CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4605-S
Project 0-4605: Stormwater Quality Documentation of Roadside Shoulders Borrow Ditches
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PROJECT SUMMARY REPORT

Stormwater Quality Documentation of Roadside Shoulders Borrow Ditches: A Summary

Nonpoint source pollution is an environmental problem that raises a concern among regulatory agencies and water quality professionals. A portion of this pollution is conveyed to receiving waters by stormwater drainage from highways, often via vegetated roadside shoulders, also referred to as borrow ditches. Vegetated filter strips are relatively smooth, moderately sloped, vegetated areas that accept stormwater runoff as overland sheet flow. The primary mechanisms for removal of pollutants are sedimentation, infiltration into the soil, and biological/chemical activity in the grass and soil media.

Vegetated filter strips are recognized by many regulatory agencies as a Best Management Practice for the control and treatment of stormwater; however, the relationship between pollutant removal and design parameters such as length, width, and vegetative cover is not well understood. Therefore it is important to evaluate and document the extent to which these vegetated areas reduce pollutant loads in runoff and mitigate the effects of discharging untreated highway runoff directly into receiving bodies of water. The primary objective of this research is the documentation of the stormwater quality benefits of these vegetated sideslopes typical of common rural highway cross sections in Texas.

What We Did...

The effects of vegetation cover and slope on pollutant concentrations were assessed in two geographic areas in Texas (Austin and College Station) to evaluate the effect of different vegetation assemblages and slopes on pollutant reduction. Multiple sites within each geographic area were evaluated to increase the confidence in

Figure 1: Photograph of installed collection pipe at Austin Site 2

observed pollutant reductions. The scope of this project included:

- Selection of three sampling sites in the Austin area and three in the College Station area that met a predetermined list of site criteria.
- Installation of four passive stormwater samplers and collection systems at each selected site (edge of pavement and 2, 4, and 8 meters away), for a total of 24 samplers.
- Monitoring of sites and collection of runoff samples from storm events over a 14-month period.
- Laboratory analyses of each of the runoff samples.
- Compilation of results into a database.
- Statistical and graphical analyses of results to determine differences between sites and different conditions
- Evaluation of the performance of each of the vegetated filters and recommendations of site conditions conducive to maximum pollutant removal.

In addition, a permeable friction course (PFC) overlay was applied to the road surface at one of the Austin sites during the course of the study. This allowed an evaluation of the differences in runoff quality from a conventional hot mix asphalt surface and PFC overlay.

What We Found…

The key findings of this research project are as follows:

1. The pollutant concentrations in runoff at the edge of pavement were similar for most sites and within the expected range of concentrations for highway runoff. This allows for direct comparisons of the vegetated buffer strips and their associated site characteristics (vegetation density, slope, etc.).
2. Although concentrations observed at the edge of pavement and at 8 m in Austin and College Station were similar, the high degree of variability observed at the College Station sites meant that no statistically significant differences could be documented for those sites for almost all constituents. Performance of the College Station sites appeared to be compromised by a number of factors including sampler placement, traffic mix, and herbicide use. The traffic at this site consisted of a high volume of solid waste and construction material trucks that resulted in the deposition of a substantial amount of dust and debris in the test sections. In addition, herbicide was inadvertently applied to the test sites in College Station reducing the vegetation coverage.
3. Vegetation density was observed to have a direct effect on the performance of vegetated filter strips. Areas with dense vegetative covers had better pollutant removal than other sites, even when the other sites had lower slopes. Vegetative

