2009 Stormwater Planter Bench Test Report

Materials Testing Lab and Sustainable Stormwater Management Program

December 2009
Summary. Portland’s Bureau of Environmental Services conducted hydraulic bench tests on six stormwater planters in June 2009. The configuration of the planters was consistent with the requirements of the City’s Stormwater Management Manual although no plants were installed. The purpose of the tests was to document the performance of the systems in relatively extreme conditions, with prolonged wetting and without the soil-binding influence of established plants. After a start-up wetting period, staff monitored the pass-through rates of the planters while enough water was added to keep the soil mass completely saturated. Falling head tests (draw-down tests) were then conducted in four-inch-diameter rings embedded in the centers of the planters, also with the soil in saturated conditions. Changes in soil density, fines content, and settlement were recorded. Each planter was wetted for a total of more than 30 hours over the course of the tests. All of the results from the planter trials exceeded two inches per hour, which is the minimum standard for draw-down in vegetated stormwater management facilities in Portland. In the ring tests, just one of the planters recorded draw-down rates of less than two inches per hour. Soil settlement ranged from 2.4 to 3.1 inches and dry densities ranged from 70-78 pounds per cubic foot in the lower half of the soil profiles at the end of the tests. The fines content of the soil was slightly higher in the lower half of the planters at the conclusion of the tests. In summary, the tests documented substantial declines in pass-through and draw-down rates with continued wetting and settling, but they produced minimal evidence of a risk of sub-standard hydraulic performance in the tested conditions.

1. Introduction

The Bureau of Environmental Services (BES) began researching vegetated stormwater management systems more than a decade ago. Today the systems are used on both private property and as part of public green street projects. A number of the standard configurations for stormwater planters and swales include a layer of drain rock beneath a layer of imported soil. The drain rock increases the storage volume of infiltration facilities, but it’s also used in “flow through” (lined) systems such as planters as part of the collection system at the bottom of the facility.

In 2008 the Bureau revised its soil specification to obtain more consistent results. The previous specification called for a simple three-way mix that occasionally yielded low infiltration rates, most frequently in green street facilities subject to foot compaction. Two inches per hour is the standard minimum for imported soil under the requirements of the City’s Stormwater Management Manual. The new specification limits fines to a maximum of fifteen percent by weight. The setting of that limit was influenced by engineering tests by other organizations showing that in some conditions silt and clay can substantially reduce the permeability of bioretention soils.

Portland’s soil specification requires a minimum fines content of five percent, reflecting the importance of silt and clay for plant health. Plants are crucial to the many functions of vegetated stormwater management systems, including immobilization and transformation of pollutants and retention and infiltration of runoff. Roots promote soil biological activity, stabilization of soil particles in aggregates, and increases in water retention and permeability. Part of the goal in requiring a fines content of between five and fifteen percent is to ensure the imported soil material will support plants throughout the year, including Portland’s dry summer months. Most vegetated stormwater systems are watered for only two years after construction.

Figure 1. Planter cross-section
The Bureau’s specification for the “filter medium” in green street facilities has changed in the last couple of years. The filter medium is the layer between the soil and underlying drain rock. It’s designed to hold the soil layer, preventing movement of soil material into the coarser layer of drain rock. In 2008 the Bureau shifted away from filter fabric as the filter medium in green street facilities because of concerns about the potential for clogging of the fabric. Although filter fabric is still allowed in private facilities, almost all green street facilities now have angular rock aggregate rather than filter fabric between the soil and drain rock.

The tests were an opportunity to document the hydraulic performance of planter systems built with the new soil specification in combination with different filter media. The tests were not a full simulation of field installations: the systems weren’t planted and allowed to mature. The planters also received substantially more water over the period of the tests than they would in typical field installations. The goal was to monitor infiltration rates as the lightly-compacted material shifted and consolidated under the hydraulic loads introduced by the tests.

