Appendix C

Research Proposal Template

Roads & Highways Monitoring Committee

Subgroup of the Stormwater Working Group

1. RESEARCH PROPOSAL TITLE

The Effectiveness of Ditch Water-Quality Enhancements for Pollutant Removal from Rural Roads

2. RESEARCH PROBLEM DESCRIPTION

Stormwater runoff has been identified as the single most significant source of pollution in Puget Sound and a major environmental stressor in other areas of Washington State. Jurisdictions across the state are under increasing pressure to manage stormwater discharges from roads and highways. Finding effective, low cost best management practices (BMPs) that can be broadly applied to treat stormwater runoff is a priority.

In rural areas, roadside ditches function as the primary conveyance for stormwater runoff. Currently, these ditch systems are not designed to provide water-quality (WQ) treatment of stormwater road runoff. This existing conveyance network appears to be a significant missed opportunity to treat stormwater from roads and reduce downstream pollutant loads.

Based on current literature (see section 4 below), Kitsap County has developed a Roadside Ditch WQ Enhancement Manual. The various techniques and methods identified in this manual would be tested and their effectiveness evaluated.

ftp://kcwppub3.co.kitsap.wa.us/pw/sswm/Kitsap_Roadside_Ditch_WQ_Enhancement_Plan.pdf

3. RESEARCH OBJECTIVE

Evaluate treatment performance of roadside ditches modified for WQ treatment in rural areas.

_√__*Effectiveness* ____*Source Identification* ____*Status & Trends*

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY

King County, 2011. In-Line Ditch Stormwater Treatment BMP Program Final Report.
This study explores the use of ditch BMPs to promote storage, treatment and infiltration of stormwater within the existing ditch network. The BMPs were designed to function within the constraints of road engineering and safety standards. Each BMP comprised a treatment cell encapsulated by a modified rock check dam placed in a roadside ditch. The treatment cell contained compost for water quality treatment. Together, the treatment cell and rock check dam were designed to decrease storm flow energy and volume via ponding and infiltration; and improve water quality via settling, adsorption and filtration.
Water quality benefits were seen as modest decreases in pollutants including TSS, TKN, total metals (arsenic, chromium, copper, lead, nickel, zinc), dissolved metals (copper, lead and zinc), PAHs, and turbidity. Water quality benefits were achieved by detention, adsorption and filtering of stormwater through a filtration medium (coarse compost) placed directly into a treatment cell within the BMP. It is unclear how much of these benefits are due directly to filtering and/or adsorption and how much is due to the water quality benefits obtained through stormwater detention by the BMP structure. Limitations in the effectiveness of water quality treatment include the amount, or cross-sectional area of compost that could be placed securely in the ditch relative to the volume of stormwater that the ditch carried. These BMP designs would be best utilized by placing them throughout an entire section of ditch, thereby minimizing the opportunity for pollutants and solids to mobilize.

Colwell, S, et. al. 2000. A Survey of Ditches Along County Roads for their Potential to Affect Storm Runoff Water Quality. Center for Urban Water Resources Management.

A systematic survey of ditches was conducted to evaluate the water-quality performance of roadside ditches. Problems that are detrimental to water quality include: little to no vegetation, standing water, substantial siltation, yard waste, mowing near ditches land leaving grass clippings in the ditches, and steep side slopes with a maximum ratio of 2:1. The single most important factor in achieving runoff treatment and preventing ditches from becoming sediment sources is through uniform cover by fine, dense vegetation. Deposits of sediments, cut vegetation, litter, or a combination to these were the leading causes of reduced health on the ditch beds, with drought next. In persistently wet areas, planting wetland herbaceous species is the most cost-effective strategy. Continue to use U-shaped ditch profiles. Be aware of erosive velocities that will develop if ditches are placed on slopes steeper than four percent. Erosion at a steeply sloping point inlet can be avoided with an energy dissipater. Make slopes no steeper than 3:1. Attempt to avoid standing water by careful grading to avoid depressions in ditch beds and compaction of the soil. In ditches having a surface or subsurface base flow source, determine if conditions will support wetland herbaceous plants.

