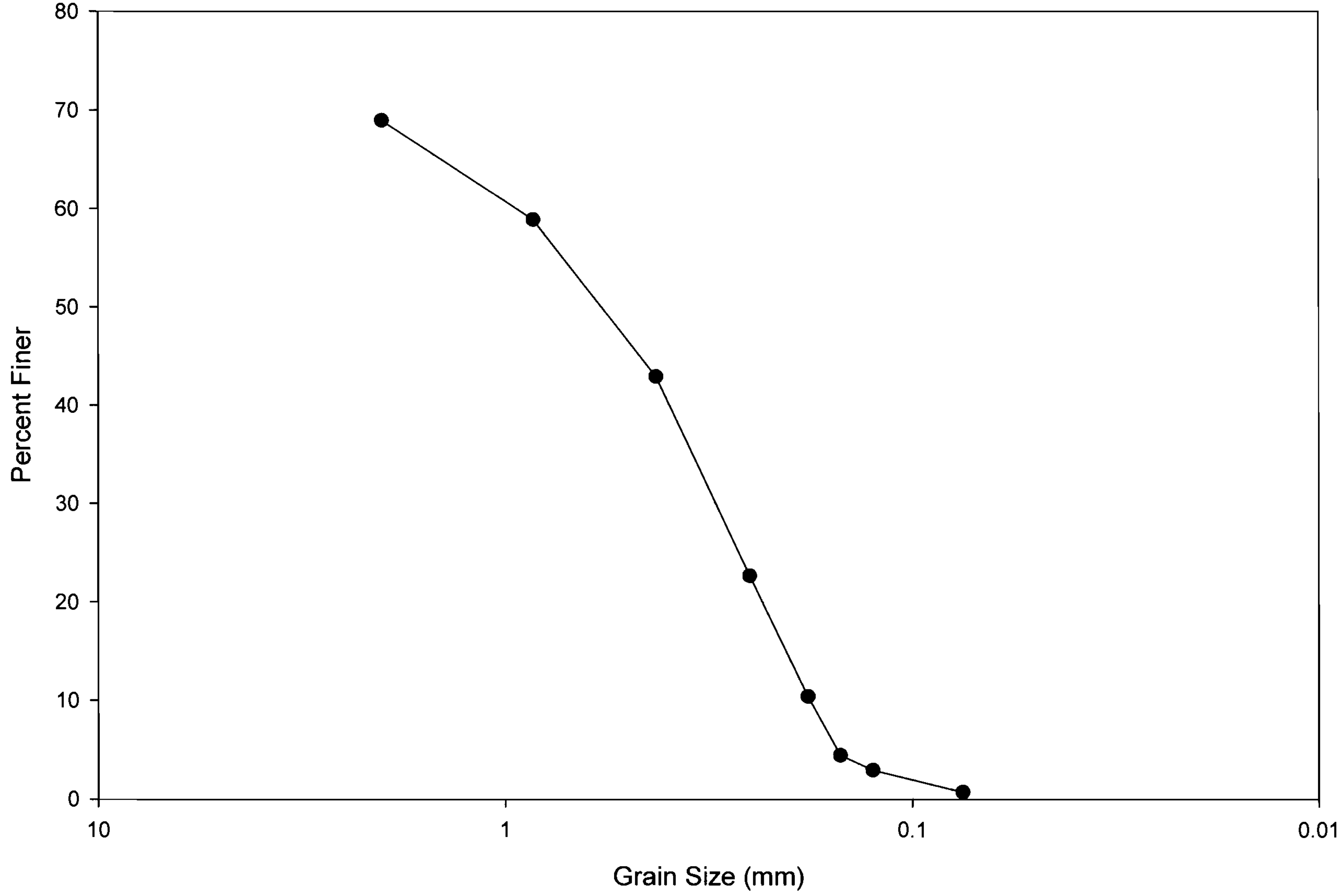


Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample H
Percent Finer
0
10
20
30
40
50
60
70
10
1
0.1
0.01
Grain Size (mm)

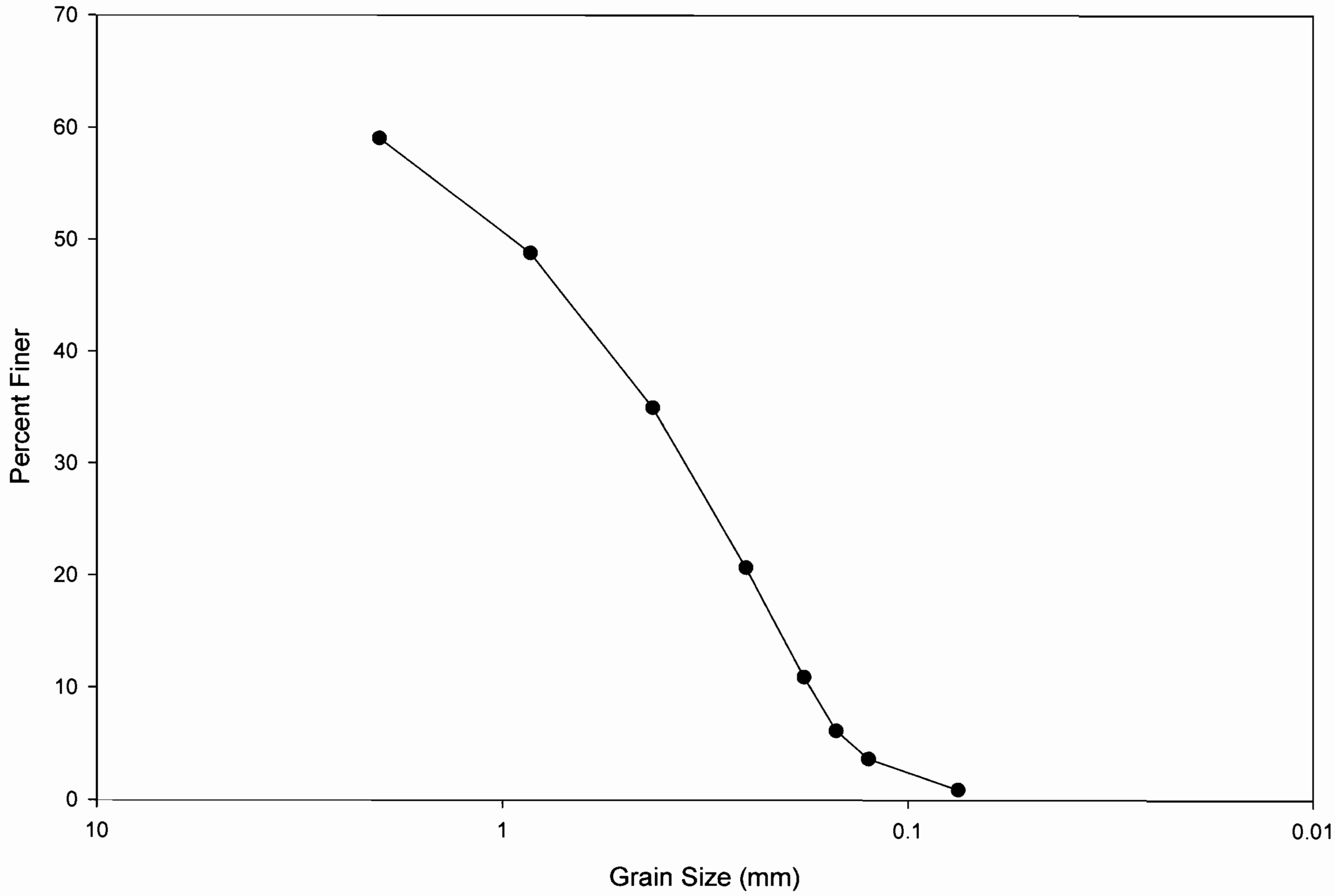
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample I



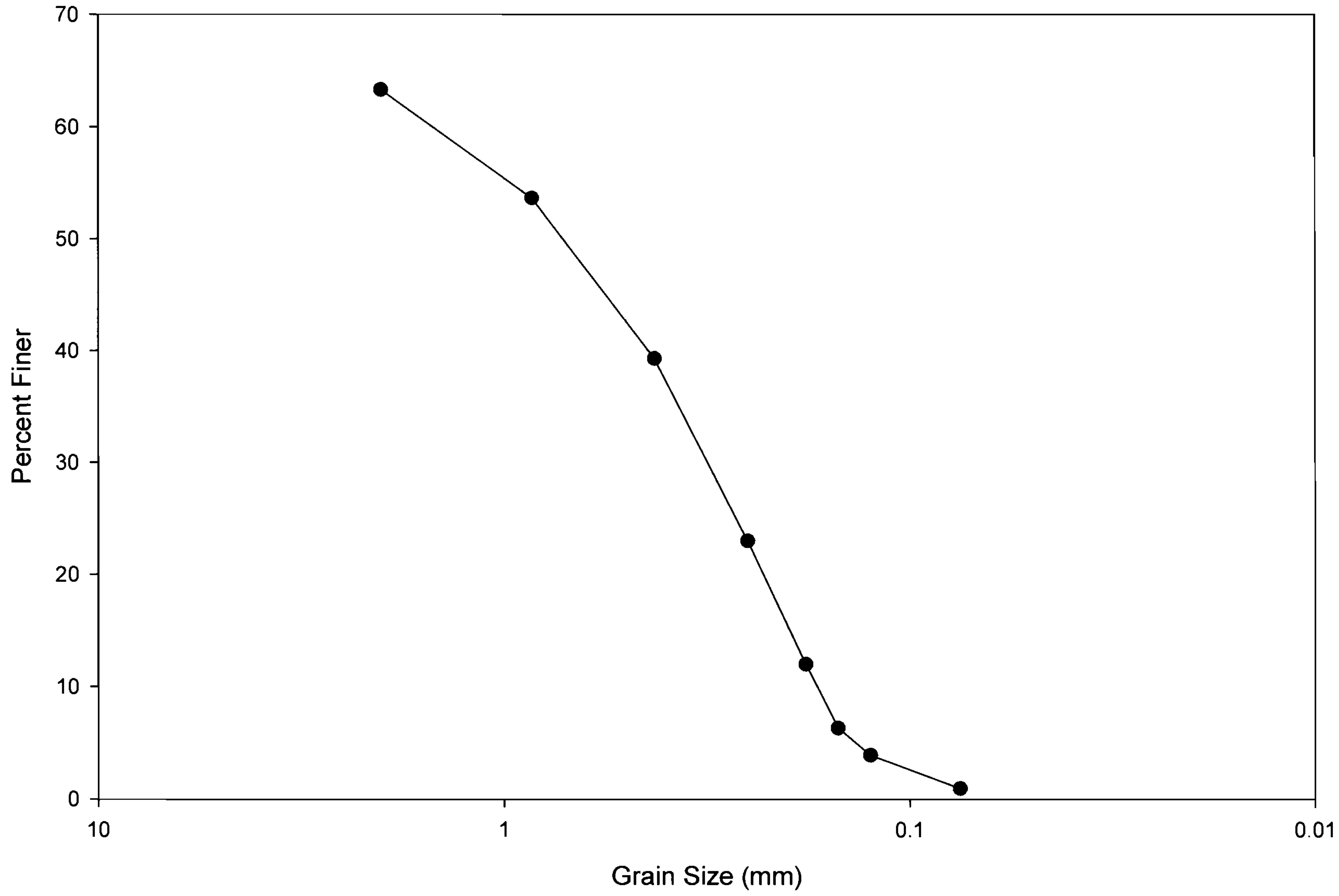
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample J



