Research Note

Washington State Department of Transportation

Eastern Washington Steep Slope Research for Management of Highway Stormwater

From the WSDOT Research Office
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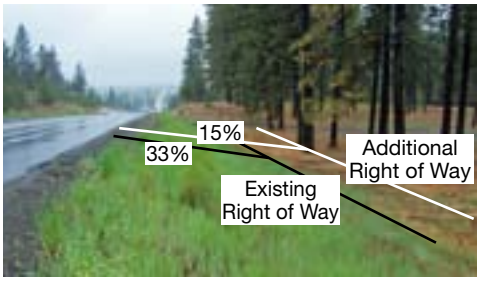
Vegetate Filter Strips (VFS) and dispersion, are sloped vegetated land areas known as best management practices (BMPs) used to manage stormwater. The above picture shows these LID approaches located along the highway embankment.



Where embankment slopes were greater than 15%, the roadway footprint would need to be flattened and may result in the purchase of additional right of way.

Erosion classification, starting in the upper left corner and going counter clockwise: none, low, medium and high.

What Problem are We Solving?

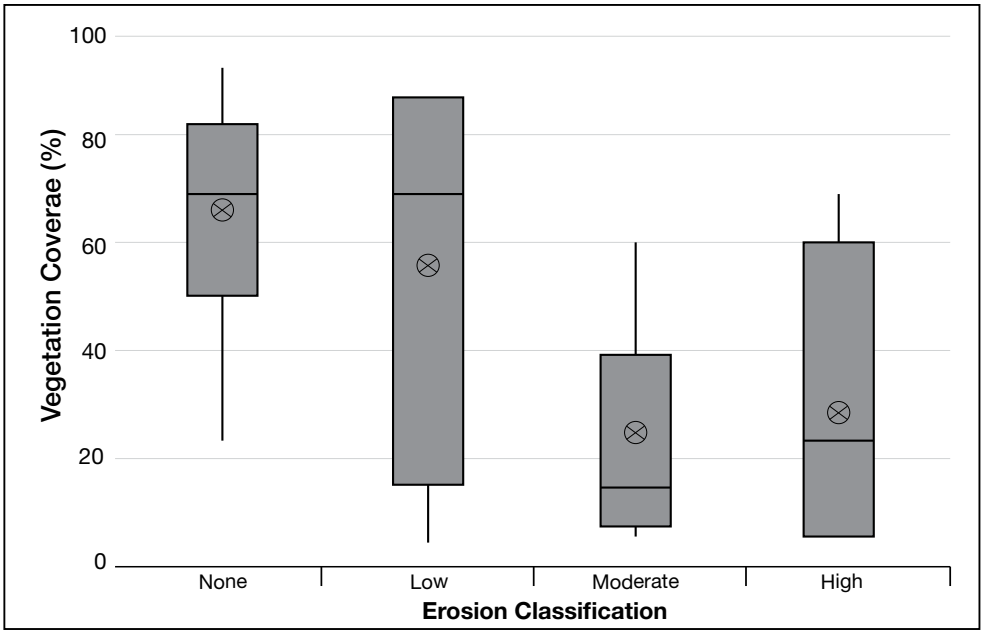
Stormwater runoff is generated when precipitation from rain or snow melt, flows over highway surfaces, accumulating vehicular pollutants. The Clean Water Act requires stormwater management of discharges from highways through the use of best management practices (BMPs) which are effective methods for removing pollutants (runoff treatment) and reducing stormwater volumes (flow control) so adjacent waterbodies are protected. In addition, new regulations require a low impact development (LID) approach to stormwater management which use the sites natural features to mimic the pre-developed hydrology to maximize infiltration, evaporation, and transpiration. Highway embankments can provide an ideal location for integrating LID BMPs; specifically vegetated filter strips (VFS) and dispersion, because they allow stormwater management of highway runoff close to the source where it would naturally fall, dispersing through vegetation, and mimicking the natural hydrological variations. Locating VFS and dispersion along the embankment also has the desirable effect of reducing the spread of noxious weeds and promoting indigenous grasses. This approach to combine stormwater management and roadside vegetation management means reduced costs to the public.