2. Procedure

The tests were conducted in May and June of 2009 by geotechnical staff at BES’ Materials Testing Lab (MTL). The planters were tested to document the hydraulic performance of systems with soils meeting the City’s 2008 specification for stormwater facilities (SPP01040.14(d)(1); Standard Blend for Public and Private Facilities). The soils were tested in combination with three different filter media.

The soil was installed in two lifts, each of which was hand-compacted with the tamper shown in Figure 4. The systems were then wetted for an extended period prior to the hydraulic tests. The tests included two main components. The first was a series of hydraulic trials in which outflow from the planters was measured while enough water was added to the planters to keep the soils saturated, maintaining a constant head. The second component was monitoring draw-down rates in rings installed in the middle of the planters, also with the soils in saturated conditions. The goal was to simulate conditions that can reduce permeability due to movement of fines and reductions in the quantity and size of pore spaces in the granular soil material.
The six planters were set up specifically for the tests, allowing staff to control a number of factors that are typically strong variables in field installations. Creating uniform conditions, particularly for compaction and wetting, was crucial to the goal of isolating the influence of the different soils and filter media.

3. **Planter and Test Setup**

**A. The Planters**

The six identical planters were open-top polyethylene boxes obtained from a water tank manufacturer. Each box measured 36 inches high by 24 inches wide by 36 inches long. The height of the boxes was adequate to represent the standard cross section of stormwater planters and some green street facilities that include a layer of drain rock. From top to bottom there was 12 inches of freeboard; 18 inches of soil; filter media of variable depth; and 3 inches of drain rock. Figure 1 depicts the standard cross section. The main difference between the cross section of the test planters and field installations was the depth of the drain rock at the bottom of the test planters – facilities with drain rock typically have 12 inches of rock in the base layer.

The planters were as big as logistically feasible in order to limit the influence of preferential flow pathways along the walls. City staff has observed gaps along facility walls in a number of field installations. The gaps appear to be dynamic and the result of expansion and contraction of the soil during wetting and drying cycles. The gaps can allow some of the incoming water to travel more directly to the layer of drain rock, by-passing at least part of the soil column. This short-circuiting has been documented by BES staff during flow tests at the Bureau's test planters at the Water Pollution Control Lab (*Stormwater Facilities Monitoring Report, 2008*).

Parallel one-inch perforated pipes were embedded in the layer of drain rock on the floor of the planter. The three PVC pipes were connected to a single exit pipe, a spigot, in the wall of the planter. The setup was designed to create a free-draining system.

**B. Filter Materials and Soils**

Two different soils, both of which met the 2008 soil specification, were tested in combination with three different filter media. The six planters allowed for a single sample of each combination of soil and filter media (there weren't any replicates).
The three filter layers were as follows.

- Four inches of ¾ inch - 1/4 inch angular washed aggregate. The material is standard filter material on public stormwater projects in the City of Portland. (See Figure 7.)

- Four inches of ¼ inch - #10 angular washed aggregate. The product is commonly available and is an alternative to the ¾ inch - 1/4 inch standard. It has finer particle sizes and is closer to the standard product used in bioretention facilities by Seattle Public Utilities ("Type 26" aggregate). It has not previously been used by BES in this application.

- Coir Erosion Control Fabric ("Landlok C2"). Three layers of the material were installed, alternating the direction of the weave. The material was selected as a coarser, biodegradable alternative to synthetic filter fabric. It has not previously been used by BES in this application. (See Figure 6)

The goal was to test two soils with different percentages of fines as allowed by the Bureau's soil specification. Despite the fact that the two blends were from different vendors, an analysis of the products showed they happened to be very similar in appearance, range of particle sizes and composition. Documentation showed the compost was from the same supplier, and staff ultimately concluded that the soil and sand components were from the same suppliers after talking with the vendors. Both vendors reported they blended the materials in the same proportions (1/3rd; 1/3rd; 1/3rd by volume). Both of the blends had approximately 15 percent fines passing the #200 sieve, by weight, which is the maximum allowed by the 2008 soil specification.

