**1. Title of the proposed study:** Effectiveness of bioretention in reducing flows and pollutants

**2. Topic and question addressed (must be on the list provided in Attachment A):**

*Topic:* LID: Flow and pollutant reduction benefits to receiving waters

Questions:

1) How are collective installations of stormwater retrofits working to protect receiving waters at receiving water scale?

**3. Lead entity and partners expected to be involved:**

King County (lead)

Partners:
City of Federal Way

**4. Abstract (200 words max):**

Bioretention areas, including rain gardens, are increasingly recognized as viable components of stormwater management. However, there is a need to document the effectiveness of these facilities in the field within the Western Washington region. This monitoring study will measure the benefits to municipal stormwater flow quantity and water quality from treatment through large rain gardens. The City of Federal Way has finished construction and is now planting native plants in two new rain gardens that will treat stormwater runoff from a heavily developed, commercial 23-acre drainage basin near SR99. The rain gardens were designed to allow for effectiveness monitoring but currently, the City has limited funding for monitoring. These large-scale rain gardens have been engineered such that we can quantify the flow and contaminant loads entering and leaving the system, thereby accounting for any change in flow and water quality across a variety of storm events. The treated stormwater will flow into Hylebos Creek, allowing for monitoring of potential benefits to this receiving water body. This study will provide data to demonstrate the potential effectiveness of bioretention systems in a commercial drainage basin, and will inform future rain garden design and monitoring studies.

**5. Approach to answer the question (300 words max):**

This study is designed to measure flow and water quality of stormwater entering and exiting the rain gardens as well as of stormwater leaving the site and entering the North Fork of West Hylebos Creek. The rain gardens in Federal Way are constructed to allow access at the necessary points in the system needed for continuous flow monitoring and sampling from each of the two rain gardens (e.g., untreated water in the inflows, treated water in the underdrains, and water in the receiving stream, Hylebos Creek). To quantify water quality benefits, we anticipate analyzing samples for turbidity, temperature, metals, nutrients, other conventionals, PAHs and PCB congeners. We will also collect water from the inflow pipes, underdrains, and Hylebos Creek for toxicity testing to measure the water quality benefit of treatment to organisms.

We anticipate installing flow meters for continuous flow monitoring and sampling 5-8 storms per year, at all the inflow/outflow points mentioned above (5 sampling points in all). Depth gauges would also be installed at the overflow points in both rain gardens to assess how frequently and under what storm conditions the rain gardens overflowed. Sampling would begin as soon as possible to allow for some collection of baseline data for Hylebos Creek before treatment of stormwater through the new rain

gardens begin. We will sample for three 3 years starting in Fall 2014, to allow adequate time for sample analysis, data analysis and reporting in the fourth and final year of the grant. Comparison of changes in flow, water chemistry and toxicity at inflow and underdrain points will demonstrate measurable improvement in a working rain garden treatment facility.

**This question can be answered in: ____ less than 5 years; __X__ 5-10 years; or ____ >10 years**

**7. Monitoring sites and locations, or existing data sources to be evaluated**:

City of Federal Way newly constructed two rain gardens for treatment of stormwater runoff from commercially developed drainage basin. The rain gardens were constructed such that inflows and outflows can be accounted for in each rain garden, and flow weighted water samples can be collected. The two rain gardens received water from the same commercial basin (i.e., water from a single pipe is diverted into the two gardens simultaneously), but the gardens are somewhat different in their size and shape and in the vegetation that is being planted. These two gardens therefore give us a unique opportunity to assess how water from a single drainage is affected by two different rain gardens. Other rain garden projects that allowed for similar sampling could be added for comparison.

**8. Intended outcome(s) of the study that would inform stormwater management programs and practices, including expected improvements to sediment or water quality, habitat or biota**:

This study will provide a greater understanding of the measureable benefits from rain garden treatment of stormwater in a field setting using a facility designed by a Western Washington permit holder. The rain gardens were designed according to the specifications in the Rain Garden Handbook for Western Washington (WSU, 2007), and because of this, monitoring data related to effectiveness should inform other rain gardens designed according to the established specifications. Data from large-scale rain gardens like these are especially valuable, because these are increasingly being included in retrofit designs in commercial areas. Stormwater runoff from these basins is often of higher volume and more contaminated than runoff that is treated by smaller, residential rain gardens. Understanding the effectiveness of these larger rain gardens in reducing peak flows and reducing contaminant loads is critical for informing future designs and in assessing how these may influence receiving water bodies. Our data will simultaneously address questions regarding flow, water quality and toxicity for a variety of storms.

**9. In less than 500 words, describe what is known about the effectiveness of this stormwater management practice from studies in Puget Sound and elsewhere? Make an explicit connection to the white papers at http://www.awcnet.org/TrainingEducation/StormwaterProgram.aspx, also linked under "Synthesis of findings of Effectiveness Study Literature Review" at http://www.ecy.wa.gov/programs/wq/psmonitoring/swgreports.html**:

Individual bioretention areas have been found to be quite effective in reducing flow and pollutants (reviewed in LID white paper). Rain gardens, among other relatively inexpensive and small scale LIDs (e.g., grass strips, swales), have been found to be particularly effective in reducing flows (LID white paper). Rain gardens with underdrains have been found to reduce peak flows during small and medium storm events, but are less effective during large storm events when soils are saturated. Understanding how rain gardens function in the Pacific Northwest, with our often-continuous storms, has been highlighted as a data gap that this study will address.

