WSU Puyallup Green Stormwater Infrastructure
Research Program

Comments submitted by:

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Comments for Phase I and II Permit Appendix 1: Minimum Technical Requirements for New Development and Redevelopment

Section 2 Definitions

Pg 5:
Rain Garden – A non-engineered shallow landscaped depression, with compost-amended native soils or a designed soil mix and adapted plants. The depression ponds and temporarily stores stormwater runoff from adjacent areas. Designed to allow stormwater to pass through the amended soil profile. Stormwater that exceeds the storage capacity is designed to overflow to an adjacent drainage system. Refer to the Rain Garden Handbook for Western Washington Homeowners (WSU 2007 or as revised) for rain garden specifications and construction guidance.

We will be completing a minor update to the RG Handbook in Feb 2012 and submitting a proposal for a major update starting summer 2012.

Section 4 Minimum Requirements

Pg 22
13. Protect Low Impact Development BMPs

Add “see Chapter 5: Precision Site Preparation and Construction in the LID Technical Guidance Manual for Puget Sound for more detail on protecting LID integrated management practices”.

Pg 25

3. Bioretention BMP's (See Chapter 7 of Volume V of the SMMWW) that have a minimum horizontally projected surface area below the overflow which is at least 5% of the of the total surface area draining to it. If the short-term native soil infiltration rate is less than 0.3 in/hr, do not use this option unless the roof is classified as pollution-generating impervious surface.

See comment pg 37 for minimum infiltration rates and bioretention.

Pg 37 Bioretention feasibility

Where the field testing indicates potential bioretention/rain garden sites have a short term (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.30 inches per hour. In these instances bioretention/rain gardens serving pollutant-generating surfaces can be built with an underdrain, preferably elevated within the underlying gravel layer, unless other feasibility restrictions apply.

An infiltration rate of 0.3 in/hr will limit the beneficial application of bioretenion in Puget Sound. Bioretention is feasible on sites with infiltration rates less than 0.3 in/hr and adoption of this standard will contradict the intent of the PCHB decision to use LID as a first stormwater management option. The beneficial use of bioretention on soils less than 0.3 in/hr is supported by Dept of Ecology models and project monitoring, specifically:

- Several projects currently in the ground are operating very well in conditions that would not qualify under the potential new guidance. One of those I've measured in detail and data is available upon request.
- Numerous modeling scenarios for various precipitation amounts using WWHM for bioretention on infiltration rates of 0.1"/hr show significant volume reduction (up to 90% at a contributing area ratio of 5:1).
- Seattle has completed modeling bioretention with under-drains and orifices for the Ballard fix and they show significant benefit for CSO reduction with the controlled drains.

On the other hand, the margin of error and risk of problems or failure goes up as site condition become more complex and particularly with low permeability or higher groundwater. So, the question is how do we apply LID to the greatest benefit and manage risk. Instead of an infiltration threshold for feasible or infeasible, I suggest that certain conditions trigger more detailed site analysis and perhaps (likely) certain design criteria. This could follow already existing criteria in Ecology's guidance where conditions (e.g. low permeability) triggers the "detailed site analysis approach" (e.g. monitoring wells, mounding analysis or additional analysis the qualified professional deems appropriate) instead of the "basic site analysis approach".

Additional design requirements could include under-drains with accessible (of course) orifices or control structures as extra insurance. These could be adjusted given observed performance. We already do this…it's nothing new and it provides jurisdictions with tools to manage risk and places an appropriate level of design decision with the designer (just as we do now). While this can be used to define feasible/not feasible, it is really an approach that uses analysis and

design tools appropriate for the setting to get the best benefit where LID infiltration strategies are appropriate (and while that is in many locations it's not everywhere).

Pg 37 Bioretention feasibility

Where they are not compatible with surrounding drainage system as determined by the local government (e.g., project drains to an existing stormwater collection system whose elevation or location precludes connection to a properly functioning bioretention facility).

Delete this criteria. No one knows what it means and will never be defined properly and it is not a meaningful/useful criteria.

Pg 37 Permeable pavement feasibility

In the drive aisles of parking lots as long as runoff is directed to pervious pavement parking spaces.