The soil material was relatively dry and granular when it was installed, and appeared to be well mixed. Staff placed the material in two nine-inch lifts. Each lift was manually compacted with a tamper made from a four-inch by four-inch post attached to a one-foot square piece of plywood. The tamper was approximately four feet tall. It was dropped from nine inches above the soil surface and applied systematically across the soil surface. A total of 14 blows were applied across the floor of each planter. The tamper is shown in Figure 4.

Since achieving a specific material density was unfeasible, the goal was to achieve a consistent rate of compaction in all of the planters. Further settling was observed during wetting of the soils during the trials – see section six (Results) for more information.

The planter configurations are presented in the following table.

<table>
<thead>
<tr>
<th>Filter Medium</th>
<th>4 inches of 3/4&quot;-1/4&quot; washed rock</th>
<th>4 inches of 1/4&quot;- #10 washed rock</th>
<th>3 layers of coir erosion control fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil 1</td>
<td>Planter 1</td>
<td>Planter 3</td>
<td>Planter 5</td>
</tr>
<tr>
<td>Soil 2</td>
<td>Planter 2</td>
<td>Planter 4</td>
<td>Planter 6</td>
</tr>
</tbody>
</table>
C. Measurement of Inflow and Outflow

Water was delivered to the soil surface in each planter through a soaker hose connected to the building water supply via a manifold. Adjustable valves allowed staff to vary the inflow rate as needed to maintain a constant head. The inflow rate was checked between one and four times a day. (See Figure 8 for a photo of one of the manifolds.)

Staff measured the outflow rate by placing a cup with a known volume under the outlet and timing how long it took to fill the cup. Flow rates were measured approximately every half hour during the tests.

4. The Hydraulic Tests

A. Schedule

The first tests occurred the last week of May after the pre-test (soaking) phase and the tests continued periodically through the third week of June. The planters were dismantled the last week of June.

B. Phase 1: Pre-test (Soaking) Phase

The planters were slowly wetted initially to avoid suspension of fines on the surface and to allow natural consolidation of the material prior to the hydraulic tests. Although field conditions vary, gradual wetting is common in Portland given typical rainfall intensities. In addition, the goal was to document changes in pass-through rates related to the permeability of the soil, as a result of movement and consolidation of soil particles within the soil mass. (This is in contrast to changes in infiltration at the soil surface that's due to clogging of the soil surface with erosion and deposition of fines.)

After spraying the soil with water to dampen the surface, the soaker hoses were turned on and the planters were wetted for three consecutive days during working hours. At the end of each work day the water systems were turned off and the planters were covered with plastic sheets. The inflow rate was as high as 0.4 gallons/minute, the equivalent of roughly six inches per hour. The rate was adjusted to gradually wet the material without saturating it.
C. Phase 2: Planter Hydraulic Tests

Staff measured rates in saturated conditions with no standing head on the soil surface. Inflow was adjusted to keep the static water level just at the surface of the soil - it was never allowed to fully pond across the surface. The surface water level was checked, and inflow adjusted as needed, every half hour on average. (See Figure 9 and Figure 10 for photos of the setup.)

There were four trials in each planter, each lasting five to seven hours, over the course of two weeks. For most of the planters there were trials on two successive days the first week and a similar program the following week. Outflow was measured approximately every 30 minutes during the trials. The outflow rate from the base layer of drain rock was measured and converted to inches per hour of draw-down, calculated based on the area of the planter.

D. Phase 3: Falling-Head Tests/One Inch of Water

Staff recorded falling head data in four-inch diameter cylinders embedded in the center of the tanks. The cylinders were embedded to a depth of six inches. A single cylinder was installed in each planter. Water was added to the cylinders with a hand-held water sprayer. (See Figure 11 for a photo of the setup.)

