UP-FLO™ FILTER

HYDRAULIC CHARACTERIZATION OF VARIOUS FILTRATION MEDIA

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1.0 INTRODUCTION

Upflow filters are filtration devices that utilize an upward flow path through filtration and absorption media to separate suspended particulate matter and other pollutants out of a liquid. They have been shown to be more efficient than traditional down flow or radial flow filters offering a smaller footprint than down-flow filters because they have a higher flow-through capacity per unit of surface area. Flow in an upward direction counters gravitational forces to fluidize the media allowing the entire depth of the media bed to be utilized.

The Up-Flo™ Filter has been designed as a modular filtration system. Each Filter Module has a treatment capacity of approximately 25 gpm, depending on the filtration media type. Each Filter Module has a surface area of 1.1 ft^2 and up to 6 modules can fit into a 4-ft catch basin (either round or square), for a combined surface area of 6.6 ft^2 and treatment flow rate of up to 150 gpm. Its unique siphon-activated bypass is capable of discharging up to 4 cfs for a standard 4-ft diameter manhole.

The principles governing the flow rate through an upflow filter are:

- Height of driving head

- Filtration bed properties
  - Surface area of filtration bed
  - Bed depth

- Media-specific properties
  - Expansion velocity
  - Particle size distribution
  - Density

For an upflow filter with a given media composition, bed depth and driving head, the flow rate through the filter will be proportional to the surface area and water pressure head acting on the filtration bed. The flow rate through each Up-Flo™ Filter Module depends on the height of driving head acting on the top level of the filter media. Generally, filtration rate increases proportionally driving head. The standard Up-Flo™ Filter is designed with a bypass weir set at 20 inches above the top of the media or 29.5 inches from invert to the bypass weir.

2.0 OBJECTIVES

One of the key attributes of the Up-Flo™ Filter is that its filtration media may be customized to target site-specific pollutants. However, different media will have different flow-through capacities. Because the Up-Flo™ Filter is most often sized to meet a treatment flow rate, a hydraulic characteristic for each media in the Up-Flo™ Filter portfolio is required.

The objective of the Hydraulic Characterization is to determine the flow rate in gallons per minute per square foot of different media through the Up-Flo™ Filter. This testing program evaluated the filtration rate of four separate media mixes: Filter Sand, CPZ Mix™, CPS, Perlite.

3.0 THE UP-FLO™ FILTER TEST FACILITY DESCRIPTION

3.1 LABORATORY SET UP

The Hydro International test facility contains a 23,000-gallon clean water storage reservoir equipped with a Flygt submersible pump to distribute feed water. The 3-inch Flygt pump delivers water to the Up-Flo™ Filter through an 8-inch PVC pipe network that freely discharges into the open top of the test tank. The 8-inch PVC delivery line is equipped with clear standpipes and a Hershey VP-820 butterfly valve that redirects flows in excess of the desired influent flow rate back into the feed reservoir.

3.2 UP-FLO™ FILTER CONFIGURATION

The 4-ft x 4-ft polypropylene test tank stands 7-ft high and houses from one (1) to six (6) Up-Flo™ Filter Modules. The test tank has a 12-inch outlet pipe that discharges into a large underflow basin on the floor of the lab. Two, 2-inch Flygt pumps send water from the underflow basin back into the feed reservoir.

A Catch Basin configuration Up-Flo™ Filter equipped with one (1) Filter Module is used for testing. The Filter Module is filled with two (2) Media Bags and latched shut. A more detailed description of the laboratory set-up can be seen in Appendix A.

3.3 EFFLUENT MONITORING ARRANGEMENT

The hydraulic monitoring program determines the flow characteristic of the Up-Flo™ Filter on a per Filter Module basis. The flow rate of a single module is predicted to be in the 15-25 gpm range. Due to the low flow rates expected, the methodology of using flow monitoring sensors to determine the flow rate per Filter Module was rejected for the more reliable Volumetric Time-To-Fill test method.