Rain gardens have also been found to be effective in reducing pollutants (TSS, metals, and some nutrients), although fewer data exist for other compounds of concern in stormwater including PAHs and PCBs. The reductions in flow are often highly correlated with reductions in TSS and other contaminants,

and therefore the literature suggests rain gardens will be most effective at reducing concentrations during small and medium storm events, or when there is minimal if any overflow. There are some suggestions that soil type, amendments, and plants can affect the initial and potential long-term effectiveness of contaminant removal. The Federal Way site has used the standard soil mix recommended by Ecology and WSU (Rain Garden Handbook for Western Washington, 2007 and 2013), and native plants, and will therefore be a good site to assess how current recommended soils and plants perform in large rain gardens.

**10. Expected duration of the project:** 4 years

**11. Approximate cost**: $ 500,000

**12. How would the findings of this study best be shared with stormwater practitioners?**

Project website, SWG meetings, report

**13. Other information**:

**14. Your name, email address, and phone number**:

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**Attachment A**

Effectiveness study topics and associated questions prioritized by the Stormwater Work Group

No priority *order* is given for these topics of interest

June 2013

| Topic | Recommended questions for 2014-2108 RSMP effectiveness studies |
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| Source control: temporary erosion control performance and inspections | • Conduct a study of collective BMP performance in meeting water quality standards under field conditions in western WA. Identify situations where approved plans are not being followed versus situations in which plans are not adequate. Combine this with an inspection study.<br>• What frequency of construction erosion and sediment control inspections are most effective for achieving compliance with codes/ordinance requirements at new development and redevelopment project sites? Gather professional knowledge. Look at balance of benefits of pre-, during-, and post-rainfall inspections to confirm implementation of CESCL plans and prevent, identify, and respond to problems. |
| Source control: inspections of existing sites | • What is the optimum frequency of inspections to maintain the functionality of stormwater treatment and control facilities and ensure the proper use of source control BMPs at businesses?<br>  ○ Which is more effective for specific high value BMPs: focusing on the property owners or focusing on the business owners, or a combination of the two?<br>  ▪ Target both structural and operational BMP types, and situations where a business owner is and is not cooperative and willing.<br>  ○ Which required BMPs were implemented based upon follow up inspection? Which optional BMPs were installed based upon follow up inspection?<br>  ○ What were the primary barriers to not adopting or installing BMPs?<br>  ○ Address the connection between in-person visits and source control BMPs, and identify situations where technical assistance and/or follow-up inspections are needed to ensure required BMPs are implemented.<br>  ▪ Gather data about percent compliance. Partner with LSC to do this study.<br>• Are stormwater source control inspections more effective if combined with other types of inspections? How can coordination of inspections be improved or better organized regionally for referral of issues to the correct entity? |
| O&M – Pollution Prevention: Catch basin inspections | • Analyze/synthesize the catch basin inspection data previously collected by Phase I and some Phase II permittees to help permittees determine individual inspection frequency needs to comply with new permit requirements based on permittees' known areas of concern (and relative unconcern). |
| Low Impact Development (LID): Flow and pollutant reduction benefits to receiving waters | • How are collective installations of stormwater retrofits working to protect receiving waters at receiving water scale?<br>  ○ Look for opportunities to measure current condition and monitor receiving water after retrofits are applied. Focus on developed areas. Modeling will be useful.<br>  ○ How can we avoid failures?<br>  ▪ Need better sizing information to avoid facility bypass in moderate rainfall events.<br>  ▪ How do we best ensure that LIDs are not only properly designed but also properly constructed/installed?<br>  ▪ How do you do cost-effective testing for single family infiltration? |

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| | • At what density of LID measures will a developed basin show measurable differences in pollutant loads compared to a similar basin with a lower density of LID measures?<br>  ○ What are the watershed scale effects of LID alone?<br>  ○ What administrative and other actions are needed and effective to achieve more LID implementation?<br>  ○ What are site suitability characteristics for deciding what LID to apply where?<br>• Conduct soil amendment and bioretention soil mix leaching studies combined with plant selection studies for optimum removal of nutrients, bacteria, and metals.<br>  ○ Where and when are nutrient and metal outputs from LID of concern? |
| <u>LID</u>: long-term performance | • What type and frequency of maintenance is needed to ensure the longevity and long-term performance of bioretention facilities? How does maintenance affect function? Is maintenance as critical to function as it is for traditional BMPs? Where is minimal maintenance of LID installations recommended?<br>  ○ Consider a visual inspection and paper approach to this study, rather than measuring.<br>  ▪ Use annual inspection of new systems as a data source.<br>  ○ Study long-term infiltration rates.<br>  ○ Study long-term adsorption capacity. |
| <u>Retrofits</u>: Water quality and habitat benefits of retrofit efforts | • Which combinations of retrofit BMPs and LID in a basin are most effective at reducing stormwater impacts in receiving waters? Perform field studies of existing urban retrofitted BMPs in WWA to assess effectiveness at pollutant removal.<br>  ○ Select a stream in a developed area that is funded for retrofitting and establish baseline conditions with in-stream monitoring of water quality and hydrology. Measure changes in the stream's water quality and hydrology in response to retrofits being implemented.<br>  ○ Conduct a more extensive literature review, build on current work.<br>  ○ Compare model predictions to field data.<br>  ○ Compare BMPs and combinations for specific pollutants.<br>  ○ Develop urban-specific models. |