Each test started with one inch of water in the cylinder. The surrounding soil surface was kept saturated with the soaker hoses as in the planter tests. The goal was to create testing conditions similar to those in double-ring infiltrometer tests. Staff documented the draw-down time and repeated the tests at least three times in succession. In some of the planters the test was repeated as many as nine times.

E. Phase 4: Falling-Head Tests/Six Inches of Water

After the third phase staff removed the cylinders from the planters and installed taller four-inch diameter cylinders to record falling head data starting with a water depth of six inches. The cylinders were embedded to a depth of six inches. Six inches of ponded water was maintained throughout the planters by increasing the flow rate for the soaker hoses. Four planters were tested in this phase; testing in two of the planters was abandoned when the water system for the soaker hoses couldn’t deliver enough water to achieve a ponding depth of six inches (outflow rate exceeded inflow rate).
5. Materials Tests and Observations

A. Particle Gradation and Organic Content

A single sample was taken from each of the two delivered soils prior to the tests. The sieve analysis and organic content tests followed the requirements of the City’s soil specification; the sieve analysis conformed with ASTM C136/C117 (AASHTO T27/11) and the protocol for organic content followed ASTM D2974.

Soil samples were taken from the planter after the hydraulic tests to document changes in the percentage of total fines (combined clay and silt) related to settling and migration of particles. Three samples were taken within each planter: at 3-6 inches below the initial soil surface; at 6-12 inches depth; and at 12-18 inches depth. The samples were analyzed for fines (percentage of particles passing the #200 sieve, by weight).

B. Soil Density

Samples for density tests were taken from each of the planters after the hydraulic tests. The samples were taken with a six-inch brass cylinder at two depths. One sample was taken at 6-12 inches below the elevation of the original soil surface depth. A second sample was taken at a depth of 12-18 inches. The cylinders were pushed in by hand, covered with a piece of plywood, and lightly tapped with a rubber mallet. The cylinders were dug out by hand, dried, and weighed. The procedure for the tests followed ASTM 07263. (See Figure 12)

C. Filter Media Hydraulic Rates

After digging holes in the soil media and taking samples for the density tests, staff deepened the holes to expose the filter media and tested the ability of the material to pass water. The holes were approximately six inches in diameter. In all six tests a gallon of water was poured down the hole and then the draw-down time was recorded. (See Figure 13)

D. Export of Fines

Staff took samples of the flow coming out of the bottoms of the planters to visually monitor the export of fines based on the color of the outflow. Representative samples were taken over time and kept in glass jars to allow comparison of the color of the discharge. (See Figure 14)

E. Soil Settlement

Settlement was measured along the edges of the planters over the course of the tests. Staff measured changes relative to a line that was drawn at the elevation of the soil immediately prior to the start of the pre-test (soaking) phase.
6. Results

A. Phase I: Pre-test (Soaking) Phase

The amount of water infiltrated during the pre-test phase varied, but it’s reasonable to assume each planter passed at least 60 inches of water during the three days water was applied. This estimate assumes an average inflow rate of four inches per hour over the course of 15 hours.

B. Phase 2: Planter Hydraulic Tests

See tables 2-4 and Graph 1 (below) for summaries of the data. Appendix C contains the test data.

In more than half of the 24 trials (15 of 24) there was an overall downward trend in rates from the beginning to the end of the individual trials. For one planter, Planter 3, all four trials showed an upward trend. In many cases the data was somewhat scattered; in other cases the data points describe a fairly smooth curve.

The planters with Soil 1 (Planters 1, 3, and 5) had slightly lower median rates than the planters with Soil 2. There were otherwise no discernable differences in results related to the combinations of soil and filter material.

There were some trends related to antecedent conditions. Trials that were the second of two successive trials generally yielded lower median rates than the preceding tests, and trials occurring after a break in the testing (usually a week) generally yielded higher average values than the previous test.

Just one planter, Planter 5, had more than a couple of data points below four inches per hour. The lowest value from all of the trials was 2.7 inches per hour (for Planter 5). All of the planters had top values exceeding 10 inches per hour. The highest data point was more than 25 inches per hour for Planter 2. Median values from the individual trials ranged from 5.4 inches per hour to 10.5 inches per hour.