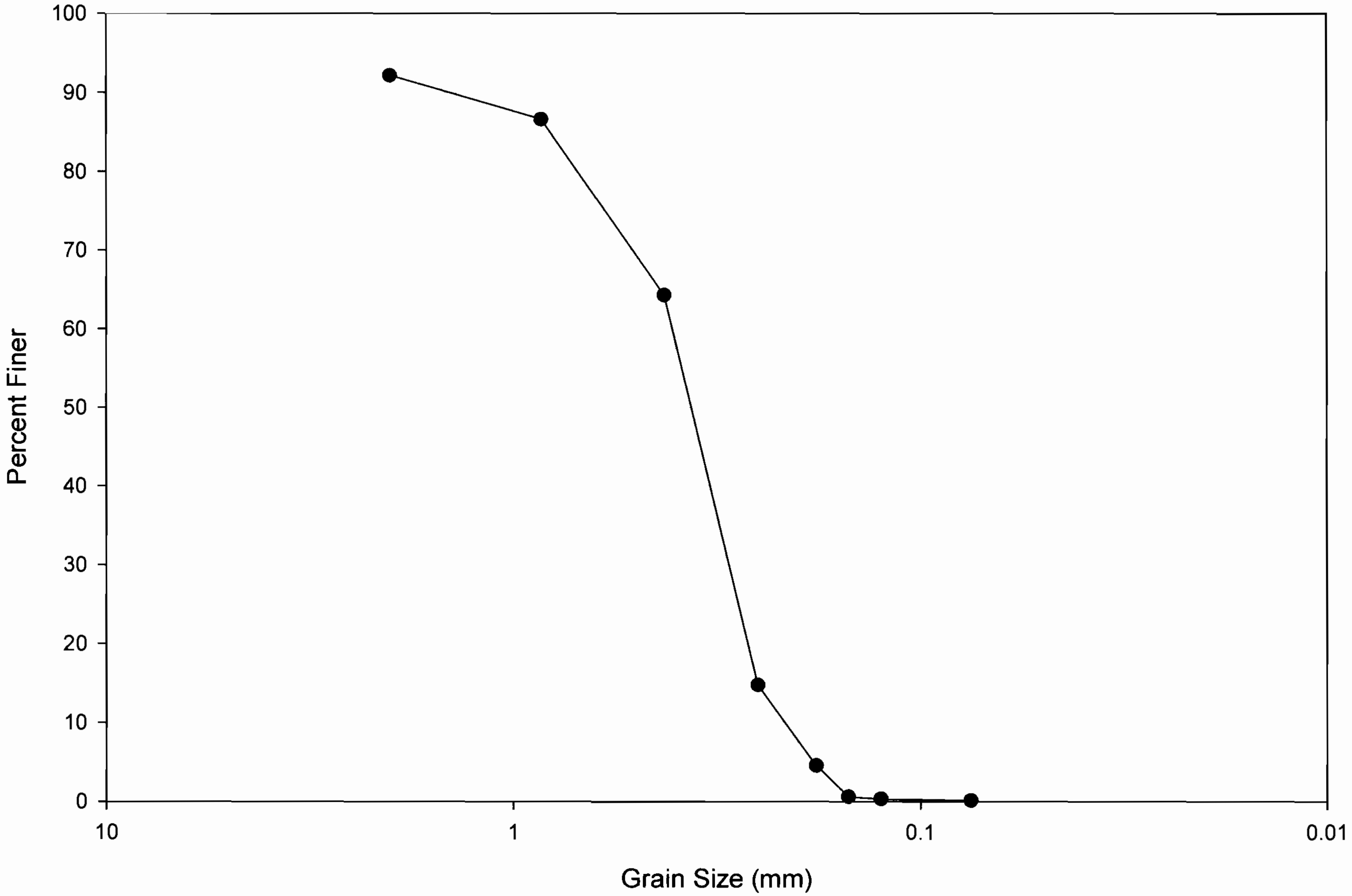
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample K



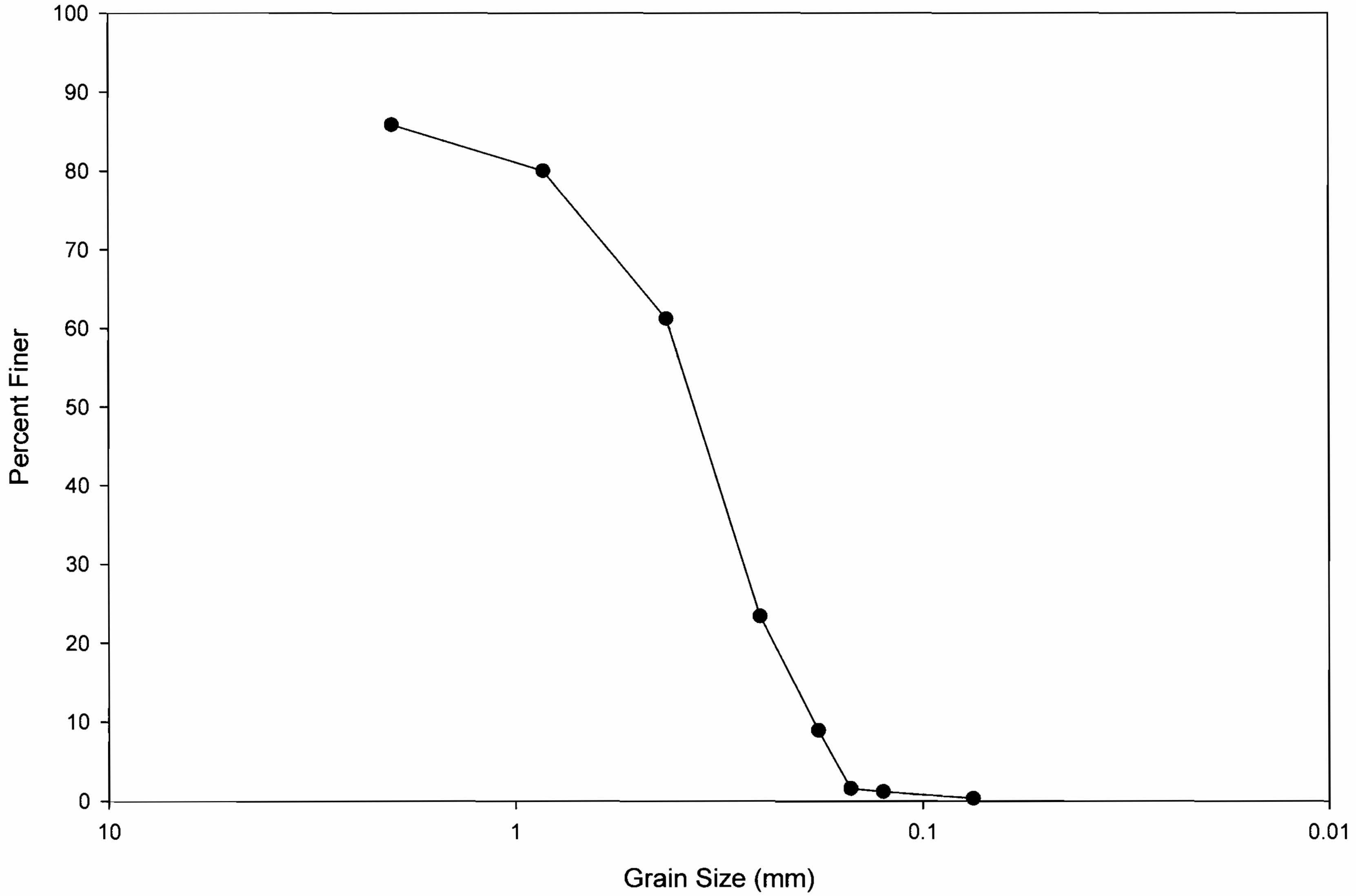
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample L



