2019-27TS
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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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TOTAL PROJECT COST:
$200,036

LRRB COST:
$100,018

Near the end of the study, workers used a boring machine to take core samples of the ditch check and the filter insert.

DEPARTMENT OF TRANSPORTATION
OFFICE OF RESEARCH & INNOVATION

Evaluating Iron-Enhanced Swale Ditch Checks for Phosphorus Removal

Researchers documented performance of an iron-enhanced ditch check filter to remove phosphorus from stormwater over three years. The filter was effective, but its performance decreased over time, and it will require relatively frequent maintenance. Several design changes may be considered.

What Was the Need?

The Minnesota Pollution Control Agency (MPCA) requires that developments adding more than an acre of impervious land must try to include methods to infiltrate the first inch of stormwater runoff. This "first flush" of stormwater from impervious road pavement contains pollutants that could contaminate watersheds.

To meet its MPCA permit requirements, MnDOT might consider constructing strategically designed ditch blocks and swales: wide, shallow ditches with mounds of engineered soil and sand mixtures and vegetation along roadways that manage stormwater flow.

Previous research has shown that MnDOT's linear swales are effective filters of contaminated highway runoff. That study also conducted laboratory investigations into enhanced ditch checks—low permeable mounds placed in a swale to reduce water velocity. Researchers tested the ability of various media in an experimental ditch check filter to remove more pollutants. A subsequent MPCA study examined the capability of an iron-enhanced sand trench to remove phosphorus.

In September 2014, MnDOT constructed two iron-enhanced ditch checks in a swale along CR15 (TH5) in Washington County to test two design versions. One failed to function effectively; the other was monitored for four months in 2015, showing effective phosphorus and metals retention.

What Was Our Goal?

The goals of this project were to investigate the long-term effectiveness of iron-enhanced ditch checks in retaining pollutants and to develop recommendations for maintenance actions needed to support effective filter performance.

What Did We Do?

Researchers monitored the performance of the CR15 (TH5) iron-enhanced ditch check from 2016 through 2018 while temperatures were above freezing. A tipping-bucket rain gauge was connected to a data logger to record rainfall at the site. Water samples were collected automatically through tubing at four points: the inflow and outflow of the check dam and filter insert. (Two monitoring wells had been built into the filter.) An automated sampling instrument was triggered by flow through the filter insert. The data logger recorded water levels, flow rate, cumulative flow volume and rainfall depth information continuously at five-minute intervals.

Pressure transducers installed inside the monitor wells measured upstream and downstream water levels at the filter insert section. Flow rate through the filter was calculated. Researchers retrieved inflow and outflow samples within 24 hours of the end of a rain event. The University of Minnesota St. Anthony Falls Laboratory tested these samples for phosphorus and metals.

continued

"Enhancing ditch checks with iron filings will aid in the removal of phosphorus in stormwater. However, since the bottom of the filter receives the most flow, more frequent mixing of the iron filings is required than originally anticipated."

—Beth Neuendorf,
Water Resources Engineer,
MnDOT Metro District

"Our success in removing phosphorus from stormwater runoff using iron particles in filtering ditch checks showed strong proof of concept. Modification of the filters' orientation in the ditches could result in a device that is both more effective and low maintenance for MnDOT."

—John Gulliver,
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The iron-enhanced filter installed in this ditch check holds iron filings and sand in a geotextile fabric envelope and is supported by a metal filter cage extending across the swale. Topsoil and sod will cover the entire ditch check.

In July 2018 researchers collected three core samples from the ditch check sides and the filter to test for retained phosphorus and signs of diminished performance.

What Did We Learn?

The iron-enhanced ditch check filter successfully removed phosphorus during the majority of the 40 rain events, reducing the phosphate mass loads between 22 percent and 54 percent. However, the cumulative phosphorus retention in the filter decreased from 42 percent in 2015 to 30 percent in 2016, 25 percent in 2017 and 23 percent in 2018. The core tests confirmed that the bottom 3.9 inches of the filter media filtered most of the inflow volumes of the runoff. This heavy runoff load reduced its sorption capacity over three years while the upper part of the filter was active only infrequently.

The ditch check itself showed a somewhat lower phosphorus retention performance than the filter insert, though performance varied some years. Researchers considered that the soil and sod covering may have leached phosphates into the ditch check and filter insert, affecting its overall performance.

Neither the ditch check nor the filter insert were very effective in copper and zinc retention, although the metal concentrations in the inflow and treated runoff were generally lower than in typical highway runoff.

Regarding maintenance, researchers recommended the filter insert medium be mixed up every other year to redistribute the filter media at the bottom. They also recommended that the entire filter insert be replaced after six years.

What's Next?

Researchers presented possible design changes that could improve performance, such as using peat instead of soil and sod to cover the ditch check. They also suggested installing ditch checks in series and re-engineering the filter to address the findings revealing the heavy runoff load taken by the filter's bottom 3.9 inches. Reducing the depth of the filter berm could avoid the excessive inundation of the bottom media while the upper portion remains unused. Maintenance frequency could then be reduced.

This Technical Summary pertains to Report 2019-27, "Iron-Enhanced Swale Ditch Checks for Phosphorus Retention," published July 2019. The full report can be accessed at mndot.gov/research/reports/2019/201927.pdf.