Appendix 2-C

Low Impact Development Flow Modeling

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Washington State Department of Ecology Low Impact Development Flow Modeling Guidance

Clark County requires the use of the Western Washington Hydrology Model (WWHM) and other approved runoff model for estimating surface runoff and sizing stormwater control and treatment facilities. Clark County allows use of ~~either the previous version of WWHM, WWHM 3, or the current version,~~ WWHM 2012. MGSFlood has not been approved by Ecology for modeling bioretention facilities.

Check the Ecology webpages for the latest information use of the WWHM. Also refer to the SWMMWW 2019, Volume III Chapter 2 for information on the WWHM use for modeling LID BMPs.

~~Part 1 of this appendix explains how to represent various LID techniques within WWHM 3 so that their benefit in reducing surface runoff can be estimated. The lower runoff estimates should translate into smaller stormwater treatment and flow control facilities. In certain cases, use of various techniques can result in the elimination of those facilities.~~

~~Part 2 of this appendix discusses direct modeling of some LID techniques in the WWHM 2012 version, which better represents how these techniques function to reduce runoff.~~

As Puget Sound gains more experience with and knowledge of LID techniques, the design criteria will evolve. Also, our ability to model their performance will change as our modeling techniques improve. Therefore, we anticipate this guidance will be updated periodically to reflect the new knowledge and modeling approaches.

~~Part 1: Guidance for Use with WWHM 3~~

~~C.1 Permeable Pavements~~

~~*C.1.1 Porous Asphalt or Concrete*~~

~~Description~~	~~Model Surface as~~
~~1. Base material laid above surrounding grade:~~	
~~a) Without underlying perforated drain pipes to collect stormwater~~	~~Grass over underlying soil type (till or outwash)~~
~~b) With underlying perforated drain pipes for stormwater collection:~~	

~~at or below bottom of base layer~~	~~Impervious surface~~
~~elevated within the base course~~	~~Impervious surface~~
~~2. Base material laid partially or completely below surrounding grade:~~	
~~a) Without underlying perforated drain pipes underlying soil type~~	~~Option 1: Grass over~~
	~~Option 2: Impervious surface routed to a Gravel Trench/Bed[1]~~
~~b) With underlying perforated drain pipes:~~	
~~at or below bottom of base layer~~	~~Impervious surface~~
~~elevated within the base course[2]~~	~~Model as impervious surface routed to a Gravel Trench/Bed[1]~~

~~*C.1.2 Grid/lattice systems (non-concrete) and Paving Blocks*~~

~~Description~~	~~Model Surface as~~
~~1. Base material laid above surrounding grade~~	
~~a) Without underlying perforated drain pipes~~	~~Grid/lattice systems: grass on underlying soil (till or outwash).~~
	~~Paving Blocks: 50% grass on underlying soil; 50% impervious.~~
~~b) With underlying perforated drain pipes~~	~~Impervious surface~~
~~2. Base material laid partially or completely below surrounding grade~~	
~~a) Without underlying perforated drain pipes~~	~~Option 1:~~ ~~Grid/lattice as grass on underlying soil.~~

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[1] See Section C.11 for detailed instructions concerning how to represent the base material below grade as a gravel trench/bed in the Western Washington Hydrology Model.

[2] If the perforated pipes function is to distribute runoff directly below the wearing surface, and the pipes are above the surrounding grade, follow the directions for 2a above.

	~~Paving blocks as 50% grass; 50% impervious.~~ ~~Option 2:~~ ~~Impervious surface routed to a Gravel Trench/Bed.~~~~[1]~~
~~b) With underlying perforated drain pipes~~	
~~at or below bottom of base layer~~	~~Impervious surface~~
~~elevated within the base course~~~~[2]~~	~~Model as impervious surface routed to a Gravel Trench/Bed.~~~~[1]~~

~~C.2 Dispersion~~

~~C.2.1 Full Dispersion for the Entire Development Site~~

~~Residential Developments that implement BMP T5.30 do not have to use approved runoff models to demonstrate compliance. They are assumed to fully meet the treatment and flow control requirements.~~

~~C.2.2 Full Dispersion for Part of the Development Site~~

~~Those portions of residential developments that implement BMP T5.30 do not have to use approved runoff models to demonstrate compliance. They are assumed to fully meet the treatment and flow control requirements.~~

~~C.2.3 Partial Dispersion on residential lots and commercial buildings~~

~~If roof runoff is dispersed on single-family lots or commercial lots according to the design criteria and guidelines in BMP T5.10C in Book 2 through undisturbed native landscape or lawn/landscape area that meets the guidelines in BMP T5.13 in Book 2, the user has two options.~~