Minnesota Board of Water and Soil Resources. 2006. Public Drainage Ditch Buffer Study

A fundamental purpose of this study was to assess the implementation of required grass buffer strips along public drainage ditches. Grassed channels and buffers along drainage ditches provide benefits in four primary categories: sediment and erosion control, water quality control, ecological and habitat benefits, and economic benefits. This study conducted a literature review of the benefits of grass buffers along watercourses and inferred the benefits of narrow buffers along drainage ditches. Sediment and Erosion Control Grassed channels and buffers can reduce erosion and control sediment through four mechanisms:

- By trapping sediment through the use of dense grass stems.
- By reducing the velocity of surface flow. This allows sediments to settle out of water and be
- deposited before they reach the channels.
- By stabilizing ditch banks, preventing soil detachment.
- By moderating water flow in the ditch during storms, effectively reducing bed and bank scour.

Grass buffers contribute significantly to water quality control by reducing the concentration of contaminants and pollutants in several ways, including:

- filtering out sediment and other particulate-bound pollutants/contaminants and decreasing
- the concentration of pollution in surface flow before it reaches a water course;
- increasing the infiltration rate within the buffer zone and consequently reducing surface
- runoff; and
- providing suitable areas for allowing biodegradation or biochemical circulation to occur.

Benefits of Narrow Grass Buffers Along Drainage Ditches include:

- stabilizing ditches;
- trapping of water-borne sediment and trapping of wind-born sediment; and
- improving water quality through trapping of sediment and microbes and recycling of nutrients.

Narrow grass buffer provide ecological and habitat benefits. The potential economic benefits of grass buffers are due to decreased ditch maintenance and cleaning costs.

Elfering, J, and Biesboer, D. 2003. Improving the Design of Roadside Ditches to Decrease Transportation-Related Surface Water Pollution.

The results suggest that properly designed, short (130-foot) vegetative strips and swales, which include peat and rock check dams can substantially reduce pollutant levels from the stormwater roadways. The objectives of this research project were to perform field tests on typical Minnesota vegetative swale and determine the pollutant removal efficiency under different storm conditions and to modify the swale with a simple rock and soil media system to limit non-point source pollution in stormwater. In analyzing the storms, it was evident that a 130-foot vegetative swale was effective at reducing total suspended solids and total phosphorus given an adequate vegetative cover. In conclusion the model vegetated ditch and check dam was found to reduce pollution in the swale by as much as 54 percent. The check dam was able to compensate for the lack of vegetation during these seasonal changes. The average removal efficiency of total phosphorus was 54 percent and ortho-phosphorus was 47 percent. Results show that filter used by MnDOT and stormwater managers will be more effective at mediating stormwater runoff only if they avoid laminar flow. Laminar flow can occur when you have large pore sizes. Smaller pore soils, such as peat soils, were able to retain the anion tracer throughout the 30 minute sampling period and indicate the ability of the peat to retain potassium bromide.

Reiser, M. and Younge, D. 2005. Application of a Simplified Analysis Method for Natural Dispersion of Highway Stormwater Runoff
Natural dispersion runoff infiltration performance was evaluated by utilizing simulated rainfall/runoff data collected using a field-scale rainfall simulator coupled with a numerical model to study the effects of slope length, angle, and impervious contributory area on natural dispersion applications. The use of Low Impact Development (LID) BMP design in lieu of traditional stormwater treatment is beneficial because it is more aesthetically acceptable by the public and also because of its ability to reduce maintenance needs and increase groundwater recharge. Comparisons between LID area slope and runoff are not conclusive and vegetative cover effect is the only considerable variation. The LID areas on the 3:1 and 4:1 slopes outperformed the 6:1 slope. This can be attributed to the relatively high micro topographic and micro porous characteristics.

Schneider, R. 2007. Roadside Ditch Management to Reduce Stormwater Runoff, and Mitigate Floods and Droughts, presented to Delaware River Basin Commission.
Four recommendations for improving the rainwater runoff flow path.