However, the design criterion at Washington State Department of Transportation (WSDOT) as well as many other agencies, limits embankment slopes to 15% maximum when used for stormwater management. The theory is that slopes steeper than 15% might concentrate the water flow, encourage water to channelize, and create conditions that may lead to the erosion of the embankments.

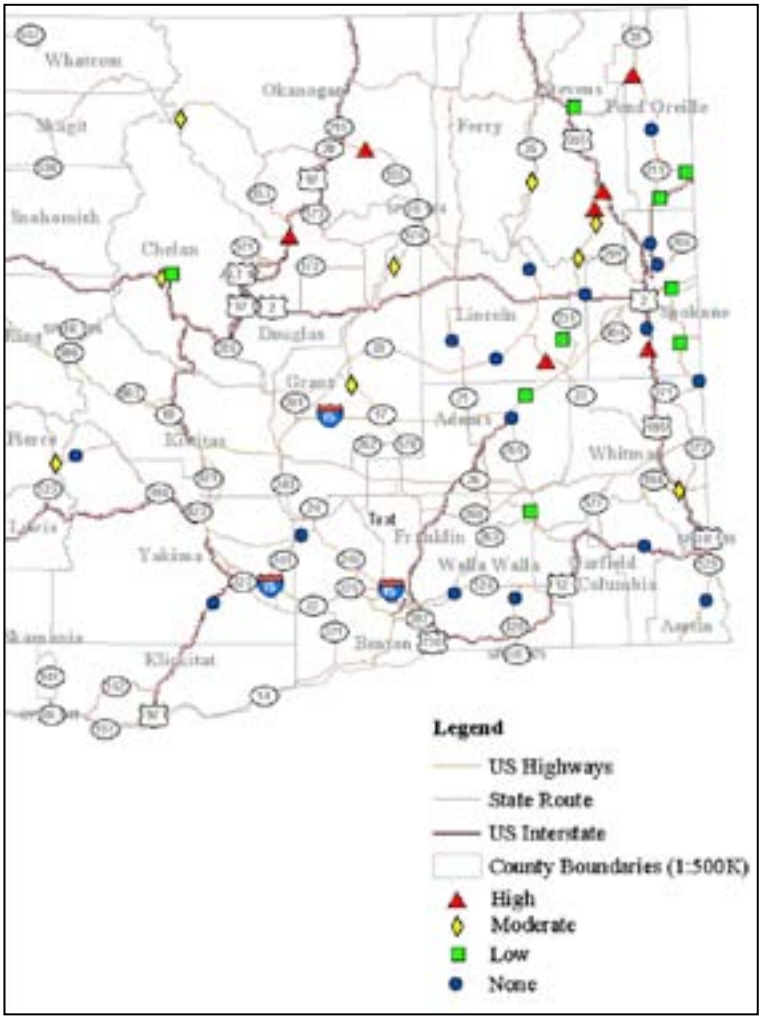
This design criterion can present a challenge to WSDOT because highway embankments can be constructed without vehicle safety barriers on slopes as steep as 33%. Locations where vehicle safety barriers are not required are ideal for dispersion and VFS. In addition, these locations are ideal for LID approaches to managing stormwater along the embankment. When VFS or dispersion is required on slopes greater than 15%, embankments need to be flattened and the roadway footprint expanded. This sometimes results in additional right of way (ROW) acquisition as well as additional construction and ecological impacts from the expanded embankment. While studies have shown that VFS and dispersion areas can successfully meet runoff treatment and flow control goals on 33% slopes, limited research was found that evaluated the site characteristics of steeper slopes that support stable embankments (without erosion) when used for stormwater management.

