

**Using the Western Washington Hydrology Model to Size Silva
Cells for Stormwater Filtration**



SILVA CELLS:

Using the Western Washington Hydrology Model to size Silva Cells for Stormwater Filtration

Below is a procedure for sizing Silva Cells to meet the Washington State Department of Ecology water quality treatment standard using the Western Washington Hydrology Model Version 3.0 (WWHM3). The goal is to provide water quality treatment by filtration of storm water runoff through soil media. The model reflects Silva Cells designed with a piped overflow drain that transports overflow water away from the Silva Cells.

Parameters and assumptions:

- The document “Silva Cells: Using the Western Washington Hydrology Model to size Silva Cells for Stormwater Filtration” is based the following documents. User is responsible to verify that their work is consistent with current versions of these documents:
 - Western Washington Hydrology Model Version 3.0 (WWHM3)
 - Volume V of the Stormwater Management Manual for Western Washington (SMMWW) (2005)
 - Volume III of the SMMWW, Appendix III-C (2005)
- Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.1 for the Silva Cell for Stormwater Filtration Design Criteria. The soil media in the Silva Cell shall match the soils specified for Bioretention areas (rain gardens).
 - NOTE: soil media that meets the City of Seattle bioretention soil specification is exempt from required soil tests. All other soil must be tested per ASTM Designation D 2434 (Standard Test Permeability of Granular Soils) at 80 percent compaction per ASTM Designation D 1557.
 - NOTE: the City of Seattle bioretention soil specification is included in the “Supplemental Text to the 2008 Edition of the Standard Specifications”. The information can be found in Section 7-21, Section 9-03, and Section 9-14.
 - NOTE: the City of Seattle specification is attached as Appendix A of this document. The specification can also be found at www.seattle.gov/util/greeninfrastructure after November 31, 2009.
- Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.3 for Stormwater Filtration-Runoff Model Representation.
- Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.4 for Stormwater Filtration-Infiltration Rate Determinations.
- Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.4.1 for Stormwater Filtration-Imported Soil for the Rain Garden.
- Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.4.2 for Stormwater Filtration-Underlying Soil.
- High groundwater may damage underground structures or affect the performance of filter underdrain systems. There should be sufficient clearance (at least 2 feet is recommended) between the seasonal high groundwater level (highest level of ground water observed) and the bottom of the

filter media to obtain adequate drainage (from Volume V of the Stormwater Management Manual for Western Washington (SMMWW), page 8-18). The bottom of the filter media for the Silva Cells is defined as the invert elevation of the underdrain. The underdrain is assumed to be installed flat (zero slope). The underdrain shall be designed to collect and move the filtered runoff away from the site.

- For basic instructions on the how to set up the model, refer to the WWHM3 Users Manual.

Define Precipitation Data

- 1. Click on the Map Information toolbar button. The map information button is the first toolbar button on the left (the toolbar is located at the top of the screen below the pulldown menus).**

This will bring up the map information screen where the user chooses the county and project site location.

- 2. Click the down arrow on the pulldown menu located in the upper left corner directly above the map. Left click on the county name in which the project site is located.**

This will bring up the county map screen. The map is directly linked to the meteorological database that contains precipitation and evaporation data.

As an alternative, the user can elect to use Washington State Department of Transportation (DOT) precipitation data by checking the "Use DOT data" box to the right of the map. When the DOT data box is checked the map screen changes to show a map of the counties of Western Washington with the area for which the DOT precipitation data are available outlined (the data are not available everywhere).

- 3. Locate the project site on the map screen and use the mouse to left click on the project site location.**

A red square will be placed on the map identifying the project site. The precipitation gage and precipitation multiplication factor are shown to the right of the county map and will vary depending on the project site location. For users that elect to use DOT data, the DOT zone and isohyetal value are shown to the right of the DOT map.

Clicking the + and – buttons located in the lower left corner of the map screen will zoom the map in and out, respectively. Clicking the cross hair button zooms the map out to the full county view, and clicking on the arrow keys scrolls the map view.

Define Developed Land Use (Mitigated Scenario)

- 4. Click on the General Project Information toolbar button (second toolbar button from the left).**

This will bring up the schematic screen where the user defines the information about a project site for predeveloped and/or mitigated (developed) land use conditions.