This criteria is not defensible, is contrary to observed permeable pavement performance and should be deleted. When designed and constructed properly, all permeable pavements perform well for load bearing and surface wear with heavy traffic moving straight ahead and short radius turns. Some pavements have surface wear problems when the vehicle is stopped and the wheels are turned dislodging surface aggregate. Porous asphalt is particularly susceptible to this is in warm weather (although the specifications and performance are improving).

There is no structural or other performance information to support not allowing permeable pavement in the drive isles. There are numerous projects with permeable pavement in drive isles or other higher traffic areas performing well. The surface wear issue (if present) can occur in parking stalls and drive isles as well. If fact, this criteria may promote the inappropriate application of permeable pavement where run-on (with sediment) is directed to permeable pavement shoulders and parking stalls and, as a result, the permeable areas clog prematurely.

Pg 38 Permeable pavement feasibility

Where the site cannot reasonably be designed to have a porous asphalt surface at less than 5 percent slope, or a pervious concrete surface at less than 6 percent slope, or a pervious paver surface (where appropriate) at less than 10 percent slope. Portions of pavements that must be laid at greater than 5 percent slope must prevent drainage from upgradient base courses into its base course.

Delete this criteria and use the subsequent bullet to determine appropriate application on slopes.

Pg 39 Permeable pavement feasibility

Where appropriate field testing indicates soils have a short-term (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.3 inches per hour. In these instances, roads and parking lots can be built with an underdrain, preferably elevated within the base course, unless other feasibility restrictions apply.

An infiltration rate of 0.3 in/hr will limit the beneficial application of permeable pavement in Puget Sound. Permeable pavement is feasible on sites with infiltration rates less than 0.3 in/hr and adoption of this standard will contradict the intent of the PCHB decision to use LID as a first stormwater management option. The beneficial use of permeable pavement on soils less than 0.3 in/hr is supported by Dept of Ecology models and project monitoring, specifically:

- Several projects currently in the ground are operating very well in conditions that would not qualify under the potential new guidance. One of those projects, on subgrade soils with infiltration rates two orders of magnitude lower, I've measured in detail and data is available upon request.
- Modeling scenarios for various precipitation amounts using WWHM for infiltration rates of 0.1"/hr show significant volume reduction.

The margin of error and risk of problems or failure goes up as site condition become more complex and particularly with low permeability or higher groundwater. So, the question is how do we apply LID to the greatest benefit and manage risk. Instead of an infiltration threshold for feasible or infeasible, I suggest that certain conditions trigger more detailed site analysis and perhaps (likely) certain design criteria. This could follow already existing criteria in Ecology's guidance where conditions (e.g. low permeability) triggers the "detailed site analysis approach" (e.g. monitoring wells, mounding analysis or additional analysis the qualified professional deems appropriate) instead of the "basic site analysis approach". Additional design requirements could include under-drains with accessible (of course) orifices or control structures as extra insurance. These could be adjusted given observed performance. We already do this…it's nothing new and it provides jurisdictions with tools to manage risk and places an appropriate level of design decision with the designer (just as we do now). While this can be used to define feasible/not feasible, it is really an approach that uses analysis and design tools appropriate for the setting to get the best benefit where LID <u>infiltration</u> strategies are appropriate (and while that is in many locations it's not everywhere).

Comments for SWMMWW Volume 1 Minimum Technical Requirements and Site Planning

Chapter 2

Pg 2-8

Rain Garden – A non-engineered, shallow, landscaped depression, with compost-amended native soils or design soil mix and adapted plants. The depression ponds and temporarily stores stormwater runoff from adjacent areas. Designed to allow stormwater to pass through the amended soil profile. Stormwater that exceeds the storage capacity is designed to overflow to an adjacent drainage system. Refer to the *Rain Garden Handbook for Western Washington Homeowners (WSU,* 2007 or as revised) for rain garden specifications and construction guidance.

Pg 2-30

Element 13: Protect Low Impact Development BMPs

Add "see Chapter 5: Precision Site Preparation and Construction in the LID Technical Guidance Manual for Puget Sound for more detail on protecting LID integrated management practices".