A compartmentalized underflow tank is situated next to the test tank. The Up-Flo™ Filter outlet pipe discharges directly into one of two 18-cubic foot compartments. A 4-gallon bin is also kept on hand to use when filtration flows are suitably low.

3.4 INFLUENT FLOW RATE

The flow rate to the Up-Flo™ Filter can be adjusted from 0-450 gpm (0.0 - 1.0 cfs) using the notched Hershey VP-820 butterfly valve fixed to the delivery pipework.

The chosen influent flow rate will vary with the number of Filter Modules included in the Up-Flo™ Filter test tank. The testing takes place under steady-state conditions, where the influent flow rate equals the filtration flow rate. The filtration flow rate of each Filter Module is approximately 20 gpm. Accordingly, the target influent flow rate is 20 gpm multiplied by the number of Filter Modules in the test tank.

4.0 TESTING PROCEDURE

4.1 MEDIA

Two (2) media bags of a specified filtration media were filled and placed into the Up-Flo™ Filter Module.

4.2 INFLUENT FLOW RATE CALIBRATION

A 3-inch, non-variable Flygt pump delivers flows at a constant rate of 448 gpm (1.0 cfs). A series of butterfly valves, a Hersey VP-820 valve and a notched Hershey VP-812 valve, are used to step the flow down to the desired influent flow rate. Excess flows are directed back to the storage reservoir. When the butterfly valves are being used, the flow rate is calibrated using the Volumetric Time-To-Fill Method. After the valves have been set to their desired notches, time to fill the tank to the 8-cubic feet mark is recorded. The flow rate equals the volume divided by the time-to-fill the volume.

4.3 FILTRATION FLOW RATE MONITORING

The filtration rate is determined by monitoring the effluent flow rate of an Up-Flo™ Filter consisting of one (1) Filter Module.

4.3.1 EFFLUENT MONITORING

The following procedure is used:

1. Place two (2) filled media bags in the Filter Module and latch the Filter Module shut.
2. Plug the weep holes located at the bottom of the Outlet Module.
3. Start the 3” submersible pump and allow it to pump water into the Up-Flo™ Filter test tank until there is enough driving head to start pushing water up through the filter.

4. Continue to pump flows into the tank until the desired operating head of 20 inches is reached. When the water is at 20 inches of operating head, use the butterfly valves to reduce the influent flows until they are equal to the effluent flows, stabilizing the water level within the Up-Flo™ Filter test tank.
5. Decant flows from the underflow collection tank by switching on the 2-inch Flygt pump.
6. When the underflow collection tank is decanted, start the stopwatch and turn off the decanting pumps, allowing the effluent to fill the volumetric bin.
7. Be sure to keep the water head in the test tank level at 20 inches by adjusting the butterfly valve on the influent line.
8. Record the amount of time it takes to fill the volumetric bin.
9. Let the water level in the tank drop one (1) inch so that there is an operating head of nineteen (19) inches acting on the filter. Repeat Steps 6-8.
10. Repeat Step 9 until there is less than one (1) inch of driving head remaining.
11. Stop influent pump. Drain the test unit and prepare to repeat hydraulic characterization.

4.3.2 EFFLUENT FLOW RATE CALCULATION

Calculate the flow rate, Q, for a given operating head using the following calculation:

$$\mathbf{Q}_{(gpm)} = \mathbf{V}\text{olume of bin}_{(gal)} / \mathbf{t}\text{ime-to-fill}_{(min)} \qquad \textbf{Equation 1}$$

5.0 RESULTS

5.1 CPZ Mix™

The CPZ Mix™ is Hydro International's custom blend of granular activated Carbon, Peat, and manganese-coated Zeolite. The mix is designed to remove fine sediments, metals, nutrients and organics from stormwater runoff.

The flow rate through the CPZ Mix™ was determined to be 24.7 gpm per module at an operating head of 20 inches. The flow rate per Filter Module of the CPZ Mix™ is shown below in Figure 1. The critical driving head, defined to be the driving head required to initiate flow through the media, was determined to be 6 inches. The critical driving head is denoted by the red data point in Figure 1.