- 5. Check the box in front of the mitigated scenario in the upper left corner of the schematic screen.**

Mitigated is defined as the developed land use with mitigation measures. Water quality features such as the Silva Cell are sized based on runoff from the mitigated land use only.

- 6. Left click on the Basin element under the Elements heading. The basin element is the upper left element.**

Each element under the Elements heading represents a specific feature (basin, pond, etc.). The Basin element represents the Silva Cell tributary drainage area that can have any combination of soils, vegetation, and land uses.

- 7. Select any grid cell and left click on that grid (the grid is located to the right of the elements). The basin element will appear in that grid cell.**

This grid, called the schematic editor, is where elements are placed and linked together. The scroll bars on the left and bottom of the grid expands the grid as large as needed to contain all of the elements for the project.

To move the entire grid up, down, left, or right, click on the Move Elements arrow buttons located in the lower left corner of the schematic screen.

The grid coordinates from one project can be saved by clicking on the Save x,y button and used for new projects by clicking on the Load x,y button, located in the bottom left corner of the schematic screen.

- 8. Input the land use area (in acres) of the mitigated basin. A list of available land use options is located to the right of the grid. The areas are input in the appropriate box located to the right of each item on the list.**

Pervious land use information is in the form of soil, vegetation, and land slope.

- *Soil type categories: A/B (outwash soils), C (till), and SAT (saturated/wetland/hydric soils).*
- *Vegetation categories: forest (second growth Douglas Fir), pasture (non-forested natural areas/scrub/shrub rural vegetation), and lawn (sod lawn/grass/landscaped urban vegetation).*
- *Land slope categories: flat (0-5%), moderate (5-15%), and steep (>15%).*

(from page 28 of the WWHM3 users manual)

Impervious areas are divided into five types with three different slopes. The five types are: roads, roofs, driveways, sidewalks, and parking. The slope categories are the same as for the pervious land use (flat, moderate, steep).

(from page 28 of the WWHM3 users manual)

If pervious pavement is being installed directly above the Silva Cells, the pervious pavement should be modeled as an impervious surface in the WWHM3. See Volume III, Appendix C on pages C-2 to C-4 for further information.

Define the Silva Cell Water Quality Facility

- 9. Left click on the Sand Filter element under the Elements heading and place this element in the grid below the Basin element. The Sand Filter is located in the third row of elements, third from the left.**

The Sand Filter element is used to model facilities that provide water quality treatment by filtration through a medium. This element will represent the layer of soil in the Silva Cell from the invert of the underdrain to the top of the cell. Stormwater runoff will be treated as it filters through this layer.

- 10. Connect the Sand Filter element to the Basin element by right clicking on the Basin element and selecting Connect to Element in the pulldown menu. A green line will appear with one end connected to the basin element, and the other end connected to the mouse pointer. With the mouse pointer, pull the line down to the sand filter element and left click on the element. This will bring up the From Basin to Conveyance window that allows the user to specify which runoff components to route to the sand filter element. Both the surface runoff and interflow should always be checked. Groundwater should only be checked when there is observed and documented groundwater surfacing from the upstream basin. After the appropriate boxes have been checked, click the OK button.**

A line will appear on the grid between the sand filter and the basin. By connecting the sand filter to the basin, runoff from the Silva Cells tributary drainage area is routed into the below grade soil media within the Silva Cell.

Surface runoff and interflow are the two flow components of stormwater runoff. The default setting is for the surface runoff and interflow to go to the stormwater facility.

The Basin screen will show that surface and interflow flows to the Sand Filter (groundwater will also be shown if checked).

- 11. Click on the Sand Filter element that was placed in the grid. This will bring up a screen to the right of the grid where the Silva Cell parameters will be defined.**
- 12. Enter the dimensions of the Silva Cell in the boxes under the Facility Dimensions heading.**

- a. Enter the length and width of the Silva Cells (in feet) in the first two boxes under the Facility Dimensions heading.**
- b. Enter the effective depth of the Silva Cells (in feet) in the third box under the Facility Dimensions heading.**

The effective depth for a sand filter element in the WWHM3 is defined as the depth of available ponding volume located above the top of the filter media. The effective depth for the Silva Cell is the depth of the air space above the soil media.