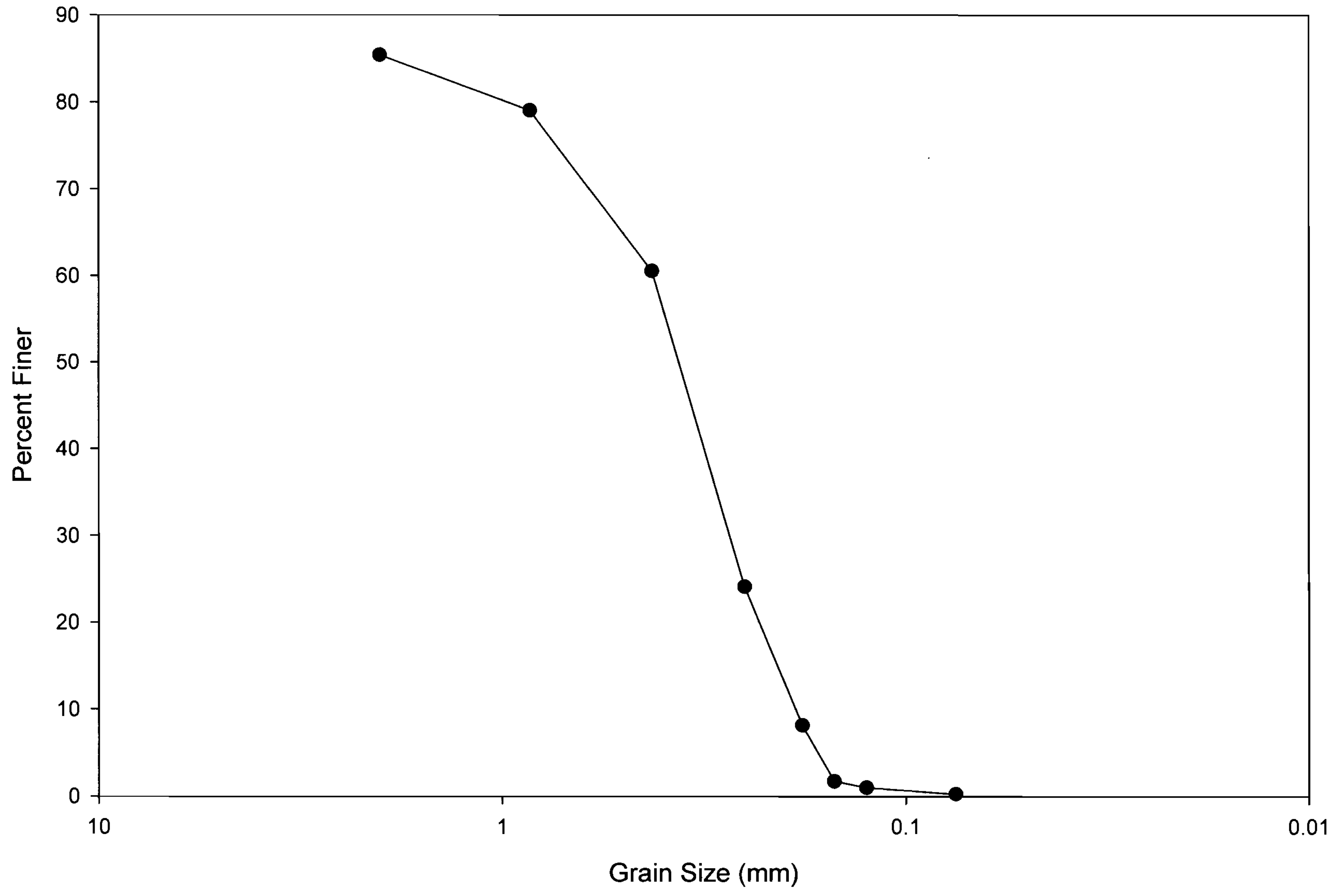
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample M



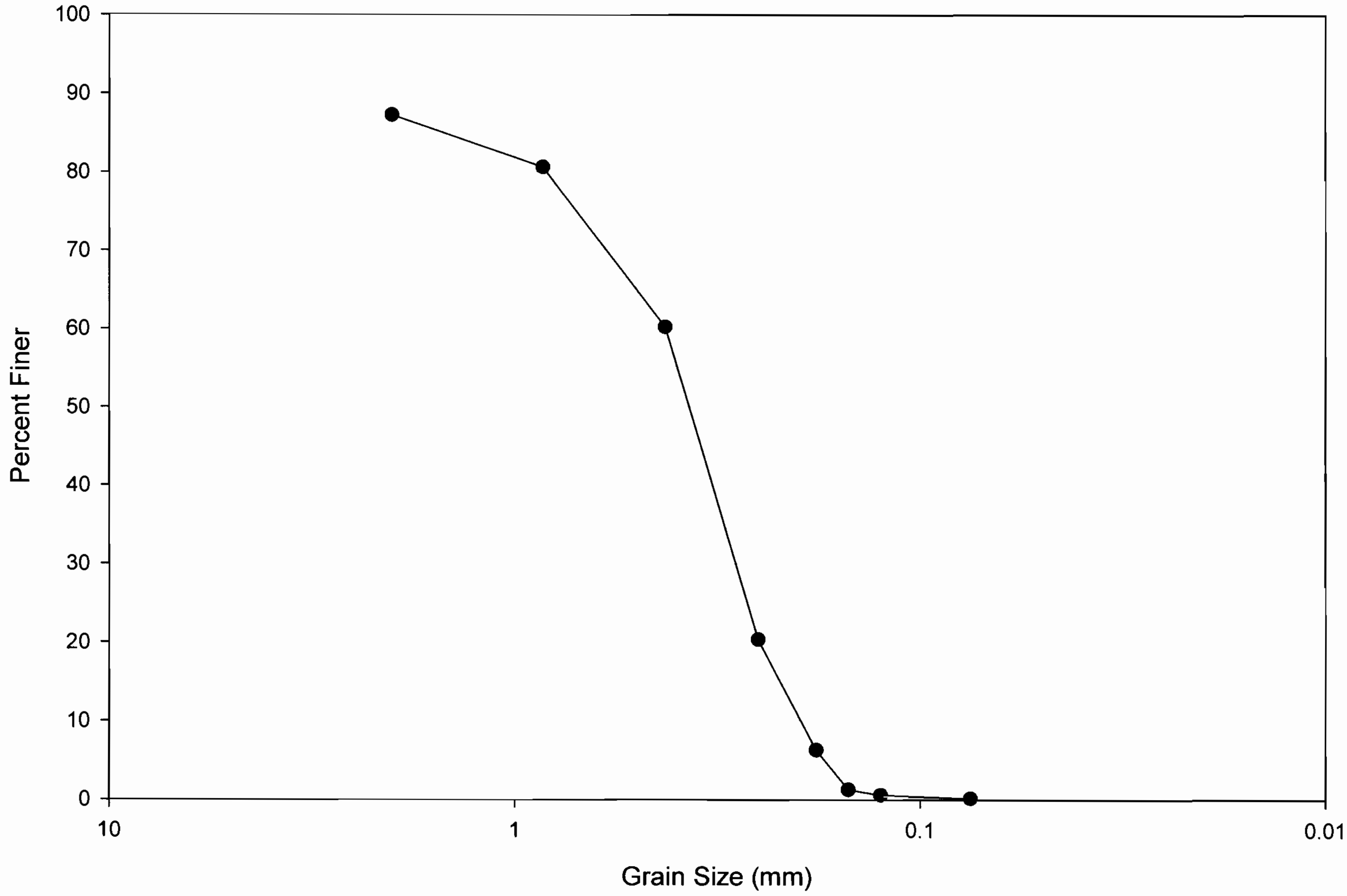
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample N



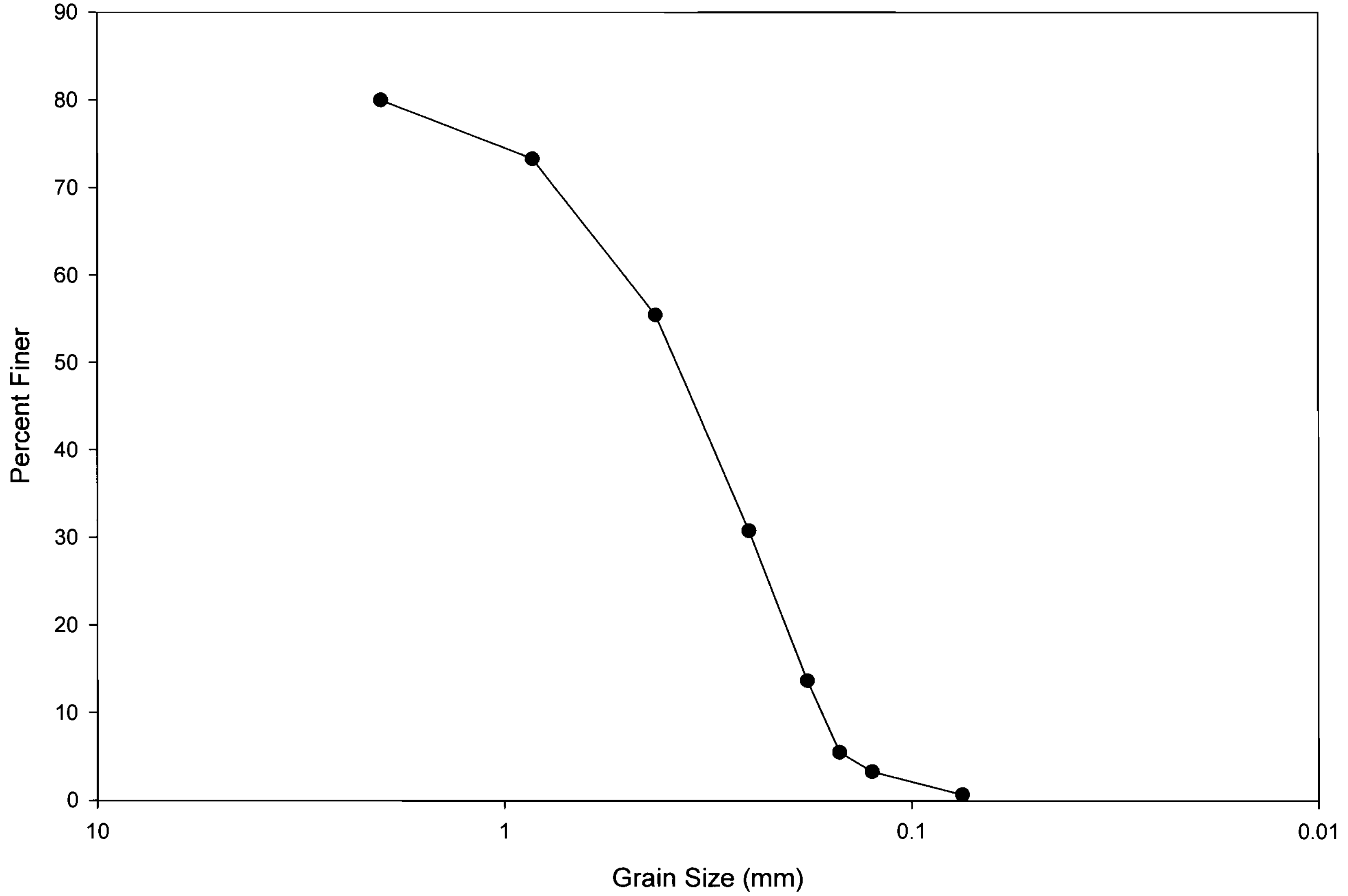
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample O