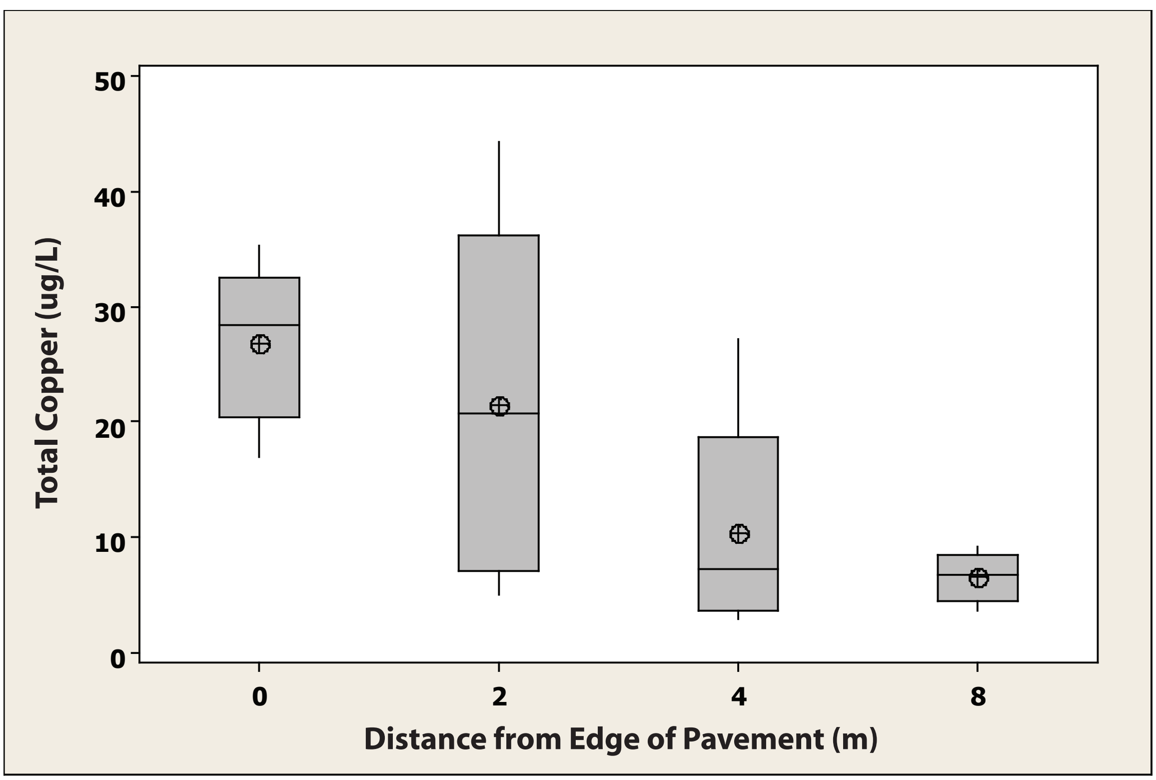

Figure 2: Total copper concentrations at Austin Site 1

covers of at least 90% provided the best performance, but substantial reductions in concentration were observed for sites with as little as 80% coverage.

4. A thin layer of biosolids compost material had no discernable effect (positive or negative) on the performance of densely covered vegetated filter strips. However, the test site had good vegetation coverage before application of the compost. Further testing is required to determine if compost could provide an improvement where the initial vegetation establishment is poor.
5. Statistically significant reductions in TSS concentrations were observed at all three research sites in Austin. The majority of removal occurred within the first two meters of the vegetated filter at two sites, and within the first 4 meters at another site.
6. Concentrations of total copper exhibited statistically significant decreases at all six research sites (College Station and Austin) within the first 8 meters. An example for one site in Austin is presented in Figure 2.
7. Concentrations of total lead also exhibited statistically significant decreases at all three of the Austin sites with those decreases occurring within the first 8 meters.
8. Statistically significant reductions in COD occurred over the width of the vegetated filter at the Austin sites.
9. No consistent increases or decreases were observed for nutrients.
10. Total and dissolved concentrations of zinc were elevated at the 2, 4, and 8 meter sampling points at all six sites, believed to be caused by leaching of zinc from the galvanized metal flashing used in the collection apparatuses.
11. Vegetated filter strips with a minimum width of 4 m and a minimum vegetation density of 80% are recommended for treating stormwater runoff from highways with rural type cross sections in Texas.
12. The permeable friction course has a significant impact on the quality of runoff leaving the road surface. Runoff generated from the PFC has lower concentrations of TSS, total metals, and COD. These improvements in water quality are as great as, if not greater, than the improvements gained from the vegetated area adjacent to the roadway.

The results from this research indicate that vegetated filter strips should be utilized by TxDOT as a Best Management Practice for controlling and treating stormwater runoff from Texas's highways. These filter strips demonstrate consistently high removal efficiencies for many of the pollutants of concern in stormwater runoff and can therefore mitigate the effects of discharging untreated highway runoff directly into receiving bodies of water. In addition to providing water quality benefits, these vegetated areas are inexpensive, easy to implement, easy to manage, and provide aesthetic benefits to the surrounding environment.

The Researchers Recommend...

The following design guidelines are based on the water quality performance observed at the test sites in Austin and College Station.

- Slopes should not exceed 6:1 (H:V) to encourage sheet flow, increase contact time of the runoff with the vegetation, and prevent erosion.
- Where space is constrained along highways, a fully vegetated grassy shoulder 6 feet wide will provide removal of almost all the solids.
- To provide maximum pollutant removal for all constituents, a width (in direction of flow) of 26 feet is required.
- Vegetative cover should be at least 80% to reduce the concentrations of pollutants in runoff. Best performance is obtained where coverage approaches 100%.
- Pollutant removal in grassy shoulder areas has been observed in several studies with a variety of vegetation, so no special mixture is required as long as the soil on the roadside is adequately stabilized.

Some maintenance of grass shoulders is required to maintain the water quality benefits. Routine mowing and litter removal activities at the test sites were sufficient to provide the documented water quality benefits. Recommendations include:

- Grass height and mowing frequency may have little impact on pollutant removal; however, the standard mowing schedules in Austin and College Station were employed during the study and the resulting performance of the filters was positive. Consequently, mowing may be necessary only once or twice a year for safety or aesthetics.
- Trash tends to accumulate in vegetated areas, particularly along highways and when grass is high. The need for litter and debris removal is determined through periodic inspection, but litter should always be removed prior to mowing.
- Any substantial erosion observed during routine maintenance activities should be repaired and the area re-vegetated to maintain water quality benefits and protect the roadway embankment, as well as for safety purposes.
- Performance of grass shoulder approaches maximum when the vegetation cover is near 100%. Herbicide application could kill all vegetation cover and leave the bare ground uncovered. Special care in applying herbicide is needed.

For More Details...

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The research is documented in the following reports:

0-4605-1 Pollutant Removal of Vegetated Highway Shoulders

To obtain copies of a report: CTR Library, Center for Transportation Research,
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