Pg 2-37

Mandatory List #2

If the short-term native soil infiltration rate is less than 0.3 in/hr, do not use this option unless the roof is classified as pollution-generating impervious surface.

If the short-term native soil infiltration rate is less than 0.3 in/hr, do not use this option unless the hard surface is classified as pollution-generating.

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Appendix I-F

Pg F-2 Bioretention feasibility

Where the field testing indicates potential bioretention/rain garden sites have a short term (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.30 inches per hour. In these instances bioretention/rain gardens serving pollutant-generating surfaces can be built with an underdrain, preferably elevated within the underlying gravel layer, unless other feasibility restrictions apply.

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Pg F-2 Bioretention feasibility

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Pg F-3 Permeable pavement feasibility

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Pg F-4 Competing Needs

Public health and safety standards.

It is very difficult to find LID practices that are in conflict public health and safety standards, and even more difficult to find LID practices that, with minor adjustments, cannot compensate for perceived problems. In fact, there are many cases where the LID approach improves health and safety and conventional stormwater management practices are in conflict with health and safety. This criteria is not necessary, creates unnecessary barriers and if applied to LID should

also be applied to conventional practices. Specific examples of how LID can enhance health and safety and how conventional practices can be in conflict with health and safety are available upon request.

Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.

This can be applied to any infrastructure associated with roads. LID approach/practices should not be called out specifically in this setting and doing so creates unnecessary barriers to LID application.

Comments for SWMMWW Volume 2 Minimum Technical Requirements and Site Planning

Chapter 3

Pg 3-29
Element #13: Protect Low Impact Development BMPs

Add “see Chapter 5: Precision Site Preparation and Construction in the LID Technical Guidance Manual for Puget Sound for more detail on protecting LID integrated management practices”.

Comments for swmmww Volume 3 Hydrologic Analysis and Flow Control Design/BMPs

Chapter 3

Pg 3-72 through 3-89
3.3.5 Site Characterization Criteria
3.3.6 Saturated Hydraulic Conductivity Guidelines

Align LID site characterization guidelines with LID manual (see LID manual).

Pg 3-92
SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer
The base of all infiltration basins or trench systems shall be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the ground water mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the site professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

Include separation criteria for bioretention which is 1 ft or 3 ft depending on contributing area criteria

Pg 3-115
3.4.2 Description
After developing a preliminary development layout in consideration of the procedures outlined in Chapter 3 of Volume 1 and XX of the LID Manual for the Puget Sound Basin, the designer must perform sufficient pilot infiltration tests to confirm the feasibility of proposed bioretention and permeable pavement sites, and to provide a basis for estimating their contribution to meeting the treatment and flow reduction requirements. Testing should occur between December 1 and April 1.

Chapter 2 Site Assessment and Chapter 3 Site Planning and Layout.
Infiltration test procedures provided in Chapter 2 Site Assessment of the LID Manual.

Bioretention/Rain Gardens:
In all cases, it is necessary to perform small-scale Pilot Infiltration Tests (PIT).

Or grain size analysis as outlined in LID manual and SWMMWW?

Pg 3-116
For these native soils below bioretention soils, the variability correction factor, CFv, and the test correction factor, CFt, come into play.

For small-scale PIT in bioretention areas, a test correction factor is not necessary because the test should be sufficiently representative of the smaller infiltration area of the bioretention facility

compared to larger-scale facilities where test variability and associated correction factors are applicable.

Pg 3-117
Permeable Pavement:
For these native soils below permeable pavement, values for the variability correction factor, CFv, and the test correction factor, CFt, should be applied.

Align correction factors with LID manual. From LID manual

Correction factors for subgrade soils underlying permeable pavement installations
The correction factor for in-situ, small-scale pilot infiltration test is determined by the number of tests in relation to the size of the permeable pavement installation, site variability and the quality of the aggregate base material. Correction factors range from 0.33 to 1 (no correction). Tests should be located and be at adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the permeable pavement is located. If used, the correction factor depends on the level of uncertainty that variable subsurface conditions justify. If enough pilot infiltration tests are conducted across the permeable pavement subgrade to provide an accurate characterization or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors) then no correction factor for site variability may be justified. Additionally, no correction factor may be necessary if the aggregate base is clean washed material with , 1% fines passing the 200 sieve. See Table ???: Correction factors for in-situ Ksat measurements to estimate long-term (design) infiltration rates.