What We Did

The objective of this study is to evaluate whether embankment slopes steeper than 15% slopes maintain sheet flow for VFS and dispersion BMPs. In an effort to evaluate a design criteria, for both VFS and dispersion, that aligns with the 33% highway embankment limit, 45 sites in Eastern Washington were inventoried to determine the specific site characteristics that contribute to concentration of highway runoff on slopes steeper than 15%. Site selection was based on evaluating embankment slopes steeper than 15%, both with and without the presence of erosion. Another consideration in site selection was to develop an inventory that included a range of site characteristics representative of those found in eastern Washington such as: mean annual precipitation (MAP), various soil types, and vegetation coverage.



The statistical analysis indicated sites with a low percentage of vegetation coverage had the strongest correlation to sites with erosion.



Site characteristics were collected at 45 sites across Eastern Washington during the summer of 2007. The map above shows the site locations along with the corresponding erosion classification.

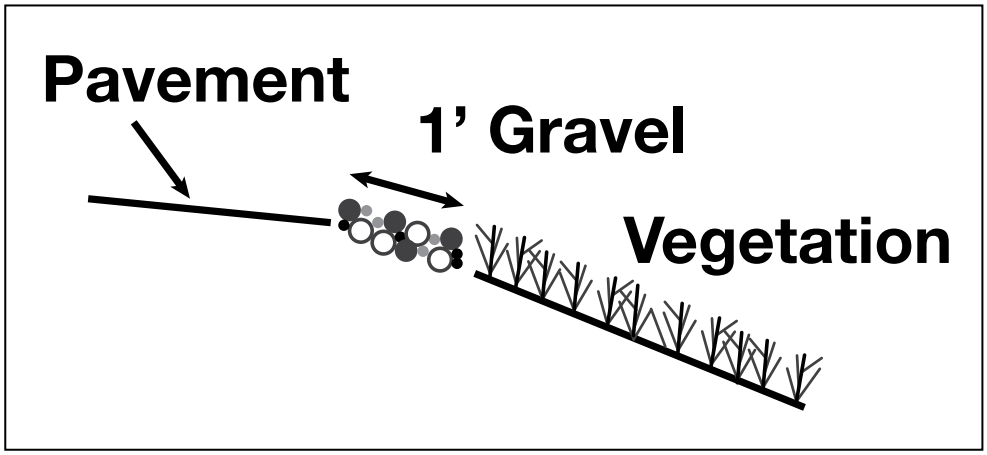
What We Learned

Based on a statistical analysis of the site characteristics, the embankment slope alone was not considered statistically significant for erosion severity compared to other site characteristics. Instead, low vegetation coverage and a high percentage of sand had the strongest correlation to erosion severity. In addition, observations at the sites noted imperfections due to normal aging of the edge of pavement which may encourage channelized flows.

What the Researchers Recommend

Based on these findings, the researchers recommend a modified design criteria for VFS and dispersion BMPs allowing embankment slopes up to of 33% when vegetation can be established. In addition, channelized flow from edge of pavement variations can be prevented by locating gravel level spreaders between the pavement edge and the VFS and/or Dispersion BMP.

Normal highway aging at the Edge of pavement (EOP) also appears to contribute to erosion along embankments. While these variations cannot be predicted, locating gravel level spreaders between the highway and embankment may prevent EOP from contributing to erosion.



Locating gravel level spreaders between the pavement edge and VFS and/or Dispersion BMP can prevent channelized flow from EOP conditions.

Summary of Implementation

This research was presented to the Washington Department of Ecology (ECY) in the fall of 2011. ECY accepted the research recommendations to modify the BMP to allow VFS on slopes up to 33% and the WSDOT 2011 Highway Runoff Manual was modified to reflect these changes. This change means that these BMPs will be used at many existing and proposed locations in both eastern and western Washington without the additional cost to flatten the roadway footprint and/or sometimes widen the ROW to accommodate this. Not only do these BMPs satisfy regulatory requirements for stormwater management but also align with WSDOT roadside management goals which require the embankment to be vegetated to reduce the spread of noxious weeds. By meeting both roadside management and stormwater requirements in the same location costs are reduced for Washington taxpayers.

Contact Information

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