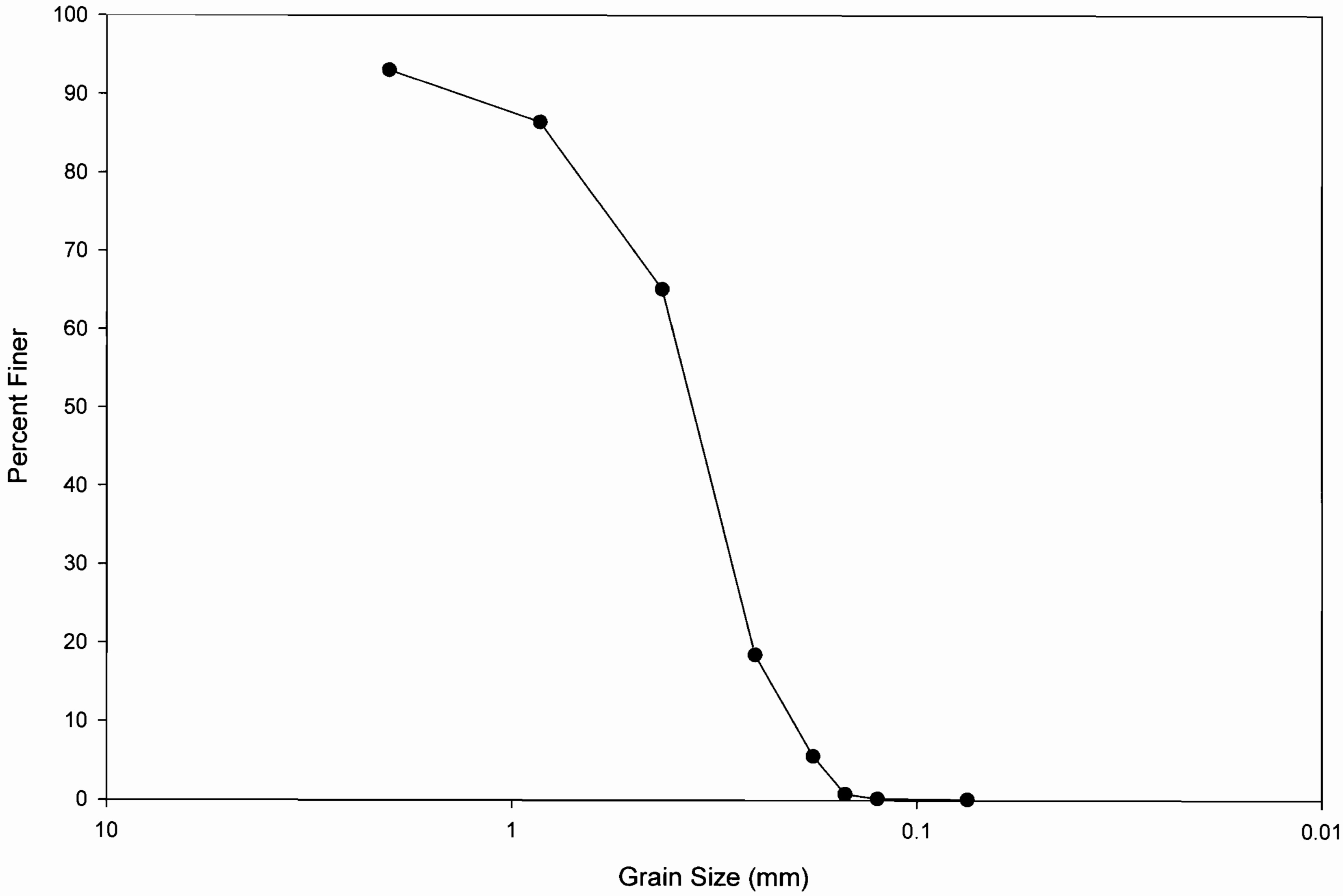
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample P



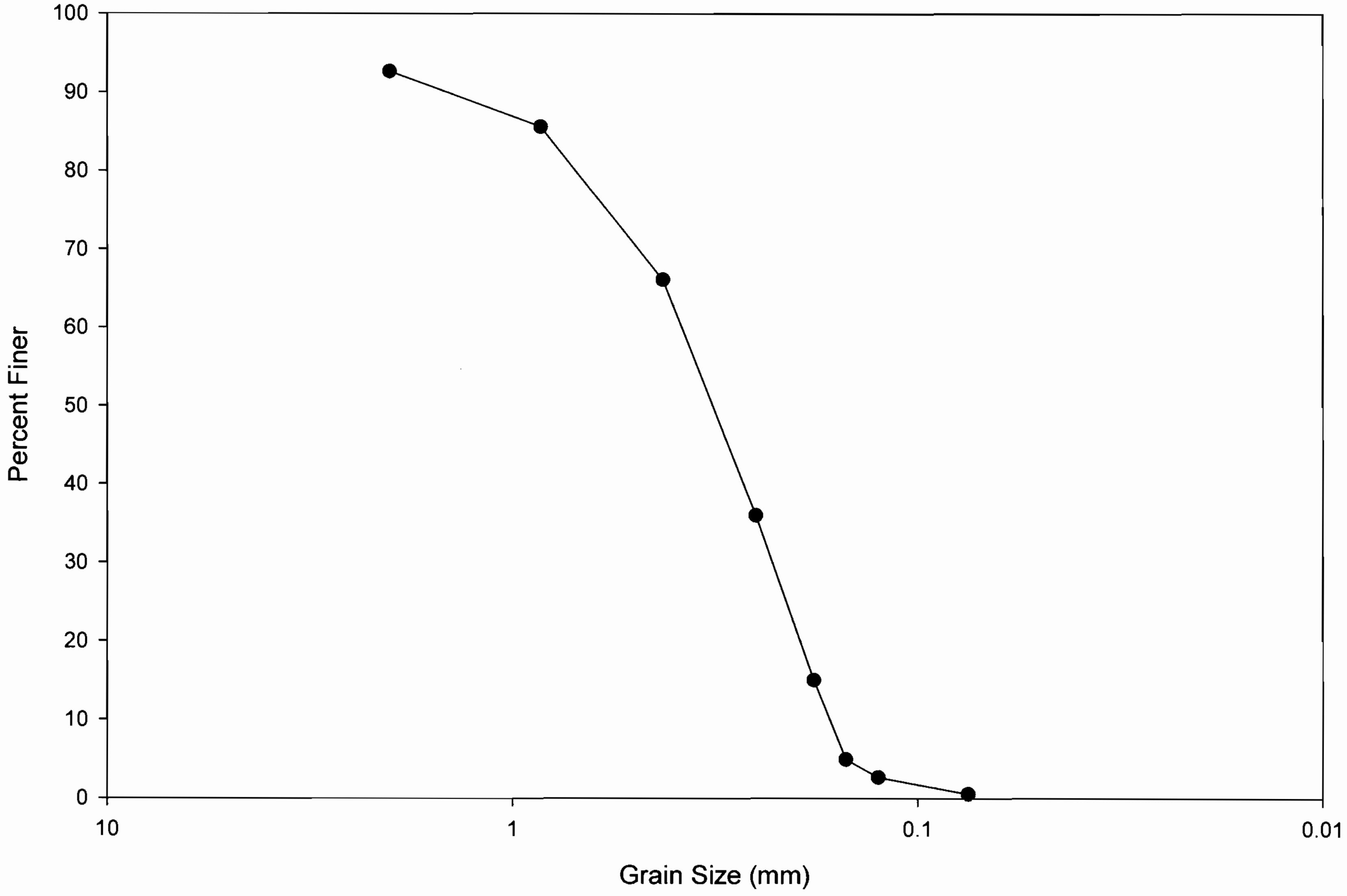
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample Q



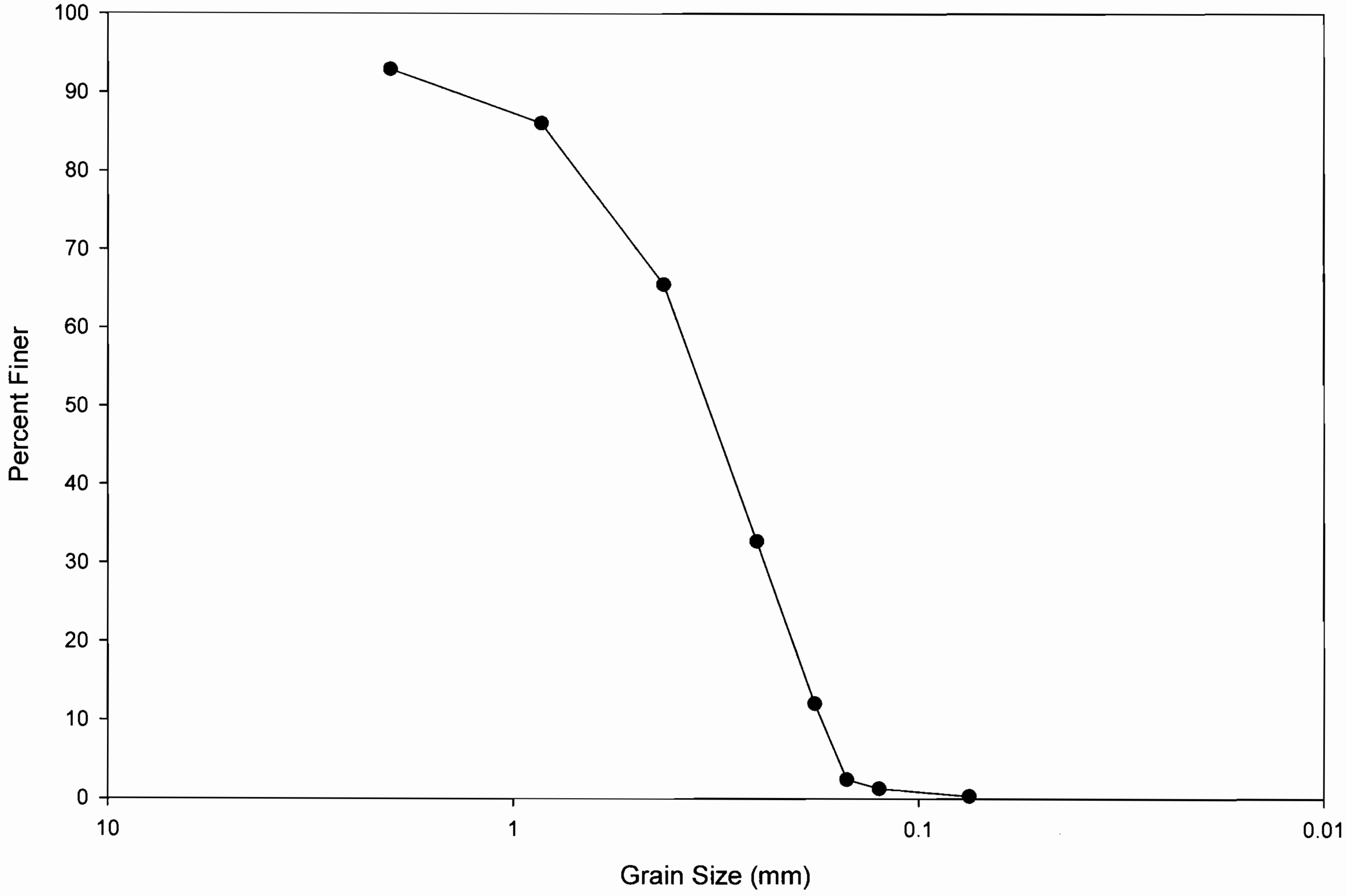
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample R