If the level of uncertainty is high, a correction factor near the low end of the range may be appropriate. Two example scenarios where low correction factors may apply include:

- Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
- Conditions are variability, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Table ???: Correction factors for in-situ Ksat measurements to estimate long-term (design) infiltration rates

Site Analysis Issue	Correction Factor
Site variability and number of locations tested	CFy = 0.33 to 1
Quality of pavement base material aggregate	CFin = 0.9 to 1

Total correction factor (CFt) = CFy x CFin

Pg C-3

To estimate the runoff reduction benefit from permeable pavements that are modeled using the Permeable Pavement Element in the WWHM, the user must enter an infiltration rate for the native soil. This will require site-specific tests using the methods specified in Section 3.3.6, i.e., Pilot Infiltration Tests or Grain Size Analyses. Ecology is interested in comments concerning whether and which correction factors, as discussed in Section 3.3.6, should apply to the initial infiltration rate estimated for the native soils below permeable pavements. Where a single Pilot Infiltration Test is used to estimate the infiltration rate for one small area (such as a private driveway), a correction for site variablility seems unnecessary. But where multiple pilot infiltration tests are averaged to estimate the infiltration rate for one long facility (e.g. a subdivision road), should a correction factor for site variability be considered in setting the design infiltration rate?

See comments above (pg 3-117).

Pg C-5

Subgrade

• Compact the subgrade to the minimum necessary for structural stability. Use static dual wheel small mechanical rollers or plate vibration machines for compaction. Do not allow heavy compaction due to heavy equipment operation. The subgrade should not be subject to truck traffic.

• Use on soil types A through C.

Refer to guidance in LID Manual pages 169 and 176.

Pg C-5

Base material

• Many design combinations are possible. The material must be free draining. For more detailed specifications for different types of permeable pavement, see section 6.2: Permeable Paving.

o Driveways (recommendation):

☐ > 4" layer of free-draining crushed rock, screened gravel, or washed sand.

☐ < 5% fines (material passing thru #200 sieve) based on fraction passing #4 sieve.

o Roads & Parking lots: The standard materials and quantities used for asphalt roads should be followed. For example:

☐ Pierce Co. cites larger rock on bottom, smaller on top (e.g., 2" down to 5/8"); compacted; minimal fines; 8 inches total of asphaltic concrete and base material.

☐ WSDOT lists coarse crushed stone aggregate (AASHTO Grading No. 57: 1.5 inch and lower); stabilized or unstabilized with modest compaction; meets fracture requirements.

FHWA suggests three layers between the porous pavement and geotextile. Typical layers would be:

Filter course: 13 mm diameter gravel, 25 to 50 mm thick. Stone reservoir: 40-75 mm diameter stone. Filter course: 13 mm diameter gravel, 50 mm thick.

Do not use these guidelines. Refer reader to Section 6.3.2.2 Types of Permeable Pavement in the LID Manual for specific aggregate base material for specific types of permeable pavement.

Pg C-6

For all surface types, a minimum initial infiltration rate of 10 inches per hour is necessary. To improve the probability of long-term performance, significantly higher infiltration rates are desirable.

This is very low…likely too low. Recommend minimum new/placed infiltration rate of 200 in/hr according to ASTM 1701.

Pg C-6

Paving blocks: 6 inches of sand or aggregate materials should fill spaces between blocks and must be free draining. Do not use sand for the leveling layer or filling spaces with EcoStone.

Section 6.3.2.2 Types of Permeable Pavement in the LID Manual for specific aggregate base material for specific types of permeable pavement.

<u>For the design guidelines I would refer reader to Section 6.3 Permeable Pavement and 6.3.2.2 Types of Permeable Pavement. The guidelines in those sections have reviewed and accepted by regional and national experts.</u>

Pg C-6

Acceptance test

• Driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.