- Don't scrape ditches and leave them exposed to erosion during storm events, instead use hydroseeding immediately after ditching early in the season to allow sufficient growing time. If scraping is necessary, do it in patches with vegetated strips left downstream to capture sediments.
- Disconnect ditches from streams and use infiltration techniques for groundwater recharge.

Schneider, R. 2008. Basic Guidelines for Successful Roadside Ditch Management. Presented at Cornell Local Roads Conference.
Guideline #1: Create and maintain a shallow, gently sloping ditch that will be easier to maintain by mowing. This will be safer for traffic and is less likely to erode. Don't over ditch. 18-24 inches is plenty deep enough to carry away storm water. Avoid V-shaped ditch where the bottom is easily incised and starts the erosion process.
Guideline #2: Plan ahead to prevent erosive water flows. Consider drainage areas upslope that may contribute to erosive flows. Use check dams to slow velocities.
Guideline#3: Whenever possible, mow ditches regularly instead of scraping.
Guideline #4: Minimize erosion of gravel and rocks that move as bed loads into streams.
Guideline#5: Disconnect ditches from streams and use infiltration basins or detention ponds that allow for groundwater recharge.
Guideline#6: Reduce transfer of runoff from land to ditches.

Schultz, D. Current Status of Vegetation Management in Roadside Ditches and Stormwater Management Facilities. Center for Urban Water Resources Management.
This report compiled empirical evidence to evaluate the effects of different maintenance practices on the pollutant-removal capabilities of the facilities. The literature reviewed identified the following in relation to vegetation management and pollutant removal. Suitable filter grass species should (a) have a deep root system, (b) have a high stalk density, (c) be insensitive to submergence and droughts, and (d) be able to grow through sediment coverage (Van Dijk et al., (1995) refer to a 1967 paper by L.G. Wilson). In contrast, a study conducted in Florida in 1984 came to the conclusion that bare earthen (i.e., unvegetated) swales were more effective than grassed swales in the removal of heavy metals due to the higher surface area available for adsorption (Harper et al., 1985; Yousef et al., 1985). They suggested that the optimal strategy for increasing contact and residence times consisted of establishing a cover vegetation for erosion control, keeping the vegetation viable through removal of clippings, and planting a slow-growing species with low maintenance needs if possible.

Appendix C

5. Geographic Scope and Urgency of Research

How broadly will the results of this research apply?

__X__Nationally ____Pacific Northwest ____WA Only ____Eastern WA ____Western WA ____Puget Sound Basin

How quickly will you need the results of this research?

____ASAP ____Within 6 months ____Within 1 year ____Within 2 years ____Within 5 years __X__Ongoing

6. Conceptual Research Approach

A conceptual model for looking at the water quality of runoff from a rural road with modified ditches, shoulders, and/or embankments could be:

roadway runoff WQ = deposition by traffic + atmospheric deposition + offsite runoff + road surface degradation – removal of pollutants on roadside areas with treatment – retention on road surface

The sources of contaminants in this model are 1) deposition by traffic, 2) atmospheric deposition, 3) surface water runoff from adjacent land and 4) degradation of the road surface. The mechanisms by which contaminants are removed from the road are 1) runoff, 2) blow-off/ spray-off, and 3) sweeping.

A study of roadside ditch WQ enhancements on rural roads might not attempt to quantify the sources of roadway contaminants, but would rather focus on determining the relative importance of each of the contaminant removal mechanisms. A treatment/control study approach could be used, where treated and untreated sections of roadway would be monitored. Of the three mechanisms for contaminant removal, measuring the mass of contaminants removed would be the most straightforward and has been accomplished by past studies.

Measuring runoff water quality would require sampling runoff from sections of the paired roadways during storm events. Collecting a sufficient number of representative samples to characterize runoff water quality and detect a difference between the treated and untreated roadway sections could be technically challenging, but existing stormwater monitoring protocols would apply.

7. ESTIMATED COST AND TIMING (Optional)

Cost would vary depending on the scope of the research.

8. CONTACT INFORMATION

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