**Appendix G.** Publication from April 2008 issue of Water, Environment and Technology, describing BMP performance research conducted by DelDOT at the I-95 service plaza.


DELAWARE DEPARTMENT OF TRANSPORTATION

# TEST-DRIVING STORMWATER BMPS

## The Delaware Department of Transportation uses an interstate highway service area to monitor performance of stormwater management technologies

*Marianne Walch*

When looking for a spot to test the effectiveness of stormwater runoff best management practices (BMPs), the Delaware Department of Transportation (DelDOT) decided to take a middle-of-the-road approach — literally.

DelDOT owns and operates a 33-ac (13-ha) service area that lies in the median of Interstate 95. The service area includes two fueling stations, a large food court and rest area, pet exercise areas, and parking for trucks, cars, and buses. The site also includes a stream, Leatherman's Run, which is piped beneath the plaza through two large box culverts.

The stream directly receives all stormwater discharges from the site, making it an ideal setting for DelDOT's multiyear project. In the past 4 years, DelDOT has tested several types of stormwater quality retrofit BMPs, such as catch-basin inserts, filtration and hydrodynamic devices, and bioretention cells, during many storm events. Preliminary data indicate that these retrofits are having some benefit in reducing pollutant discharge to the stream.

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**Delaware Department of Transportation researchers replaced concrete swales located between the southbound lanes of Interstate 95 with a bioretention cell to test its how well it removes pollutants entering a nearby stream.**

## The Setup

DelDOT has a Phase I National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System, or MS4, permit that covers its operations in all of New Castle County, where the service area is located. The permit includes a requirement to monitor performance of stormwater BMPs. In 2002, DelDOT began this long-term BMP performance monitoring and research program. The major objectives of the program are to

- quantify pollution removal abilities of BMPs;
- identify types and amounts of pollutants present in DelDOT-controlled stormwater discharges;
- determine the potential impact of DelDOT discharges on surface water quality;
- provide design engineers with additional treatment options for difficult, site-specific situations; and
- evaluate and select emerging stormwater treatment technologies to provide the best benefit and cost performance.

During the past 3 years, DelDOT has installed several stormwater quality retrofit BMPs at the service plaza to assess their efficacy. The particular BMPs were selected based on what they are designed to remove and what pollutants the baseline monitoring showed were present. Also, some of the newer technologies were selected for eventual comparison of the monitoring results to those obtained from more conventional technologies, such as sand filters and retention ponds.

The BMPs include four types of catch-basin inserts, a bioretention cell to replace existing concrete swales, a media filter unit and a perimeter-sand filter installed in the gas station drainage, a hydrodynamic separator device installed in the drainage area of the food service area, and pet waste bag dispenser units with educational signs.

## Baseline Monitoring

DelDOT conducted baseline wet weather monitoring at the service plaza for more than a year prior to installation of the water quality retrofits. Five sampling points were selected on the site to provide baseline runoff quality information and to assess the impact of service plaza discharges on Leatherman's Run.

A central manhole site collects the bulk of the drainage from the parking lots and both gas stations. Effluent from the manhole discharges directly into Leatherman's Run. Two swale inlets collect runoff from concrete swales that drain the service lanes. In addition, samples were collected from Leatherman's Run immediately upstream and downstream from the service plaza.

First flush and flow-weighted composite samples were collected during qualifying storms. Criteria for a qualifying event included at least a 72-hour dry period before the rain and at least 0.1 in. (2.5 mm) of rain during the storm. Samples were placed on ice and immediately transported to the laboratory.

At the lab, samples were composited and analyzed for 50 different chemical parameters, including heavy metals, suspended and dissolved solids, oxygen demand, chloride, bacteria, petroleum hydrocarbons, benzene, toluene, ethylbenzene, xylene, phenolics, and polycyclic aromatic hydrocarbons. Some parameters, such as bacteria, were sampled only on the first flush. Attempts were made to sample all five locations during each storm, but this was not always possible.

Baseline monitoring began in April 2003 and included a total of 11 wet weather events. The event mean concentrations of nearly all parameters were highly variable. In general, the central manhole site and the southbound-side swale (along which many trucks park) had the highest concentrations of most contaminants. Samples from the Leatherman's Run site downstream of the service plaza discharge consistently had higher levels of pollutants than those from the upstream site, indicating that runoff from the plaza affects the stream.

These data provided information on total pollutant loads coming from different parts of the service plaza, as well as total loads being discharged to the stream. As the study continues, these data are being compared to data collected from the same sampling points after installation of the retrofit BMPs to determine their impacts on stormwater discharges from the service plaza.

## Catch-Basin Inserts

Four types of storm-drain inlet protectors have been installed to test their effectiveness at removing pollutants from runoff from the service

station and parking lot drainage areas. There are 60 drainage inlets at the site, and insert filters now protect all of them. All are inspected monthly and maintained as needed. The types of units under evaluation include

- a two-chambered unit consisting of a sedimentation chamber and a series of cellulose and activated charcoal filters;
- a fabric insert made of an oleophilic geotextile material;
- box filters containing oil-absorbing and antibacterial media (two types of units were installed — one with both oil-absorbing and antibacterial properties, and one with regular material, which lacks the antibacterial additive); and
- an insert consisting of stainless steel mesh screens and oil-absorbing booms.

DelDOT conducted two studies on catch-basin insert effectiveness. In 2003, eight of the two-chambered inserts were installed in a run of catch basins that collect drainage from the northwest side of one of the gas stations. A similar run of inlets on the other side of the gas station was left unprotected so that water quality from the two runs could be compared. The inserts were regularly inspected and maintained. Wet weather samples were collected from the ends of the protected and control pipe runs.