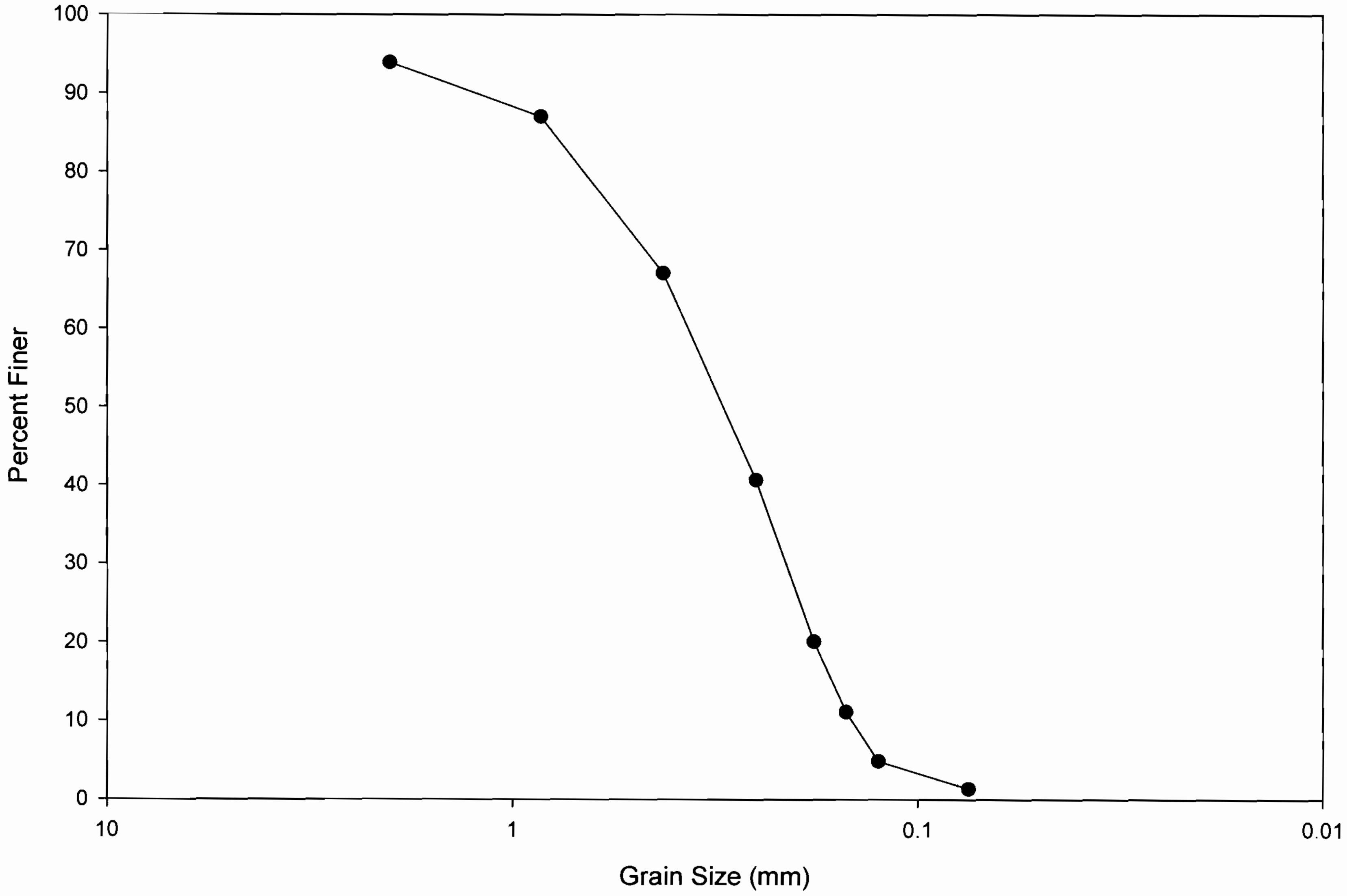
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample S



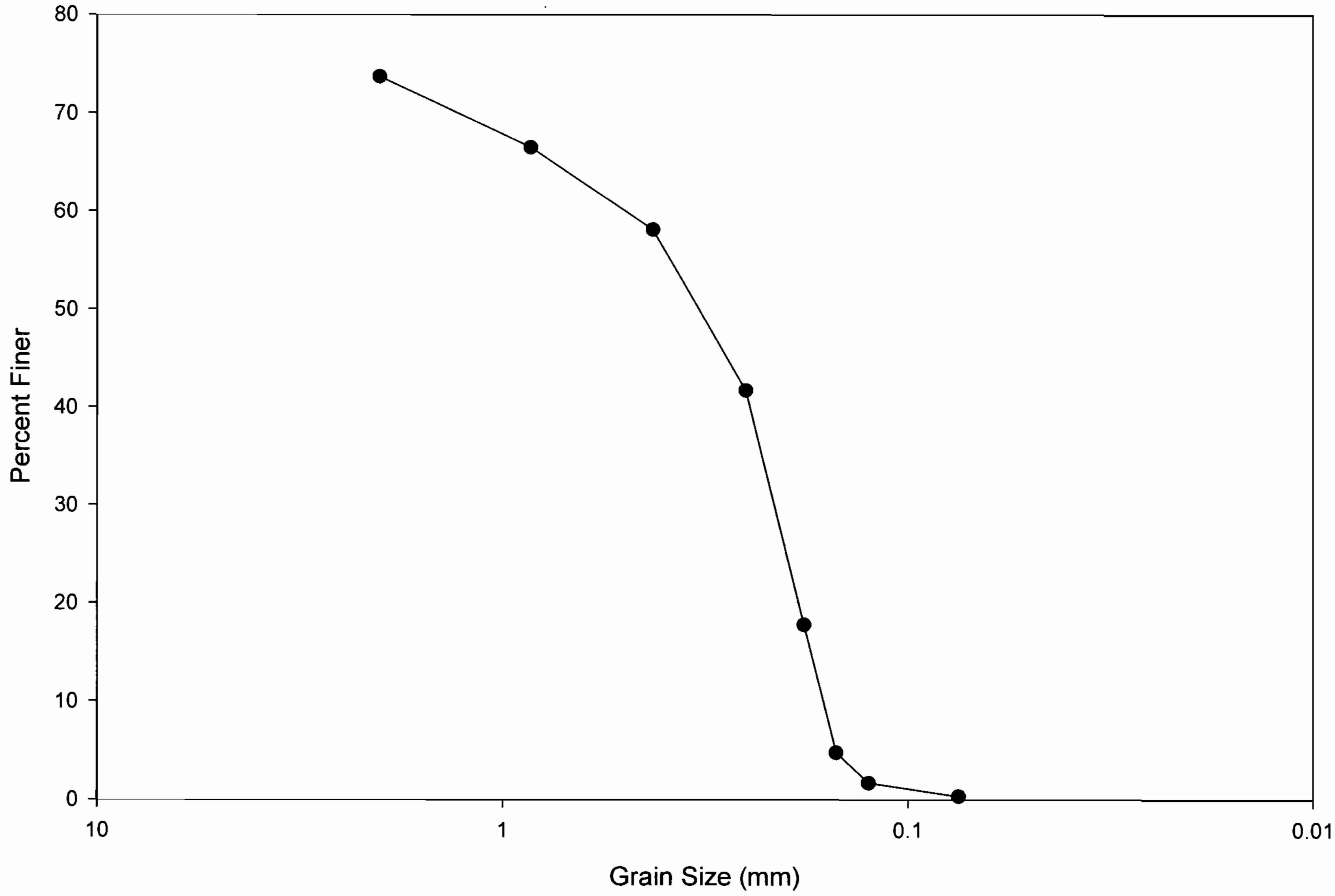
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample T