~~Option 1: The roof area may be modeled as landscaped area if the vegetated flow path is 50 feet or more. Do this in WWHM on the Mitigated Scenario screen by entering the roof area into one of the entry options for dispersal of impervious area runoff. Alternately, enter the roof area as landscaped area with the appropriate landscaped slope. Where the flow path is between 25 and 50 feet and a dispersion trench is used, the roof area may be modeled as 50% landscape/50% impervious. Do this in WWHM on the Mitigated Scenario screen by entering 50% of the roof area as impervious and the other 50% as landscaped area.~~

~~Option #2: The user may apply the "lateral flow icons." In this option, the "Lateral Flow Impervious Area" icon is used to represent the roof area(s). That icon is then connected to a "Lateral Flow Basin" icon that represents the pervious area into which the roof is being dispersed. The user should direct surface runoff and interflow from the "lateral flow basin" to a treatment system, retention/detention basin, or directly to a point of compliance.~~

~~Whether option #1 or #2 is used, the vegetated flow path is measured from the downspout or dispersion system discharge point to the downgradient edge of the vegetated area. That flow path must be at least 50 feet unless a dispersion trench is used with a vegetated flow path of 25 to 50 feet.~~

~~Where BMP T5.11 (concentrated flow dispersion) or BMP T5.12 (sheet flow dispersion) in Book 2 is used to disperse runoff from impervious areas other than roofs into a native vegetation area or an area that meets the guidelines in BMP T5.13 in Book 2, the same two options as described above are available. The user may model the impervious area as landscaped area (50 feet or more of vegetated flow path), 50% landscape/50% impervious (25 to 50 feet of vegetated flow path), or the "lateral flow" icons may be used. As above, the vegetated flow path from the dispersal point to the downgradient edge of the vegetated area must be at least 50 feet, unless a dispersion trench is used with a vegetated flow path of 25 to 50 feet.~~

~~C.3 Downspout Full Infiltration~~

~~Roof areas served by downspouts that drain to infiltration dry wells or infiltration trenches that are sized in accordance with the guidance in BMP T5.10A and BMP T5.10B do not have to be entered into the runoff model. They are assumed to fully infiltrate the roof runoff.~~

~~C.4 Vegetated Roofs~~

~~C.4.1 Option 1 Design Criteria~~

- ~~3 inches to 8 inches of soil/growing media~~

~~Runoff Model Representation~~

- ~~50% till landscaped area; 50% impervious area~~

~~C.4.2 Option 2 Design Criteria~~

- ~~≥ 8 inches of soil/media~~

~~Runoff Model Representation~~

- ~~50% till pasture; 50% impervious area~~

~~C.5 Rainwater Harvesting~~

~~Do not enter drainage area into the runoff model.~~

~~*Note:* This applies only to drainage areas for which a monthly water balance indicates no overflow of the storage capacity.~~

~~C.6 Reverse Slope Sidewalks~~

- ~~Enter sidewalk area as landscaped area over the underlying soil type.~~

- ~~Alternatively, use the “lateral flow” icons. Use the “Lateral Flow Impervious Area” icon for the sidewalk, and use the “Lateral Flow Basin” icon for the downgradient vegetated area.~~

~~C.7 Minimal Excavation Foundations~~

- ~~Where residential roof runoff is dispersed on the upgradient side of a structure in accordance with the design criteria and guidelines in BMP T5.10C of Book 2, the tributary roof area may be modeled as pasture on the native soil.~~
- ~~In “step forming,” the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards. Where “step forming” is used on a slope, the square footage of roof that can be modeled as pasture must be reduced to account for lost soils. The following equation (suggested by Rick Gagliano of Pin Foundations, Inc.) can be used to reduce the roof area that can be modeled as pasture.~~

~~$A_1 - \frac{dC(.5)}{dP} X A_1 = A_2$~~

~~A_1 = roof area draining to up gradient side of structure~~

~~dC = depth of cuts into the soil profile~~

~~dP = permeable depth of soil (The A horizon plus an additional few inches of the B horizon where roots permeate into ample pore space of soil).~~

~~A_2 = roof area that can be modeled as pasture on the native soil. The rest of the roof is modeled as impervious surface unless it is dispersed in accordance with the next bullet.~~

- ~~If roof runoff is dispersed downgradient of the structure in accordance with the design criteria and guidelines in BMP T5.10C of Book 1~~2~~, AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in BMP T5.13 of Book 1~~2~~, the tributary roof areas may be modeled as landscaped area. Alternatively, use the lateral flow elements to send roof runoff onto the lawn/landscape area that will be used for dispersion.~~

~~C.8 Tree Retention and Planting~~

~~*C.8.1 Tree Retention Flow Control Credit*~~

~~Flow control credits for retained trees are provided in Table C.1 by tree type. These credits can be applied to reduce impervious or other hard surface area requiring flow control. Credits are~~

~~given as a percentage of the existing tree canopy area. The minimum credit for existing trees ranges from 50 to 100 square feet.~~

~~Table C.1~~
~~Flow Control Credits for Retained Trees.~~

~~**Tree Type**~~	~~**Credit**~~
~~Evergreen~~	~~20% of canopy area (minimum of 100 sq. ft./tree~~
~~Deciduous~~	~~10% of canopy area (minimum of 50 sq. ft./tree~~

