Stormwater Action Monitoring

Project Title

Bioretention Hydrologic Performance Study, Phase 1

Effectiveness Study

Lead Entity

City of Bellingham Public Works - Natural Resources

Partners

Cities of Bellingham, Bellevue, Issaquah, Mill Creek, and Poulsbo; Thurston and Pierce Counties; Clear Creek Solutions; Taylor Aquatic Science; Associated Earth Sciences; Aspect Consulting; and Raedeke Associates.

Collectively improving stormwater management

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation. SAM's goal is to improve stormwater management to reduce pollution, improve water quality, and reduce flooding. We do this by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Questions about SAM? Send an email to SAMinfo@ecy.wa.gov

Study goals

The Bioretention Hydrologic Performance Study, Phase 1 is the first field-scale regional verification of the performance of early (pre-2012 design) bioretention facilities in Western Washington. The goal of the study was to evaluate how well the modeled expectations for stormwater flow control actually match observed and measured real-world performance. From this assessment, we identified elements of the site designs and performance constraints that should inform the design, model, and review processes to ensure more efficient and predictably performing facilities.

Stormwater management problem

While the use of bioretention facilities in new and re-development is increasing rapidly, there has been little formal scientific assessment of the hydrologic performance of locally-constructed facilities. As population grows and developable area is increasingly scarce, and as natural stream channels remain vulnerable to stormwater runoff, local governments need evidence that these facilities are efficient and effective for protecting water quality in receiving waters. The first step is to confirm that the models, design guidance, and baseline assumptions result in functional facilities during seasonal variations and throughout their expected life cycles.

Project findings

Ten existing bioretention facilities were selected for hydrologic evaluation. We evaluated their performance using a multi-disciplinary approach. Findings include:

Geotechnical and Soil Conditions

Site-specific geotechnical or hydrogeologic data was lacking for early bioretention facilities. Most of the native soil infiltration results were from adjacent geotechnical work. Infiltration rates for subsurface soils, typically outwash soils, were significantly greater than expected in about half the cases. Bioretention soil texture was coarse, resulting in greater infiltration rates than would be expected under the current specifications.

Site Design and Hydrologic Performance

Early bioretention performed better than expected and beyond safety factors during the study. It is plausible that some of the design mis-steps (not getting geotechnical information or getting coarser than modeled soil media) masked design errors or incorrect assumptions. The Western Washington Hydrology Model (WWHM 2012) provided accurate representation of observed hydrology at the sites including the ponding and groundwater response. Early bioretention designs used a variety models that adequately represented these bioretention facilities. Modeling problems, when found, were due to misrepresentation of the bioretention facility using a stormwater pond or gravel trench in the original model set-up.

Vegetation Survival and Establishment

Bioretention soils, and often native soils, drain rapidly. Plants should be drought tolerant, limiting the applicability of wetland species. Shrub species were surviving well. Herbaceous species are less adaptable and some species depended on irrigation. Multiple herbaceous species in a site design tend to transition to a less diverse plant community, due to conditions that are often drier than anticipated during the summer. Recurring problems include plant die-off, invasive species, having to replant cells, and greater maintenance needs than resources allow.

Recommendations

Key recommendations to improve bioretention performance include:

For jurisdictional designers/engineers/landscape architects

- Conduct observations during facility construction to confirm subsurface geologic and groundwater conditions.
- Have inspectors confirm contributing areas and overflow elevations on site.
- Improve plan review to adequately incorporate geotechnical recommendations.
- Select plant species that are consistent with each other for growing success (e.g., ensure that shrubs will not excessively shade herbaceous plants).
- Simplify the planting plan and match institutional or residential owners' needs and commitment to maintenance.
- Include a maintenance schedule and contingency plans in the bioretention design specifications.

For scientific agencies/Department of Ecology:

- Consider updating WWHM 2012 to include multiple soil layer depths, a leaf litter layer, and to set default evapotranspiration rates based on vegetation types.
- Conduct sensitivity analyses using WWHM 2012 to determine the magnitude of effect of infiltration rate variability, contributing drainage area, and use of regional rainfall records on facility performance.

Why does this study matter?

This study verifies that older bioretention facilities perform to modeled expectations for stormwater flow control. Over time, this performance appears to persist despite localized changes in vegetation, soil structure, and/or contributing area. The few facilities that were not performing entirely as expected also provided valuable lessons to include in the study recommendations.

Using the data collected from this study and the professional assessments and recommendations based on those data, we can make improvements to technical guidance, design methodologies, and review processes that govern the use of bioretention. As a result of this study, these changes can be implemented to ensure that future bioretention systems are designed, installed, and maintained to maximize water quality protection.

What should we do with this information?

Stormwater managers now have the evidence that early generation bioretention facilities generally perform as expected via WWHM 2012 to control stormwater runoff. Permittees should inspect sites for short circuited flow paths. When designing and building new bioretention facilities, designers should obtain site-specific information on infiltration rates and develop more drought tolerant planting plans.

What will Ecology do with this information?

Ecology will update the manual and encourage regional partners not to use wetland-obligate species when designing bioretention facilities. Ecology will consider updates to the evaporation rates in WWHM 2012. However, creating a leaf litter layer in the model is not likely at this time. Ecology looks forward to the results of Phase 2 of this study, which will evaluate hydrologic performance of current (post-2012) bioretention facilities.

For more information

Go to www.ecology.wa.gov/SAM and search for bioretention hydrologic performance.