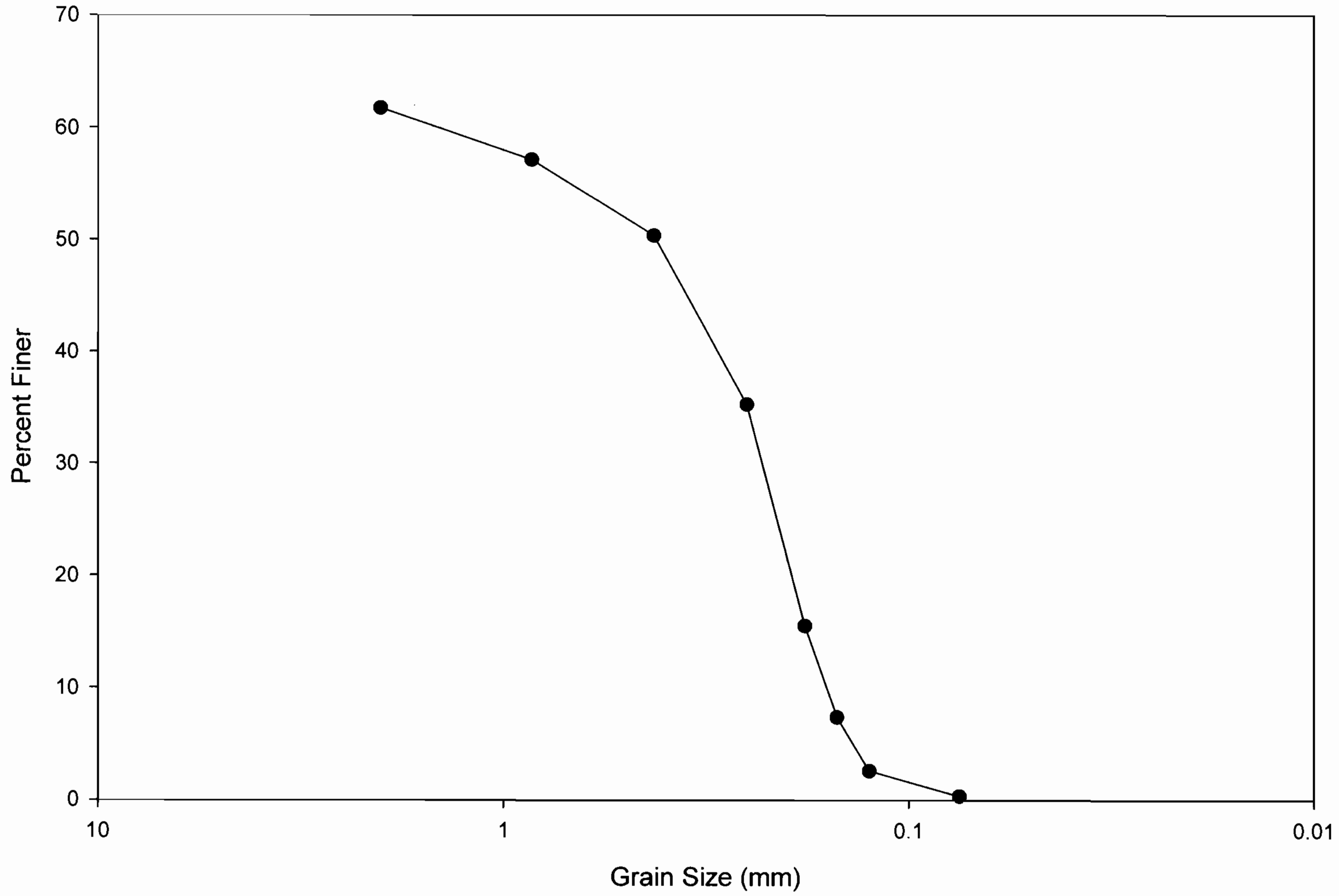
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample U



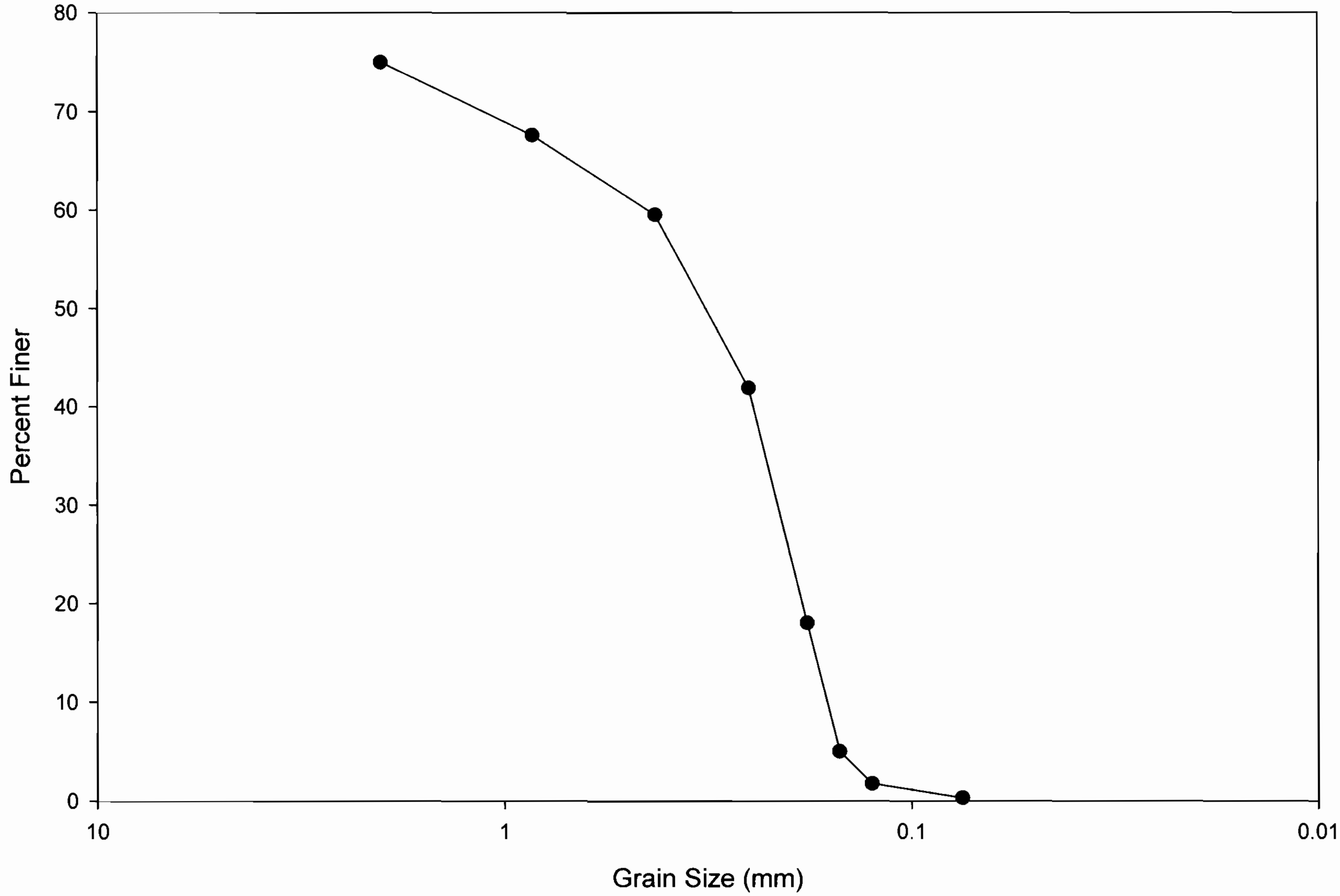
Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample V



Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample W



Palm Bay
Grain Size Distribution Curve
Residential Solids - Sample X



2. NUTRIENT CONTENT

Hyrdo-Kleen Pilot Test Samples

Total Nitrogen Contribution by Particle Size in Residential Solids Samples
(µg/g dry weight of raw sample)

Sieve	13	14	15	16	17	18	19	20	21	22	23	24	Average
> 2000	2,375	6,797	5,496	4,062	5,516	1,226	2,674	2,501	1,674	6,231	12,688	4,756	4,666
850	1,073	1,782	1,357	1,686	3,916	2,530	3,181	2,235	1,690	3,911	1,966	4,559	2,490
425	4,725	2,021	514	2,570	1,090	1,293	1,227	2,412	5,287	5,439	2,532	5,608	2,893
250	15,919	3,346	2,788	3,734	2,086	3,185	3,346	1,989	1,332	2,892	3,512	3,809	3,995
180	729	1,212	1,356	923	1,454	845	2,214	2,058	1,939	2,422	1,636	2,559	1,612
150	245	712	965	346	746	388	705	1,040	496	1,201	560	1,083	707
125	13	20	29	30	233	22	251	104	704	466	294	339	209
75	18	96	165	28	766	10	504	265	802	542	396	495	341
< 75	41	132	115	84	377	42	219	137	626	192	309	209	207
RAW	25,138	16,118	12,784	13,464	16,184	9,540	14,321	12,740	14,550	23,295	23,893	23,417	17,120

Hyrdo-Kleen Pilot Test Samples

Total Phosphorus Contribution by Particle Size in Residential Solids Samples
(µg/g dry weight of raw sample)

Sieve	13	14	15	16	17	18	19	20	21	22	23	24	Average
> 2000	308	839	762	812	696	176	325	356	251	1,069	2,436	1,130	763
850	181	245	199	252	601	342	370	245	210	1,310	217	809	415
425	904	227	627	396	227	280	251	347	759	1,116	251	821	517
250	1,960	970	769	1,107	468	952	641	568	487	410	275	713	777
180	222	357	445	314	416	291	585	601	525	515	214	596	424
150	93	228	286	111	244	119	247	351	201	311	207	330	227
125	6	8	14	13	77	11	80	36	225	106	352	106	86
75	8	37	49	12	215	4	156	81	250	218	394	104	127
< 75	14	45	37	28	133	13	80	48	218	9	15	49	58
RAW	3,696	2,956	3,188	3,046	3,077	2,187	2,736	2,633	3,126	5,064	4,361	4,660	3,394

Hyrdo-Kleen Pilot Test Samples
Total Nitrogen Content of Particle Sizes Found in Residential Solids Samples
(µg/g dry weight of each fraction)