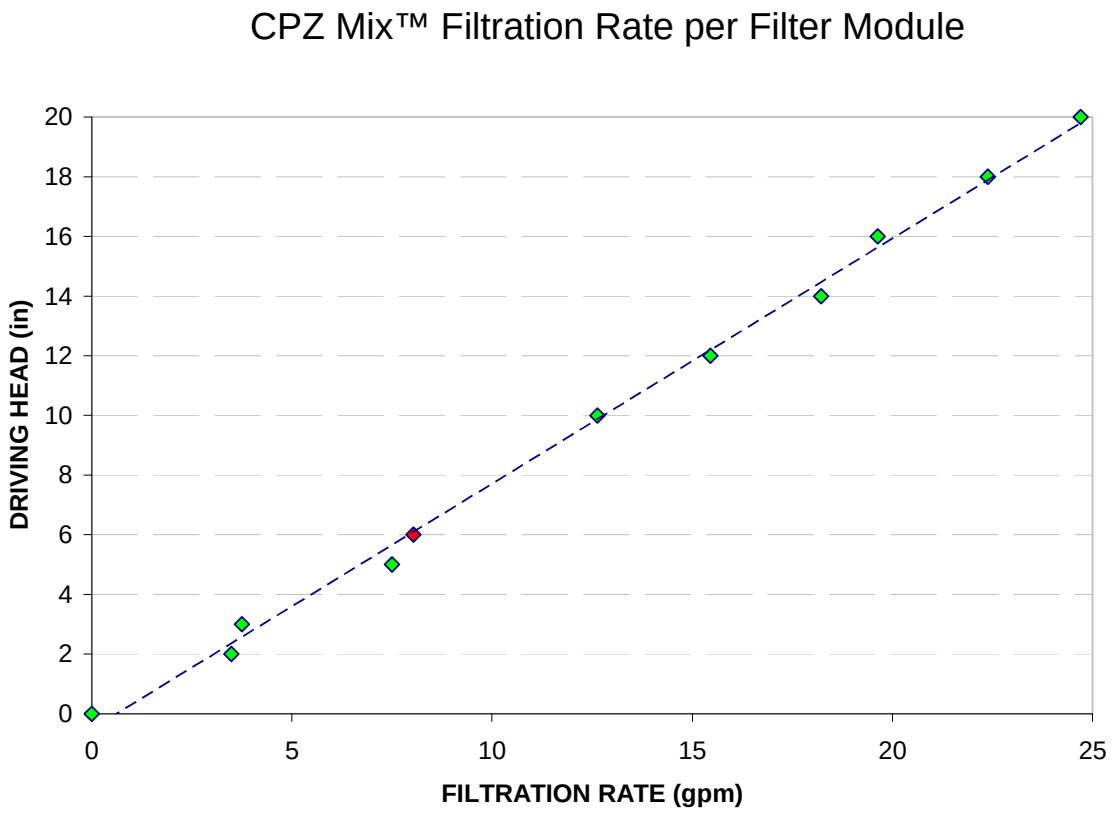


Figure 1 – Flow Rate per Unit Area of the CPZ Mix™

5.2 Filter Sand

The filter sand used in the Up-Flo Filter™ is a commercially available filter sand that is sized and graded to meet the stringent specifications of AWWA B-100 and the ANSI standards for consistently uniform and chemically inert filter media.

The flow rate through the filter sand was determined to be 23.1 gpm per module at an operating head of 20 inches. The flow rate per Filter Module of the filter sand is shown below in Figure 2. The critical driving head, defined to be the driving head required to initiate flow through the media, was determined to be 10 inches. The critical driving head is denoted by the red data point in Figure 2.

