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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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PROJECT COST:
$192,527

Low-Volume Road Runoff Analyses Suggest Optimal Treatments

What Was the Need?

When MnDOT and local transportation agencies construct new roads or improve existing highways that add linear impervious surfaces of 1 acre or more, they are required by the Minnesota Pollution Control Agency (MPCA) to meet permanent stormwater treatment requirements. The MPCA mandates that the first 1.1 inches of runoff be captured and retained in a manner that mitigates the contaminants' effects, often through wet ponds and infiltration basins. Best practices are based upon analysis of the stormwater runoff of paved urban roads with high average daily traffic (ADT) counts of tens of thousands and greater.

Analyses of kinds and concentrations of runoff contaminants from low-volume roads—those with ADTs of 1,500 or fewer—have not been conducted. Local agencies wanted to learn how runoff from low-volume rural roads differed from that of high-volume urban roads. If the runoff analyses differed considerably, alternative stormwater runoff treatments could be both more effective and less costly than the standard treatments for high-volume roadways.

MnDOT and local agencies sought to analyze low-volume road runoff contaminants and determine possible alternative runoff treatments for those roads.

Assisted by many county agency staff, researchers collected and analyzed runoff from low-volume rural roads over two years to determine how their contaminants compared to those of high-volume roadways. Results documented that runoff from low-volume roads has a lower contaminant concentration and that ditches and swales can be used to effectively treat rural road runoff.

What Was Our Goal?

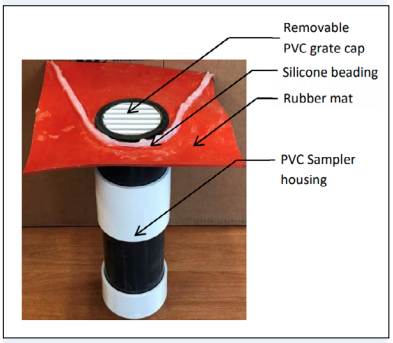
The goal of this project was to characterize contaminants in stormwater runoff from low-volume rural roads. For this study, two-lane asphalt paved rural roads with less than 1,500 ADT were considered low volume. There were two objectives: Learn what was in the runoff, and identify and provide recommendations for stormwater treatments best-suited for low-volume rural road runoff.

What Did We Do?

First, researchers conducted a literature search for studies about stormwater runoff characteristics and variables affecting water quality. Beyond traffic volume, factors such as adjacent land type and use, previous dry periods, and rainfall volume and intensity were noted.

Next, researchers asked nine county engineers to recommend low-volume road sampling sites. Ten sites across six counties were selected based on soil types, land uses, site accessibility, proximity to a weather station with a rainfall monitor (such as airports) and ease of placing a sample collector at the side of the road. In addition, researchers used sampled Mississippi River water to compare to roadway runoff samples.

From June to October 2018 and 2019, researchers devised the following runoff sampling system: They developed and built "first flush" runoff sampler collectors to be installed at the road's edge at the 10 sites. The collectors were PVC tubes set below ground that held a 1-liter bottle fitted with a ball valve closure. At ground level, a grated cap fit the tube above the bottle, surrounded by a rubber mat with a bead of silicon to funnel runoff toward the cap. Geotextile fabric was eventually installed at all sites to keep debris away from the collectors.



The runoff sampler used to collect stormwater runoff samples at the low-volume road sites.

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continued

"This study shows that low-volume rural road runoff differs substantially from high-volume urban highway runoff and can therefore be treated in ways that are more effective and at a substantially lower cost."

—John Welle,
County Engineer,
Aitkin County

"This project lets county engineers know what they need to do to treat the suspended solids and total phosphorus in the runoff from their rural roads. Now they have data showing that ditches with swales often provide the best treatment method."

—John Gulliver,
Professor, University of Minnesota Department of Civil, Environmental and Geo-Engineering

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Engineers and agency staff from the project's six counties assisted researchers throughout the study. John Welle (shown here) holds the collector apparatus, while an installed version is visible at the road's edge.

More than 15 agency staff from these counties assisted researchers. They retrieved sample bottles from the sites after each of 174 rainfall events over the two years that the project was conducted. Runoff samples were divided into three bottles for analysis: 500 milliliters for total suspended solids (TSS), 250 milliliters for metals analysis and 250 milliliters for phosphorus and nitrogen. The bottles were cold-packed and sent to a lab to determine sample concentrations of TSS; metals (cadmium, copper, lead, nickel and zinc); total phosphorus (TP); and nitrates and nitrites.

What Was the Result?

The literature search confirmed that low-volume road runoff had been rarely investigated. Some runoff variables could be tied to adjacent land types and uses.

The 10 collection sites included roads near agricultural and wooded lands. Runoff near cultivated lands showed more TP, while samples near woodlands revealed more nitrates and nitrites. All samples showed less metal contamination—some to the point of being negligible or absent—than high ADT urban road runoff typically contains. An adjustment was developed and applied to convert the first flush concentrations into equivalent whole-storm concentrations to compare with previously studied high-volume road concentrations. The adjusted concentrations of TSS, TP, nitrate+nitrite, copper and zinc were found to be lower than those in high-volume road studies in the United States.

Researchers recommended ditches with swales, which are already used along many rural roads, as an effective stormwater treatment. They are considerably less expensive than other best management practices and are often in the existing right of way, avoiding the need to acquire more land for wet ponds or other treatments.

What's Next?

Results will be shared with local agencies, providing county engineers with valuable information about how to best treat stormwater. The extensive data from the sampling will also allow them to present new information when renewing their stormwater treatment permits.

This Technical Summary pertains to Report 2020-27, "Characterization of Runoff Quality From Paved Low-Volume Roads and Optimization of Treatment Methods," published September 2020. The full report can be accessed at mndot.gov/research/reports/2020/202027.pdf.