<table>
<thead>
<tr>
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<th>4 inches of 1/4”- #10 washed rock</th>
<th>3 layers of coir erosion control fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil 1</td>
<td>P1: 8.1”/hr</td>
<td>P3: 9.6”/hr</td>
<td>P5: 5.4”/hr</td>
</tr>
<tr>
<td>Soil 2</td>
<td>P2: 9.8”/hr</td>
<td>P4: 10.1”/hr</td>
<td>P6 10.5”/hr</td>
</tr>
</tbody>
</table>

* The median value from all of the measurements taken in the four trials for each planter

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</tr>
</thead>
<tbody>
<tr>
<td>Soil 1</td>
<td>P1: 4.9 - 6.6”/hr</td>
<td>P3: 7.6 - 13.9”/hr</td>
<td>P5: 3.9 - 5.9”/hr</td>
</tr>
<tr>
<td>Soil 2</td>
<td>P2: 5.0 - 9.5”/hr</td>
<td>P4: 4.6 - 12.4”/hr</td>
<td>P6: 3.8 - 16.8”/hr</td>
</tr>
</tbody>
</table>

* The range of the final measurements from the four trials conducted for each planter
The total depth of water passed by the individual planters ranged from 10.1 to 25.6 feet over the course of the four planter trials. In most cases the depth of water passed by the individual planters substantially exceeded totals for any corresponding time period in Portland. As a comparison, Portland had an extreme sixteen-day period of rain at the end of December 2008 and beginning of January 2009. Almost eight inches of rain fell during that period, amounting to almost 25 percent of the annual average total in Portland. In theory a typical green street facility infiltrating all of the runoff from its catchment would have passed about 11 feet of water during that period. This estimate is based on a sizing factor of .06 for the ratio of the footprint of the facility to the catchment area.

Potential sources of error included preferential pathways (short-circuiting along the walls) and variations in the rate of water delivery to the planters due to changes in water pressure. Staff
occasionally observed surface water passing into gaps along the walls and sometimes noticed slight bowing of the walls. In two of the planters the effect was pronounced enough to make a falling head test at six inches depth unviable. These effects weren’t regular or predictable – the presence and influence of the gaps appeared to change over time. In addition there were periodic variations in water pressure and corresponding rates of delivery to the individual planters. In theory any resulting effect on the rates, measured as water exiting the bottom of the planters, was corrected regularly as staff adjusted the inflow valves to keep a constant state of saturation.

C. Phase 3: Falling-Head Tests with One inch of Water

Results are presented below in Graph 2.

Four of the six planters recorded declines in draw-down rates from the beginning to the end of the tests. Just one planter, Planter 3, recorded a final draw-down rate of significantly less than two inches per hour.

The three planters with Soil 1 had distinctly lower draw-down rates than the planters with Soil 2. The results were substantially different from the results for the planter tests, in which the median values for the planters with Soil 1 were just slightly lower than those for the planters with Soil 2. Planter 3 posted the lowest readings; all three readings from that planter were just below one inch per hour.
The test data (and observations) don’t provide a clear explanation for the difference in results between the two soils. One hypothesis is that although the two soils produced similar sieve-test results concerning particle sizes, including similar total percentages of fines, Soil 1 may have had a higher percentage of clay particles than Soil 2. (The soil analysis didn’t include a hydrometer test to provide detail about the composition of the fines fraction.)

As staff embedded the test cylinders in the planters there was ½ inch - ¾ inch of soil subsidence in some of the rings. There were also shallow tension cracks in the center of some of the planters at the location of the rings. There was no apparent correlation between these observations and the test results.

D. Phase 4: Falling-Head Tests with Six Inches of Water

Results are presented below in Graph 3.