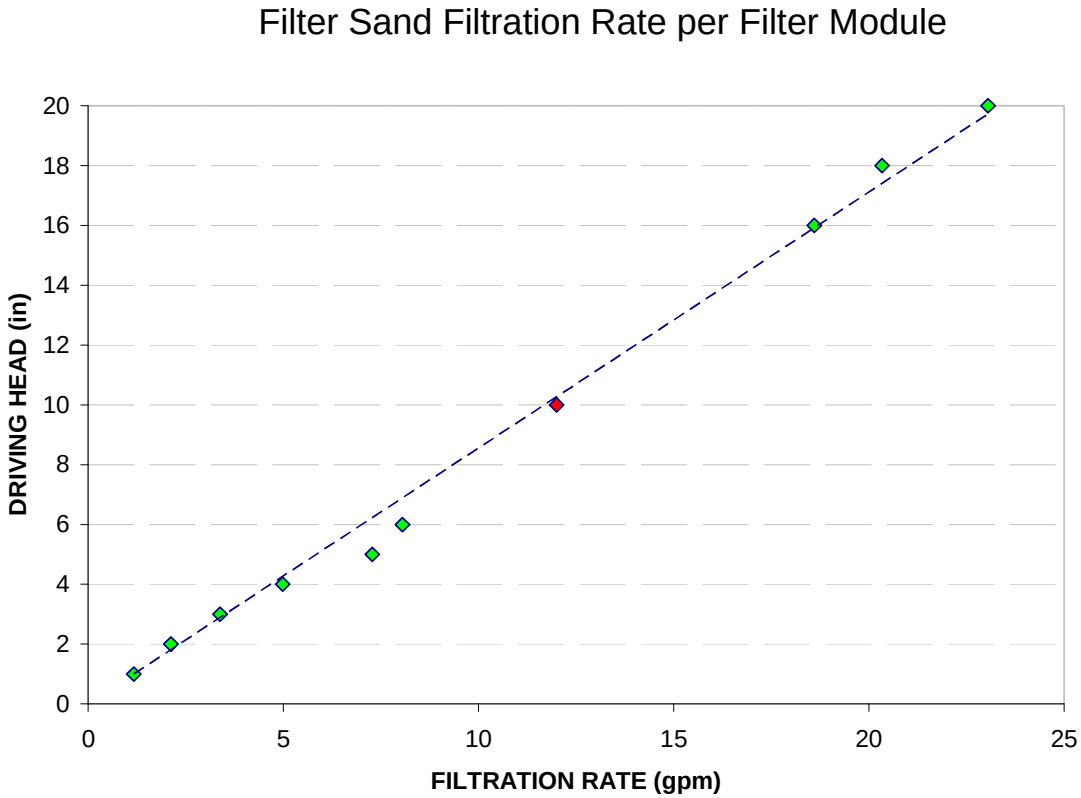


Figure 2 – Flow Rate per Module of Filter Sand

5.3 CPS Mix™

The CPS Mix™ is Hydro International's custom blend of granular activated Carbon, Peat, and Filter Sand. The mix is designed to remove fine sediments, metals, nutrients and organics from stormwater runoff.

The flow rate through the CP Mix™ was determined to be 19.6 gpm per module at an operating head of 20 inches. The flow rate per Filter Module of the CPS Mix™ is shown below in Figure 3. The critical driving head, defined to be the driving head required to initiate flow through the media, was determined to be 6 inches. The critical driving head is denoted by the red data point in Figure 3.