Sieve	13	14	15	16	17	18	19	20	21	22	23	24	Average
> 2000	30,447	48,206	37,641	31,987	27,580	17,761	36,635	35,219	27,443	23,691	33,128	19,025	30,730
850	19,510	30,205	21,200	25,162	58,443	38,336	45,444	32,396	24,486	54,326	42,734	61,607	37,821
425	21,094	10,752	2,779	12,597	6,091	6,072	6,290	11,711	26,569	64,749	37,230	69,235	22,931
250	32,159	8,852	7,639	9,359	8,444	6,819	11,116	6,063	5,025	17,636	23,261	21,644	13,168
180	7,147	8,358	8,527	6,549	8,502	6,551	10,544	9,941	9,414	10,132	8,302	10,751	8,726
150	6,137	9,755	15,072	6,916	9,212	8,092	6,981	10,831	5,506	9,235	6,831	8,331	8,575
125	6,520	4,944	4,097	4,344	10,603	3,653	10,921	8,632	11,361	15,017	6,255	10,271	8,051
75	8,863	12,002	20,610	7,119	29,467	9,686	23,998	26,469	22,916	38,711	17,990	32,985	20,901
< 75	41,482	43,944	57,418	42,053	53,859	41,651	43,723	45,643	48,175	63,919	103,083	69,740	54,558

Hyrdo-Kleen Pilot Test Samples
Total Phosphorus Content of Particle Sizes Found in Residential Solids Samples
(µg/g dry weight of each fraction)

Sieve	13	14	15	16	17	18	19	20	21	22	23	24	Average
> 2000	3,955	5,949	5,221	6,395	3,481	2,545	4,456	5,009	4,115	4,064	6,360	4,521	4,673
850	3,283	4,155	3,114	3,765	8,968	5,184	5,287	3,546	3,039	18,201	4,707	10,937	6,182
425	4,037	1,205	3,390	1,940	1,266	1,312	1,287	1,683	3,813	13,288	3,698	10,137	3,921
250	3,959	2,566	2,107	2,774	1,896	2,038	2,131	1,733	1,837	2,501	1,823	4,052	2,451
180	2,180	2,463	2,796	2,229	2,435	2,258	2,786	2,904	2,549	2,153	1,088	2,506	2,362
150	2,329	3,121	4,465	2,218	3,007	2,482	2,446	3,656	2,235	2,394	2,520	2,540	2,784
125	2,808	2,066	1,936	1,872	3,506	1,768	3,482	3,016	3,632	3,416	7,492	3,225	3,185
75	3,763	4,634	6,167	3,039	8,266	3,782	7,429	8,130	7,154	15,556	17,923	6,942	7,732
< 75	14,041	15,093	18,637	14,047	19,034	13,372	16,037	16,089	16,783	3,085	4,892	16,327	13,953

Ultra-Urban Pilot Test Samples

Total Nitrogen Contribution by Particle Size in Residential Solids Samples (µg/g dry weight of raw sample)

Sieve	1	2	3	4	5	6	7	8	9	10	11	12	Average
> 2000	4,520	5,123	1,901	3,007	2,160	2,124	2,547	20,157	8,445	11,293	8,824	8,432	7,353
850	3,123	3,412	3,241	1,571	1,338	884	1,990	3,188	2,959	3,671	3,287	2,963	2,730
425	2,771	1,647	3,075	1,449	1,930	2,980	791	4,002	3,044	3,320	4,556	4,173	1,967
250	5,222	6,497	6,006	13,576	5,518	3,072	5,965	1,630	1,336	4,531	4,107	1,272	2,934
180	2,173	1,656	1,126	146	37	662	308	685	1,248	928	1,240	1,380	1,811
150	574	198	145	228	147	2,715	700	2,107	980	1,009	845	662	965
125	20	28	35	190	40	209	112	334	363	617	167	423	265
75	74	101	27	736	280	1,150	352	597	819	1,767	578	733	955
< 75	53	282	58	543	551	1,478	742	289	528	505	385	529	556
RAW	18,530	18,945	15,615	21,445	12,001	15,273	13,507	32,989	19,723	27,642	23,987	20,566	19,538

Ultra-Urban Pilot Test Samples

Total Phosphorus Contribution by Particle Size in Residential Solids Samples (µg/g dry weight of raw sample)

Sieve	1	2	3	4	5	6	7	8	9	10	11	12	Average
> 2000	978	968	323	592	489	522	502	2,707	1,638	1,420	3,314	1,297	1,779
850	539	864	822	413	247	209	342	418	359	463	576	398	369
425	698	293	697	333	322	513	224	442	329	340	614	432	251
250	1,533	1,893	1,776	4,128	1,707	983	1,917	275	401	632	583	253	451
180	670	535	303	39	15	233	98	177	252	211	301	277	351
150	180	59	44	71	48	362	206	479	197	221	186	152	204
125	7	9	11	65	14	73	39	76	88	145	47	95	78
75	21	36	9	238	96	399	113	145	191	460	141	172	223
< 75	17	95	21	158	158	443	223	69	125	120	101	128	137
RAW	4,642	4,754	4,005	6,038	3,097	3,738	3,664	4,788	3,581	4,013	5,861	3,205	3,844

Ultra-Urban Pilot Test Samples

Total Nitrogen Content of Particle Sizes Found in Residential Solids Samples
(µg/g dry weight of each fraction)

Sieve	1	2	3	4	5	6	7	8	9	10	11	12	Average
> 2000	41,090	51,231	21,606	22,503	23,082	29,969	49,165	20,400	33,020	28,371	20,617	20,035	30,091
850	52,044	56,867	60,027	25,733	17,338	37,554	37,065	28,728	37,081	32,541	28,767	28,147	36,824
425	13,585	10,629	10,425	12,868	22,746	5,820	33,351	22,891	22,435	28,472	30,240	13,754	18,935
250	11,840	12,010	12,383	8,648	7,297	10,302	12,834	9,411	26,497	20,230	8,894	18,001	13,196
180	14,490	15,626	18,458	3,059	6,071	6,151	8,062	13,003	8,364	10,080	14,225	16,467	11,171
150	19,135	12,371	10,373	7,716	29,830	12,954	16,993	18,843	15,294	14,076	13,784	16,936	15,692
125	20,107	13,941	17,536	5,019	7,749	7,460	16,710	16,482	28,054	11,156	16,905	11,056	14,348
75	24,824	20,219	26,702	17,504	21,693	23,452	27,145	29,241	55,205	26,283	26,167	31,832	27,522
< 75	52,899	46,974	58,406	61,210	61,583	57,084	57,710	65,980	56,090	55,014	58,755	61,828	57,795

Ultra-Urban Pilot Test Samples

Total Phosphorus Content of Particle Sizes Found in Residential Solids Samples
(µg/g dry weight of each fraction)

Sieve	1	2	3	4	5	6	7	8	9	10	11	12	Average
> 2000	8,889	9,685	3,670	5,092	5,679	5,904	6,603	3,956	4,151	10,655	3,171	4,848	6,025
850	8,977	14,406	15,217	4,758	4,101	6,461	4,863	3,490	4,678	5,698	3,865	3,804	6,693
425	3,421	1,891	2,363	2,150	3,917	1,644	3,685	2,476	2,299	3,835	3,128	1,756	2,714
250	3,477	3,499	3,662	2,675	2,336	3,311	2,163	2,826	3,698	2,873	1,766	2,768	2,921
180	4,467	5,052	4,960	1,249	2,134	1,960	2,080	2,626	1,902	2,451	2,861	3,191	2,911
150	5,984	3,690	3,134	2,529	3,980	3,823	3,863	3,792	3,355	3,092	3,174	3,584	3,667
125	6,647	4,480	5,482	1,752	2,710	2,599	3,808	4,002	6,607	3,102	3,792	3,237	4,018
75	7,131	7,269	9,274	6,025	7,530	7,533	6,608	6,816	14,367	6,406	6,155	7,449	7,713
< 75	16,592	15,912	20,620	17,532	18,451	17,124	13,715	15,602	13,356	14,377	14,266	15,267	16,068

APPENDIX G

ANALYSES OF TSS, VSS, TOTAL NITROGEN, AND TOTAL PHOSPHORUS ON PILOT TEST OUTFLOW SAMPLES BY PARTICLE SIZE

1. **Ultra-Urban Filter Unit**
2. **Hydro-Kleen Filter Unit**

1. ULTRA-URBAN FILTER UNIT

Ultra Urban Total N Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp #1/A-Outfall	29.6	8.4	11.8	15.2	16.0	19.4	947.5	1,048
Palm Bay Exp #2/B-Outfall	84.9	16.9	21.5	53.0	69.4	78.6	494.7	819
Palm Bay Exp #3/C-Outfall	59.0	40.7	14.1	21.7	185.5	39.6	448.4	809
Palm Bay Exp #4/D-Outfall	7.7	8.4	5.2	4.4	5.4	36.0	1,127.8	1,195
Palm Bay Exp #5/E-Outfall	6.5	3.3	4.0	4.6	8.1	20.6	771.9	819
Palm Bay Exp #6/F-Outfall	5.4	3.6	3.0	2.8	4.6	18.3	1,067.3	1,105
Palm Bay Exp #7/G-Outfall	8.5	4.3	4.1	6.4	9.4	23.2	1,614.1	1,670
Palm Bay Exp #8/H-Outfall	3.7	2.5	1.9	1.9	7.2	21.9	1,044.9	1,084
Palm Bay Exp #9/I-Outfall	4.0	3.3	3.0	7.1	6.7	21.7	870.2	916
Palm Bay Exp 10-J Outflow	308.9	27.3	34.4	41.1	57.7	96.7	600.9	1,167
Palm Bay Exp 11-K Outflow	39.5	13.6	13.0	22.4	11.2	27.9	501.4	629
Palm Bay Exp 12-L Outflow	3.9	1.6	1.2	1.0	4.8	17.3	514.3	544
Mean	**46.8**	**11.2**	**9.8**	**15.1**	**32.2**	**35.1**	**833.6**	**983.8**