Tests were completed in four of the six planters - in two of the planters the maximum inflow rate wasn’t adequate to achieve the required ponding depth of six inches outside the ring. In three of the four planters with completed tests there were two successive draw-down tests. The six values from those tests ranged from two inches per hour to 3.5 inches per hour. In the fourth planter (Planter 3) there was a single test which yielded approximately a quarter of an inch per hour.
E. Materials Tests and Observations

Sieve Analysis and Organic Content. The results of the pre-test soil gradation analysis and organic content analysis are in Appendix A. The analysis confirmed that the delivered soils both met the 2008 soil specification for Portland’s Standard Blend for Public and Private Facilities. They both had fines contents of approximately 15 percent, the maximum allowed by the specification.

The post-test analysis of soil fines yielded the following ranges in combined silt and clay. The percentages are by dry weight.

- Three to six inches below grade: 17-20 percent silt and clay
- Six to twelve inches below grade: 19-21 percent silt and clay
- Twelve to eighteen inches below grade: 20-22 percent silt and clay

Soil Density. The data from the post-test soil density analysis was similar for all of the planters. Dry densities at 6-12 inches depth ranged from 68 to 73 pounds per cubic foot. The densities at 12-18 inches depth ranged from 70 to 78 pounds per cubic foot. Staff taking the samples noted that the deeper soil material was darker and wetter than the material from the shallow samples. The slightly higher densities in the deeper samples and the visual observations provide some evidence of migration by fines.

Filter Media Hydraulic Tests. The 3/4 - 1/4 inch aggregate drained at approximately 3000 inches per hour in both tests, which were conducted after the hydraulic tests. The ¼ inch - #10 aggregate drained at about 2000 inches per hour in both cases. The first coir test drained at about 1000 inches per hour; the second test drained at about 250 inches per hour. (In the second test the sidewall partially collapsed as the water was poured into the hole.)

Export of Fines in the Outflow. There were similar changes in the visible export of fines from all of the planters. At the start of the tests effluent was a rich dark color and a thin layer of fine particles accumulated at the bottom of the receiving containers. Over time, as the tests continued, the effluent from all of the planters became lighter in color and eventually the effluent from all of the planters became completely clear.

Soil Settlement. The drop in soil elevation, measured along the edges of the planters after the hydraulic tests, ranged from 2.4 inches to 3.1 inches. The soil in the middle of the planters settled less than along the edges, perhaps due to the configuration of the soaker hoses. The hoses were coiled around the interior of the boxes, resulting in less direct application of water to the centers of the planters.

7. Overall Findings

- The planter hydraulic tests yielded acceptable pass-through rates in a range of relatively extreme wetting conditions. (None of the rates from the planter tests were less than two inches per hour.) The planters exhibited some responsiveness to antecedent conditions: rates were generally higher after a number of days without wetting. In some planters the data points were fairly scattered, suggesting ongoing hydraulic flux.

- In the falling-head tests there was a single planter with values below two inches per hour. The falling-head tests appeared to be less prone to the influence of preferential pathways along the
walls; therefore the results may be a better indicator of the permeability of the soil than the planter tests.

- The three planters with Soil 1 had slightly lower median rates in the planter tests and distinctly lower draw-down rates in the falling head tests with one inch of water. The reasons for the lower draw-down rates are unclear given the similarity of the two soils. There may have been a difference in percentages of silt and clay.

- There wasn’t evidence of major differences in the consolidation of the material and movement of fines during the tests. The post-test soil analysis showed fairly uniform increases in density and fines content with depth in the soil columns. (The maximum fines content in the bottom six inches was 22 percent and the maximum density was 78 pounds per cubic foot.) Visual observations documented similar reductions in the export of fines over the course of the tests – the effluent from all of the planters eventually turned clear. Finally, settling was fairly uniform in the planters, ranging from an average of 2.4 inches to 3.1 inches along the walls of the planters.

- The hydraulic tests on the filter media, which were completed at the end of the main tests, indicate that clogging of the filter media was not a factor in the test results.