These inserts were selected because of their multilayer filter design for removing hydrocarbons and other dissolved organics. Monitoring showed that these inserts remove some hydrocarbons from the runoff, but they were not as successful in capturing sediment. Only marginal differences in water quality were noted between the drainage from protected and control inlets. Evaluation of the data suggested that the study was not sufficiently controlled.


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**Among other technologies, the researchers installed a perimeter sand filter to assess how well it handled polluted runoff from the service area's gas stations.**

In 2006, a more carefully controlled follow-up study was designed. Individual catch-basin insert units of each of the different types were modified so that samples of both influent runoff and treated effluent could be sampled directly in the catch basin. This modification involved configuring the units with stainless steel trays to capture effluent — including bypassed water — during a storm. Sampling tubes were added to draw water from this tray.

Collection of samples from these units during qualifying storm events began in 2007.

At the service plaza, these units have collected primarily trash, sand (in winter), grass clippings (in summer), and some leaves. They have been able to go for several months between cleanings at this site.

At press time, only a few storm events had been monitored, so no conclusions can yet be drawn. The filters have shown varying levels of sediment removal, ranging from 20% to 80%. Total suspended solids (TSS) removal rates varied widely, from 5% to 68%. The researchers have observed that resuspension of sediment within the units is sometimes a problem, so the variation in sediment removal may be correlated with the amount and intensity of rainfall. This will be investigated further. Removal rates for total copper and zinc — which are associated with particulates — were somewhat correlated with those for sediment. Other metals — chromium, lead, and nickel — seem to occur mainly in dissolved form and were not removed by the catch-basin insert filters.

## Other Structural BMPs

Four other types of structural BMPs were installed at the service plaza in 2004 and 2005. They include

- a bioretention cell to replace concrete swales located between the southbound highway lanes and the plaza;
- a media filter unit installed south of a service station;
- a perimeter sand filter (also known as a "Delaware" filter) installed north of the east end service station; and
- a hydrodynamic separator device installed in the drainage area of the food service area of the plaza.

The target is to monitor at least three storm events per year for each BMP, depending upon precipitation and budget constraints. Sites previously sampled during baseline monitoring at the service plaza also are being sampled during this study to assess the effect that the BMP installations have upon total discharges from the site.


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**The researchers collected samples during each qualifying storm. Criteria for a qualifying event included at least a 72-hour dry period before the rain and at least 0.1 in. (2.5 mm) of rain during the storm.**

Each BMP was designed and instrumented so that both influent and effluent samples can be collected. After each storm event, the influent and effluent data are used to calculate a percent mass removal for each parameter for each of the different BMPs.

Extreme variability of removal rates observed among storm events make interpretation of the data difficult. Samples from more storm events are needed to enable statistical analyses of the results. However, preliminary comparison can be made of the three manufactured BMPs.

Data obtained thus far indicate that the sand filter and media filter have comparable, good rates of removal of suspended solids, averaging 70% to 80%. TSS removal rates by the bioretention cell have sometimes been good but are inconsistent from storm to storm.

So far, the separator device has not shown a good removal of suspended solids but has had the highest removal rates for oils and greases. Percent removal values for hydrocarbons can be deceptive because of the very low to negligible concentrations that often are measured in these samples. Removal of dissolved pollutants so far has not been very good for any of the manufactured BMPs.

## Stream Assessment

In addition to monitoring individual BMPs, the study also includes a long-term condition assessment and biomonitoring study of Leatherman's Run. DelDOT contracted with KCI Technologies Inc. (Newark, Del.), to conduct this work. Each spring and fall, water quality analyses and biological monitoring (including fish studies and macroinvertebrate sampling) are conducted in the stream.

Leatherman's Run shows signs of both stormwater quantity and quality stress. The Interstate 95 corridor occupies a significant portion of the center of the stream basin. Monitoring during the past few years has indicated detectable increases in temperature, dissolved solids, and litter downstream of the interstate highway and service plaza.

Baseline water quality data from the upstream and downstream sites for both TSS and total dissolved solids showed clear increases in concentrations downstream of where service plaza runoff enters the stream. More recent data indicate that TSS and total dissolved solids still are somewhat higher downstream of the plaza, suggesting that the plaza runoff continues to affect the stream. However, both total concentrations and the net increase downstream of the plaza seem to be decreasing following installation of the BMPs in late 2004 and 2005. Thus, DelDOT is encouraged that these retrofits are being, at least, somewhat effective in reducing pollutant loads into Leatherman's Run.

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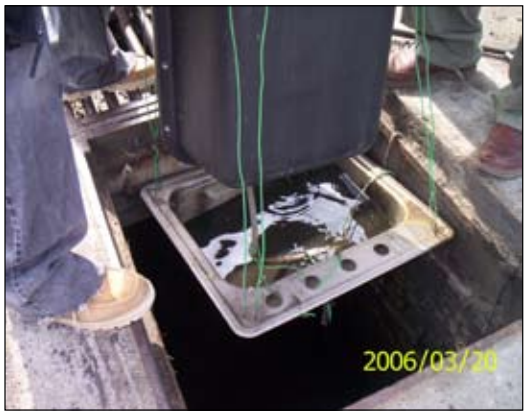


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**To understand the overall treatment abilities of the catch basin inserts, researchers installed stainless steel trays beneath the inserts to capture a combined sample of catch basin effluent as well as bypassed water.**