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LRRB
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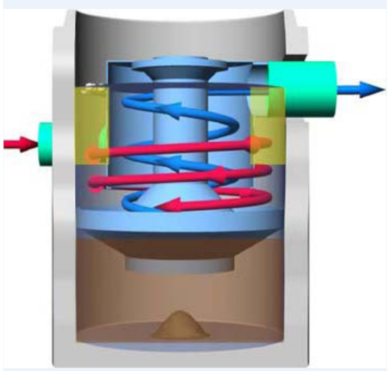
LRRB PROJECT COST:
$123,000



Water enters a hydrodynamic separator, swirls and then exits with captured sediment settling at the bottom of the chamber.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Assessment of Underground Stormwater Management Devices Under High Flow Conditions

Researchers developed tests for measuring the amount of sediment washed out of hydrodynamic separators during high flow storm events. These tests have aided in creating computer models that will be used to predict efficiencies for any manufacturer's separator under varying conditions and environments.

What Was the Need?

Excess sediments in rivers and lakes can reduce sunlight penetration, interfere with fish-gill function and, in sufficient quantities, reduce waters available for aquatic species. In addition, a number of pollutants, including heavy metals and plant nutrients (fertilizers), can bind to sediments found on roadway surfaces. These sediments can be carried by stormwater to affect downstream water sources and other environmental features.

Various stormwater treatment devices are available to address this situation. Hydrodynamic separators are widely used in urban areas for this purpose due to the limited land availability for above-ground stormwater management installations. Hydrodynamic separators are used to pretreat stormwater runoff from the drainage basins they serve. Water enters a flow-through device where sediments and contaminants can then be captured. The sizes of hydrodynamic separators are based upon the rate of runoff expected from that area. Occasionally, a storm event will result in a flow rate that exceeds that device's maximum design treatment rate. During these high flow events, previously captured sediments and pollutants can be washed back out of the hydrodynamic separator when sediment resuspension and washout takes place. This occurs when the water enters the device at such a rate as to cause turbulence sufficient to overcome the resettling of resuspended sediments, dispersing them upward to the outlet of the device.

It is consequently useful to monitor the performance of a hydrodynamic separator under a wide range of actual hydraulic and pollutant loading conditions. However, traditional methods of estimating a device's performance have displayed only limited accuracy.

What Was Our Goal?

The researchers' goal was to study the potential for scour and washout of previously deposited sediments in the collection reservoir (sump) of hydrodynamic separators during atypical storm events. By doing this, researchers could not only predict the effectiveness of a particular hydrodynamic separator, but could also minimize the costs of maintenance by accurately predicting when a separator's sump would require emptying before pollutants begin to wash out of the device.

What Did We Do?

Researchers at the St. Anthony Falls Laboratory studied three types of hydrodynamic separators used in the Twin Cities: an Environment 21 V2B1 Model 4, an STC1200 Stormceptor and a 6-foot Downstream Defender. Researchers developed a new testing procedure to assess sediment resuspension and washout for these devices under flow rates exceeding maximum design treatment rates. The first of these devices was also tested in the field using a fire hydrant to provide controlled water supply at flow rates at and above the maximum design treatment rates; these field results matched those of the laboratory tests.

continued

For the field test, water was piped from a fire hydrant directly into a storm sewer catch basin with a valve to adjust the flow rate. From the catch basin, the water flowed through a storm sewer pipe under Rice Creek Road to another catch basin, and then into the V2B1 hydrodynamic separator. Water flow and washout sediment exiting the device were measured.

"By using the testing methods developed at the St. Anthony Falls Laboratory, we determined that the separators tested in the field were in fact retaining a high degree of sediment during high flow storm events. One device in particular had no sediment washout."

–Mike Eastling,
Director of Public Works, City of Richfield

"The data collected from this study will be instrumental in developing computer models that will predict the efficiency of any manufacturer's hydrodynamic separator under a variety of conditions."

–Omid Mohseni,
Adjunct Associate Professor, St. Anthony Falls Laboratory, University of Minnesota Department of Civil Engineering

To further advance the understanding of the principal processes that govern sediment scouring, resuspension and washout, researchers built a 1:10 scale model of a swirl flow type 10-foot diameter separator. Multiple retention tests were run with sand particle sizes ranging from 180 to 250 microns, and then again with particle sizes ranging from 125 to 180 microns.

What Did We Learn?

Researchers discovered that the STC1200 Stormceptor performed well under high flow conditions, with almost no washout of sediments that the device could remove from stormwater runoff. This performance is primarily due to the bypass built inside the device and the flow patterns entering the sump. The other two devices displayed varying degrees of sediment washout.

The scale model tests showed that in general, swirl flow hydrodynamic separators are more prone to higher washout rates due to high flow velocities near the sediment inside these devices.

Researchers concluded that by using the data collected from this study, mathematical relationships could be developed that would accurately predict the efficiency of any manufacturer's hydrodynamic separator under a variety of conditions. These mathematical functions can be incorporated into computer models to aid local transportation agencies in selecting a separator for their particular environment. In addition, since efficiencies are directly impacted by how much sediment has collected in the sump, prediction models would allow maintenance schedules to be developed, which would reduce the number of scheduled cleanouts and save on maintenance costs.

What's Next?

While the mathematical relationships had not been worked out during the span of this project, researchers have since developed these functions and will soon incorporate them into computer models that will be available on the Internet. An additional report is in progress that will reference this study as the launching point for the development of these equations. Researchers hope that Minnesota transportation agencies will use these models for developing efficient maintenance schedules for existing installations, and for evaluating various manufacturers' hydrodynamic separators for the particular environments in which they will be installed.

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