Ultra Urban Total P Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp #1/A-Outfall	10.6	2.8	4.5	6.0	3.8	2.7	227.7	258
Palm Bay Exp #2/B-Outfall	12.9	3.8	13.4	14.5	14.1	17.5	165.8	242
Palm Bay Exp #3/C-Outfall	15.9	22.2	7.2	11.7	42.3	13.7	46.0	159
Palm Bay Exp #4/D-Outfall	1.2	0.6	0.6	0.5	0.7	4.2	625.3	633
Palm Bay Exp #5/E-Outfall	1.0	0.2	0.3	0.8	1.4	1.3	374.0	379
Palm Bay Exp #6/F-Outfall	0.2	0.1	0.5	0.2	0.3	1.3	339.3	342
Palm Bay Exp #7/G-Outfall	1.0	0.1	2.4	7.5	2.4	6.5	452.2	472
Palm Bay Exp #8/H-Outfall	0.2	0.2	0.1	0.2	1.6	4.3	341.4	348
Palm Bay Exp #9/I-Outfall	0.3	0.4	0.3	1.4	1.3	3.0	132.3	139
Palm Bay Exp 10-J Outflow	99.3	7.4	10.3	12.6	16.3	21.9	28.2	196
Palm Bay Exp 11-K Outflow	5.1	2.0	2.0	3.4	1.7	2.7	67.0	84
Palm Bay Exp 12-L Outflow	0.3	0.1	0.1	0.2	0.5	1.1	76.7	79
Mean	**12.3**	**3.3**	**3.5**	**4.9**	**7.2**	**6.7**	**239.6**	**277.6**

Ultra Urban TSS Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp #1/A-Outfall	172.2	1.1	12.7	10.1	6.8	2.5	109.6	315
Palm Bay Exp #2/B-Outfall	36.6	8.5	1.5	12.6	8.5	7.2	74.1	149
Palm Bay Exp #3/C-Outfall	11.8	3.6	4.8	3.6	6.3	2.8	2.4	35
Palm Bay Exp #4/D-Outfall	0.4	0.4	0.2	0.4	0.6	0.8	1.4	4
Palm Bay Exp #5/E-Outfall	0.4	0.1	0.2	0.3	0.7	0.5	1.1	3
Palm Bay Exp #6/F-Outfall	0.5	0.2	0.2	0.2	0.1	0.8	1.8	4
Palm Bay Exp #7/G-Outfall	0.2	0.1	0.2	0.3	0.4	0.5	1.3	3
Palm Bay Exp #8/H-Outfall	0.2	0.1	0.1	0.0	0.3	0.5	1.8	3
Palm Bay Exp #9/I-Outfall	0.2	0.0	0.0	0.0	0.3	0.5	1.0	2
Palm Bay Exp 10-J Outflow	6.7	2.5	3.2	3.2	2.9	3.0	2.1	24
Palm Bay Exp 11-K Outflow	2.7	0.6	0.9	1.1	1.1	1.4	0.7	9
Palm Bay Exp 12-L Outflow	0.4	0.2	0.1	0.2	0.3	0.3	1.1	3
Mean	**19.4**	**1.4**	**2.0**	**2.7**	**2.4**	**1.7**	**16.5**	**46.1**

Ultra Urban VSS Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp #1/A-Outfall	108.0	6.3	7.6	6.2	4.2	1.5	52.2	186
Palm Bay Exp #2/B-Outfall	19.6	3.0	0.9	6.2	8.2	3.1	29.1	70
Palm Bay Exp #3/C-Outfall	6.7	2.0	2.3	1.9	2.9	1.1	1.1	18
Palm Bay Exp #4/D-Outfall	0.3	0.1	0.2	0.2	0.5	0.5	1.1	3
Palm Bay Exp #5/E-Outfall	0.2	0.0	0.1	0.2	0.5	0.3	0.8	2
Palm Bay Exp #6/F-Outfall	0.3	0.2	0.4	0.4	0.3	0.5	0.9	3
Palm Bay Exp #7/G-Outfall	0.1	0.1	0.1	0.2	0.4	0.5	0.7	2
Palm Bay Exp #8/H-Outfall	0.1	0.0	0.0	0.0	0.3	0.5	1.2	2
Palm Bay Exp #9/I-Outfall	0.2	0.0	0.0	0.1	0.1	0.1	1.3	2
Palm Bay Exp 10-J Outflow	4.4	1.6	2.1	2.2	1.5	1.7	1.3	15
Palm Bay Exp 11-K Outflow	1.7	0.3	0.5	0.6	0.6	0.7	0.6	5
Palm Bay Exp 12-L Outflow	0.4	0.1	0.0	0.2	0.2	0.1	0.9	2
Mean	**11.8**	**1.2**	**1.2**	**1.5**	**1.6**	**0.9**	**7.6**	**25.8**

2. HYDRO-KLEEN FILTER

Hydro-Kleen Total N Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp 13-M	13.5	5.7	10.9	19.1	40.3	44.7	1,076.9	1,211
Palm Bay Exp 14-N	16.1	4.9	10.4	17.9	71.4	55.2	1,047.1	1,223
Palm Bay Exp 15-O	3.3	2.4	2.8	10.7	60.5	97.9	775.4	953
Palm Bay Exp 16-P	5.5	2.5	1.9	14.2	27.7	24.1	1,007.1	1,083
Palm Bay Exp 17-Q	4.9	1.7	2.2	7.8	39.5	62.8	944.1	1,063
Palm Bay Exp 18-R	2.3	1.3	0.7	3.7	27.8	55.5	711.5	803
Palm Bay Exp 19-S	9.8	4.0	4.0	11.5	34.3	49.9	595.6	709
Palm Bay Exp 20-T	6.6	5.3	6.7	13.4	49.3	49.5	453.3	584
Palm Bay Exp 21-U	4.6	2.5	3.7	6.6	35.5	54.2	439.0	546
Palm Bay Exp 22-V	4.1	3.0	4.1	7.1	20.0	25.8	696.0	760
Palm Bay Exp 23-W	5.5	3.1	7.8	12.2	33.8	45.5	455.1	563
Palm Bay Exp 24-X	6.2	12.4	4.9	5.7	27.6	36.0	635.2	728
Mean	**6.9**	**4.1**	**5.0**	**10.8**	**39.0**	**50.1**	**736.4**	**852.2**

Hydro-Kleen Total P Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp 13-M	5.3	1.3	4.6	9.2	17.8	15.3	506.5	560
Palm Bay Exp 14-N	2.8	1.0	2.8	7.2	31.0	19.8	625.4	690
Palm Bay Exp 15-O	0.8	0.7	1.1	4.3	24.9	28.3	602.0	662
Palm Bay Exp 16-P	1.5	0.7	1.0	5.2	12.2	8.7	540.8	570
Palm Bay Exp 17-Q	1.2	0.4	1.0	4.4	21.5	38.1	601.3	668
Palm Bay Exp 18-R	0.5	0.4	0.4	1.4	11.6	25.0	388.6	428
Palm Bay Exp 19-S	2.2	0.7	0.9	2.8	14.9	20.7	472.0	514
Palm Bay Exp 20-T	1.1	1.2	1.6	4.3	19.2	22.6	481.0	531
Palm Bay Exp 21-U	0.9	0.5	0.7	2.2	15.1	25.2	470.3	515
Palm Bay Exp 22-V	0.5	0.3	0.5	1.3	5.6	7.7	477.0	493
Palm Bay Exp 23-W	0.9	0.2	0.8	2.6	9.9	12.2	475.3	502
Palm Bay Exp 24-X	1.0	5.7	0.7	0.9	8.1	9.1	471.4	497
Mean	**1.6**	**1.1**	**1.3**	**3.8**	**16.0**	**19.4**	**509.3**	**552.5**

Hydro-Kleen TSS Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp 13-M	3.4	0.6	3.2	7.5	11.9	5.1	3.5	35
Palm Bay Exp 14-N	1.5	0.6	1.6	6.2	13.4	8.6	4.8	37
Palm Bay Exp 15-O	1.1	0.9	1.4	8.3	24.7	17.5	11.9	66
Palm Bay Exp 16-P	2.4	0.7	0.8	2.4	6.7	3.4	2.0	19
Palm Bay Exp 17-Q	0.7	0.2	0.3	1.3	5.9	10.1	6.1	25
Palm Bay Exp 18-R	0.2	0.3	0.2	0.9	4.7	6.7	5.3	18
Palm Bay Exp 19-S	0.5	0.2	0.3	1.0	4.1	5.5	3.6	15
Palm Bay Exp 20-T	0.3	0.4	0.5	1.5	7.3	6.9	5.7	23
Palm Bay Exp 21-U	0.2	0.3	0.3	0.8	5.4	8.3	3.9	19
Palm Bay Exp 22-V	0.2	0.1	0.2	0.4	2.6	1.8	1.5	7
Palm Bay Exp 23-W	0.2	0.1	0.3	0.2	0.9	1.3	11.4	14
Palm Bay Exp 24-X	0.1	0.2	0.2	0.4	2.1	1.9	7.1	12
Mean	**0.9**	**0.4**	**0.8**	**2.6**	**7.5**	**6.4**	**5.6**	**24.1**

Hydro-Kleen VSS Outflow Particle Size Analysis

Experiment	>180 µm	140 µm	100 µm	60 µm	30 µm	11 µm	<11	Total
Palm Bay Exp 14-N	0.8	0.4	0.9	3.0	5.3	3.2	2.1	16
Palm Bay Exp 15-O	1.5	1.6	1.6	8.4	19.0	12.8	8.8	54
Palm Bay Exp 16-P	1.6	0.4	0.5	1.2	2.8	1.3	0.9	9
Palm Bay Exp 17-Q	0.5	0.1	0.2	0.8	3.0	4.2	2.3	11
Palm Bay Exp 18-R	0.1	0.1	0.1	0.4	2.1	2.5	3.1	9
Palm Bay Exp 19-S	0.2	0.2	0.2	0.6	2.1	2.7	1.4	7
Palm Bay Exp 20-T	0.2	0.2	0.4	0.9	5.9	0.2	2.8	11
Palm Bay Exp 21-U	0.1	0.1	0.2	0.5	3.1	3.9	1.8	10
Palm Bay Exp 22-V	0.1	0.0	0.1	0.3	1.4	1.0	1.1	4
Palm Bay Exp 23-W	0.4	0.1	0.2	0.3	1.3	1.7	3.7	8
Palm Bay Exp 24-X	0.0	0.1	0.1	0.3	1.3	1.2	3.3	6
Palm Bay Exp 13-M	1.8	0.2	1.7	3.3	4.2	2.0	1.2	14
Mean	**0.6**	**0.3**	**0.5**	**1.7**	**4.3**	**3.1**	**2.7**	**13.1**