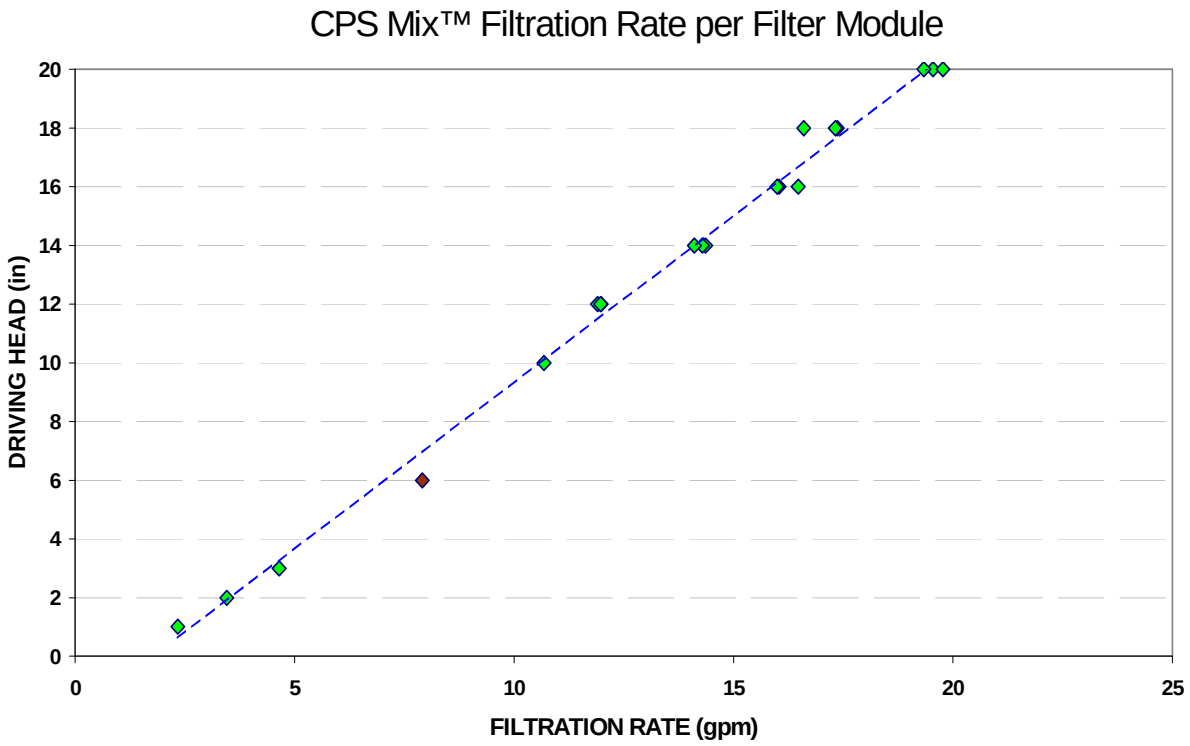


Figure 3 – Flow Rate per Module of CPS Mix™

5.4 Perlite

The flow rate through the Perlite was determined to be 28 gpm per module at an operating head of 20 inches. The flow rate per Filter Module of the Perlite is shown below in Figure 4. The critical driving head, defined to be the driving head required to initiate flow through the media, was determined to be 5 inches. The critical driving head is denoted by the red data point in Figure 4.