8. Discussion

The scatter of the data from some of the planter tests suggests some systems were still in flux hydraulically even after three days of wetting during the pre-test (soaking) phase. Potential factors include ongoing soil consolidation and changes in preferential pathways within the soil mass and along the walls. Future planter tests should better mitigate or quantify the influence of preferential pathways along the walls. Some of the data variability may also be due to dynamic water pressure in the system supplying the planters. The goal was to maintain constant head conditions, not constant inflow rates, and staff was diligent about adjusting inflow rates. Nonetheless, future tests should include a pressure regulator to remove this variable.

Future trials should create more robust data sets by testing replicate samples and including soils with different percentages of fines. The soil analysis should also include hydrometer tests to determine the percentages of silt and clay within the fines component of the soil.

In future tests it would be valuable to test densities in existing field installations to confirm the appropriate densities for lab tests. (Some jurisdictions such as Seattle have evaluated the permeability of their imported soil material at 85 percent of maximum dry compaction to represent field conditions.) Future tests could also assess the effect of foot traffic in wet conditions on compaction and infiltration rates. Initial lab work examining the interplay between fines content, moisture content, compaction, and permeability has been published by Washington State University (WSU). Based on that research, it’s likely the two tested soils would yield unacceptably low infiltration rates with some degree of foot compaction in wet conditions.
Contacts

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Tim Kurtz, BES Sustainable Stormwater Management Program
Henry Stevens, BES Sustainable Stormwater Management Program

References


Appendix A
Pre-test soil Analysis Results:
Gradation, Organic Content, USCC Compost Report

Appendix B
Growing Medium Specification for Vegetated Stormwater Systems &
& Background about the Specification

Appendix C
Test Data
Background on Portland’s Soil Specification for Stormwater Facilities

The Bureau of Environmental Services adopted a new specification for soils in stormwater management facilities in August 2008. The Stormwater Facility Growing Medium Specification is Special Provision SPP 1040.14. The following documents were important resources in the development of the new specification.

- Seattle Public Utility’s (SPU) draft specification for “Bioretention Soil for Turf and Landscape Areas” (finalized in February 2009);

Portland’s specification deviates from the SPU specification, which is consistent with WSU’s recommendations, in the percentage of allowable fines. Portland allows up to 15 percent total silt and clay, by dry weight, while the SPU specification allows no more than five percent fines. SPU’s limit on fines is based on lab research sponsored by WSU/Puyallup. The data from those tests indicate that more than five percent fines can yield unacceptably low infiltration rates at a compaction of 85% of maximum dry density. The tested soils were two parts utility sand and one part compost. The test protocol was ASTM D 2434/Standard Test Method for Permeability of Granular Soils.

Portland’s higher limit on fines (15 percent) is based in part on the low number of infiltration problems that occurred in green streets facilities constructed with the pre-2008 specification. Although the old specification didn’t put specific limits on fines in the soil component of the mix, there were few installations with unacceptably low infiltration rates. Most of the problems occurred in extreme conditions such as installation in wet weather, post-construction compaction in wet weather, and with heavy inundation immediately after construction.

Given the importance of fines for plant health and biological activity, Portland has opted to moderate the potential for low infiltration rates by avoiding the extreme conditions that lead to low infiltration rates. The City discourages installation in wet weather and over-compaction during construction. City specifications require robust planting plans with gallon containers at relatively high densities. These planting plans should help stabilize the newly-installed soils by promoting physical and chemical aggregation of the soil particles.

The second major difference between the SPU and BES specifications is the composition of the mineral component of the soil blend. (Both specifications require 30-40 percent plant-derived compost.) SPU’s specification calls for standard screened sand which is commonly available and has standard particle size gradations. In contrast, vendors of Portland’s standard mix sometimes have to blend sand and soil to meet the particle gradation requirements of the specification. In some cases a simple three-way mix (sand/soil/compost) will meet the specification, but in other cases different proportions of sand and soil are needed.