• Roads may be initially tested with the bucket test. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 10 inches per hour minimum rate.

Use ASTM 1701 for wearing course infiltration test.

Pg C-7

Maintenance

• Inspect project upon completion to correct accumulation of fine material. Conduct periodic visual inspections to determine if surfaces are clogged with vegetation or fine soils. Clogged surfaces should be corrected immediately.
• Surfaces should be swept with a high-efficiency or vacuum sweeper twice per year; preferably, once in the autumn after leaf fall, and again in early spring. As long as annual infiltration rate testing demonstrates that a rate of 10 inches per hour or greater is being maintained, the sweeping frequency can be reduced to once per year. For porous asphalt and concrete surfaces, high pressure hosing should follow sweeping once per year.

Recommend long-term minimum infiltration rate of 20 in/hr. This allows for 90% reduction of 200 in/hr (minimum new/placed infiltration rate per ASTM 1701).

Pg C-15
7.7.3 Newly Planted Tree Design Criteria

Somewhere in this section refer reader to section 6.4 Urban Trees in the LID Manual for guidelines on siting, soil strategies and tree selection for successfully growing urban trees.

Pg C-18
The comost to aggregate ratio should be 60:40.
• The mix should have a CEC > 5 meq/100 grams of dry soil; 8 – 10 percent organic matter content by dry weight; 2 – 5 percent fines; a minimum depth of 18 inches; a minimum long-term infiltration rate of 1 inch per hour (estimated by applying a correction factor of 2 or 4 –depending upon size of drainage area – to the initial rate), and a maximum initial rate of 12 inches per hour.

OM content of 8-10% is too high. Correct content is 4-8%.

Pg C-19
Bioretention areas can be designed with or without a mulch layer. Mulches should be of shredded or chipped hardwood or softwood and should not exceed XX inches thick.

Mulch thickness is 2-3 inches.

Pg C-22
Custom soil may be made for the bioretention facility. However, those soils must be laboratory tested to meet the following specification:
• CEC > 5 meq/100 grams of dry soil;
• 8 – 10 percent organic matter content by dry weight;

OM content of 8-10% is too high. Correct content is 4-8%.

Pg C-23
Ecology is interested in comments concerning whether and which correction factors, as discussed in Section 3.3.6, should apply to the native soils below bioretention facilities. Where a single Pilot Infiltration Test is used to estimate the infiltration rate for one bioretention device, a correction for site variablility seems unnecessary. But where multiple pilot infiltration tests are averaged to estimate the infiltration rate for one long facility (e.g. alongside the road), or for

multiple facilities that will be cumulatively represented as one bioretention facility for modeling purposes, should a correction factor for site variability be considered in setting the design infiltration rate below the bioretention?

From 6.1.2.1 Determining subgrade and bioretention soil media design infiltration rates of the LID Manual

Correction factors for subgrade soils underlying bioretention areas

The correction factor for in-situ, small-scale pilot infiltration test is determined by the number of tests in relation to the number of bioretention areas and site variability. Correction factors range from 0.33 to 1 (no correction).

Tests should be located and be at adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the bioretention areas are located. If used, the correction factor depends on the level of uncertainty that variable subsurface conditions justify. If a pilot infiltration test is conducted for all bioretention areas or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors) one pilot infiltration test may be adequate to justify no correction factor (see Table ???: Correction factors for in-situ Ksat measurements to estimate long-term (design) infiltration rates).

If the level of uncertainty is high, a correction factor near the low end of the range may be appropriate. Two example scenarios where low correction factors may apply include:

- Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
- Conditions are variability, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

A correction factor for siltation and bio-buildup is not necessary for bioretention area subgrades. Correction factors are applied to the BSM to account for the influence of siltation (see section below on determining infiltration rates for the BSM).

Table ???: Correction factors for in-situ Ksat measurements to estimate long-term (design) infiltration rates

Site Analysis Issue	Correction Factor
Site variability and number of locations tested	CF = 0.33 to 1
Degree of influent control to prevent siltation and bio-buildup	No correction factor required