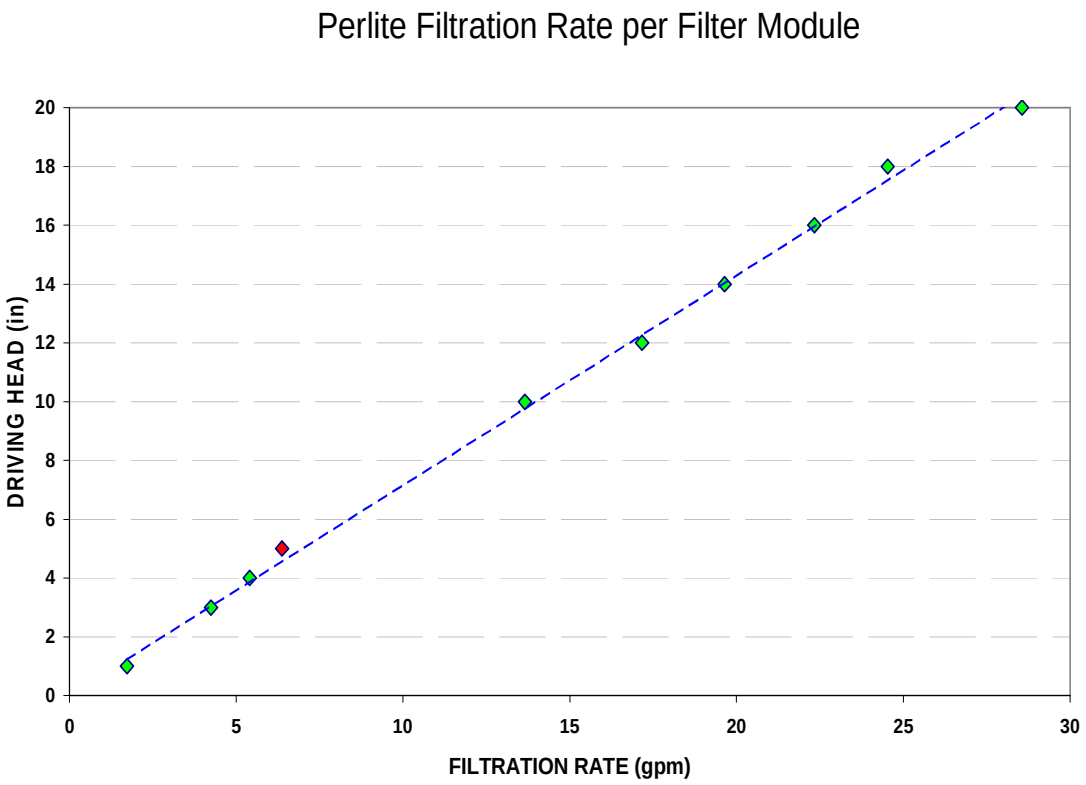


Figure 4 – Flow Rate per Module of Perlite

6.0 BYPASS CAPACITY

The Up-Flo™ Filter is equipped with a siphonic bypass designed to discharge flows in excess of the treatment flow. When influent flows exceed the filtration capacity, the water level in the Up-Flo™ Filter chamber rises above the height of the internal bypass weir in the outlet chute. If water levels continue to rise, the outlet chute will fill and displace any air, at which time the siphon is activated.

Full-scale hydraulic characterization of the siphonic bypass has been completed. The testing involved installation of the Up-Flo Filter's bypass module into a 4-ft. diameter chamber with enough height to discharge up to 5 cfs. The water elevations are minimized as a result of the siphonic actions. Once water elevation begin to flow over the weir, the siphon is activated between 30-34-inches which allows a large flow range to be discharged.

Due to the suction forces generated by the siphonic action, up to 3.4-cfs can be discharged with a water elevation that does not exceed 34 inches from invert. For flows that exceed 3.4 cfs, the following expression can be used to determine the water elevation above the invert.

$$h = 1.6(Q)^2 + 4.6(Q)$$

where; Q = flow in cfs
h* = water elevation in inches (measured from the invert of the outlet pipe)

The minimum height of a standard 4-ft diameter Up-Flo Filter measured from the invert of the outlet pipe is 45 inches, which is equivalent 4.1 cfs. If the stormdrain profile allows for more than 45 inches, additional risers can be supplied to enable a higher water elevation and thus flow.

APPENDIX A - TEST UNIT DESCRIPTION

DESCRIPTION OF THE Up-Flo™ FILTER

A full description of the system components and functionality of the Up-Flo™ Filter is presented in a Flash Animation File found on Hydro International's web page http://www.hydro-international.biz/.