Ponding volume is restricted to the void space directly above the Silva Cell soil media.

- c. The side slopes of the Silva Cells (horizontal distance over vertical distance) in the last four boxes under the Facility Dimensions heading should be set to 0.**

There are four side slopes associated with the four sides of the rectangular filter media in plan view; left, right, top, and bottom. The four side slopes of the Silva Cells are assumed to be vertical (0 value).

13. Enter the height (in feet), diameter (in inches), and type of riser under the Outlet Structure heading.

The sand filter element must have an overflow riser defined to model overflows that occur should the available ponding volume be exceeded. The riser is defined in the model as a vertical pipe with a flat (horizontal) outlet, with the option of including a vertical weir notch cut into the side of the top of the riser.

The overflow of the Silva Cell volume above the invert of the underdrain is assumed to be the top of ground (or top of pervious pavement). Enter a riser height slightly smaller than the effective depth, and enter a large value (say 10,000 inches) for the riser diameter to ensure that there is ample capacity should overflows from the Silva Cells occur. Assume a flat riser type without a weir notch.

14. Enter the Hydraulic Conductivity (in inches per hour) and Filter Media Depth (in Feet) under the Infiltration heading.

The soil mix in the Silva Cells should have a minimum short-term hydraulic conductivity of 1.0 inches/hour per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 80 percent compaction per ASTM Designation D 1557 (from Volume III of the SMMWW, Appendix III-C, page C-13). The chosen hydraulic conductivity values should be supported by documentation and will need to be approval by the reviewing authority.

Note: Unless the City of Seattle pre-tested soil specifications is used, the designer must test the initial hydraulic conductivity of the Silva Cell soil per the instructions for the "imported soil for the rain garden: in Volume III of the SMMWW, Appendix III-C

NOTE: The WWHM automatically increases the hydraulic conductivity (in inches per hour) by a factor related to the ratio of filter material depth and ponding depth over filter material depth. This factor can be calculated by the following formula:

$$\text{Factor} = (\text{Filter Material Depth} + \text{Ponding Depth}) / (\text{Filter Material Depth})$$

Because the required soil mix is not a typical sand filter media, the automatic increase in initial hydraulic conductivity that has been determined by the method described above must be corrected. In order to correct for the automatic increase, the hydraulic conductivity output produced by the model must be reduced. This can be done by dividing the hydraulic conductivity by the Factor calculated in the above formula. The final hydraulic conductivity value must reflect any factor of safety applicable per Volume III of the SMMWW, Appendix III-C, Section 7.7.4.1.

A long term correction(infiltration reduction) factor must be applied to the initial hydraulic conductivity. Refer to Volume III of the SMMWW, Appendix III-C, Section 7.7.4.1 to determine a correction factor of 2 or 4, which must be entered into the WWHM.

NOTE: The filter media depth is measured from the invert of the draitnle to the top of the soil media. Soil depth should be a minimum of 18" to provide acceptable minimum pollutant attenuation (from Volume III of the SMMWW, Appendix III-C, page C-13).

15. Use the default standard setting of not applying precipitation and evaporation to the facility (keep the boxes unchecked that are located in the upper left corner of the Sand Filter screen).
16. Optional – The user has the option to enter a pond bottom elevation (in feet) to the right of the Facility Bottom Elevation heading.

The pond bottom can be set to an elevation other than zero if the user wants actual elevations. All facility stage values are relative to the bottom elevation. Negative bottom elevations are not allowed.

Size the Silva Cell

17. Click on the Run Scenario button located in the upper left corner of the schematic screen.
18. Click on the Sand Filter element that was placed in the grid.

The total volume filtered, total volume through riser, total volume, and percent filtered is summarized in the lower left corner of the Sand Filter screen.

19. Check the volume calculations in the lower left corner of the Sand Filter screen to see if the percent filtered equals or exceeds 91%. If the value is less than 91% then the user should increase the size of the sand filter (Silva Cell).

The goal of filtration is to meet the Washington State Department of Ecology treatment standard of filtering at least 91% of the total runoff volume.

Save Project

20. To save the project click on File in the upper left corner and select Save As. Select a file name and save the WWHM3 project file.

The user can exit WWHM3 and later reload the project file with all of its information by going to File, Open.