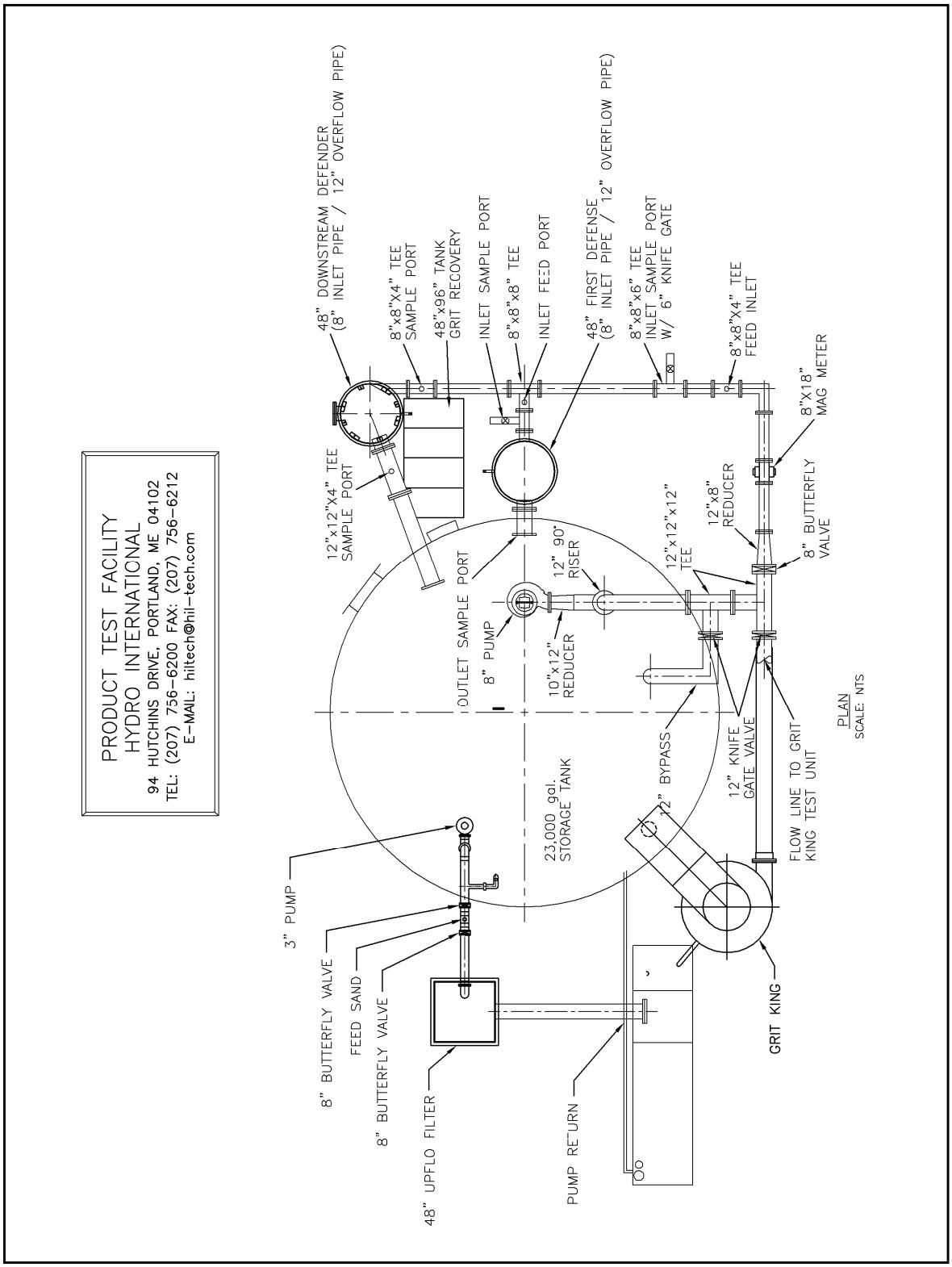
TEST UNIT DESCRIPTION

The test unit is fabricated from polypropylene and takes the form of a 4-ft x 4-ft square chamber cylinder approximately 7 ft (2.1m) high. The internal polypropylene components, 4mm perforated, Type 304 stainless steel screen and Type 304 stainless steel support frame are the same as found in actual units. There is no inlet. The set-up simulates a catch-basin insert technology which treats stormwater runoff pouring into a chamber from an overhead grate. The outlet is flanged with a 12 in. (300mm) NP16 flange. The relevant levels are as shown in the drawings and flash animation.

In order to clean out the unit and view the sediment storage area, an 18 in. (460mm) access hatch with a clear viewing port is located at sump level.

APPENDIX B - TEST FACILITY DESCRIPTION

TEST FACILITY GENERAL ARRANGEMENT



TEST UNIT PHOTOGRAPHS

Figure A-2: View showing Up-Flo™ Filter overhead Inlet Pipe, Outlet Pipe and Collection Basin

Figure A-3: View Showing a One-Filter Module Set-Up

Figure A-4: View showing closed and opened Filter Modules

Figure A-5: View showing media bag with Filter Sand being installed in the Filter Module

Figure A-6: A close-up view of the Filter Sand

Figure A-7: A close-up view of the Hydro International *CPZ Mix*™