~~Impervious Area Mitigated = Σ Canopy Area x Credit (%)/100.~~

~~Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.~~

~~C.8.2 Newly Planted Tree Flow Control Credits~~

~~Flow control credits for newly planted trees are provided in Table C.2 by tree type. These credits can be applied to reduce the impervious or other hard surface area requiring flow control. Credits range from 20 to 50 square feet per tree.~~

~~Table C.2.~~
~~Flow Control Credits for Newly Planted Trees.~~

~~**Tree Type**~~	~~**Credit**~~
~~Evergreen~~	~~50 sq. ft. per tree~~
~~Deciduous~~	~~20 sq. ft. per tree~~

~~Impervious Area Mitigated = Σ Number of Trees x Credit (%)/100.~~

~~Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.~~

~~**C.9 Soil Quality and Depth**~~

~~All areas that meet the soil quality and depth requirement may be entered into the model as pasture rather than lawn/landscaping.~~

~~**C.10. Bioretention**~~

~~C.10.1 Runoff Model Representation~~

~~Pothole design (bioretention cells)~~

~~Bioretention is represented by using the "Gravel trench/bed" icon with a steady-state infiltration rate. Proper infiltration rate selection is described below. The user inputs the dimensions of the gravel trench. Layer 1 on the input screen is the bioretention soil layer. Enter the soil depth and a porosity of 40%. Layer 2 is the free standing water above the bioretention soil. Enter the maximum depth of free standing water (i.e., up to the invert of an overflow pipe or a spillway, whatever engages first for surface release of water), and 100% for porosity. Bioretention with underlying perforated drain pipes that discharge to the surface can also be modeled as gravel trenches/beds with steady-state infiltration rates. However, the only volume available for storage (and modeled as storage as explained herein) is the void space within the imported material (usually sand or gravel) below the bioretention soil and below the invert of the drain pipe.~~

~~Using the procedures explained in Book 1, Section 2.2.1.3 and the test methods described in Book 1, Section 4.3.1.3, estimate the initial measured (a.k.a., short-term) infiltration rate of the native soils beneath the bioretention soil and any base materials. Because these soils are protected from fouling, no correction factor will be applied.~~

~~Facilities without and underdrain:~~

~~If using the default bioretention soil mix in accordance with BMP T5.14B in Book 2, 12 inches per hour is the initial infiltration rate. The long-term rate is either 3 inches per hour or 6 inches per hour depending upon the size of the drainage area and the use of a pretreatment device for solids removal prior to the bioretention facility. If using a custom imported soil mix other than the default, its saturated hydraulic conductivity (used as the infiltration rate) must be determined using the procedures described in BMP T5.14B in Book 2. The long-term infiltration rate is one-fourth or one-half of that rate depending upon the size of the drainage area and the use of a pretreatment device for solids removal.~~

~~Facilities with an elevated underdrain:~~

~~Note that only the estimated void space of the aggregate bedding layer that is below the invert of the underdrain pipe provides storage volume that provides a flow control benefit. Assume a 40% void volume for the Type 26 mineral aggregate specified in BMP T5.14B.~~

~~Linear Design: (bioretention swale or slopes)~~

~~Swales~~

~~Where a swale design has a roadside slope and a back slope between which water can pond due to an elevated, and an overflow/drainage pipe at the lower end of the swale, the swale may be modeled as a gravel trench/bed with a steady state infiltration rate. This method does not apply to swales that are underlain by a drainage pipe.~~

~~If the long-term infiltration rate through the imported bioretention soil is lower than the infiltration rate of the underlying soil, the surface dimensions and slopes of the swale should be entered into the WWHM as the trench dimensions and slopes. The effective depth is the distance from the soil surface at the bottom of the swale to the invert of the overflow/drainage pipe. If the infiltration rate through the underlying soil is lower than the estimated long-term infiltration rate through the imported bioretention soil, the trench/bed dimensions entered into the WWHM should be adjusted to account for the storage volume in the void space of the bioretention soil. Use 40 percent porosity for bioretention planting mix soils recommended above for Layer 1 in WWHM.~~

~~This procedure to estimate storage space should only be used on bioretention swales with a 1% slope or less. Swales with higher slopes should more accurately compute the storage volume in the swale below the drainage pipe invert.~~

~~For a swale design with an underdrain, the directions above under Pothole design apply.~~

~~*C.10.2 WWHM Routing and Runoff File Evaluation*~~

~~In WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage be exceeded. So in the Riser/Weir screen, for the Riser head enter a value slightly smaller than the effective depth of the trench (say 0.1 ft below the Effective Depth); and for the Riser diameter enter a large number (say 10,000 inches) to ensure that there is ample capacity for overflows. The overflow should be routed to the point of compliance or a downstream facility. If the facility is underdrained, the underdrain must be similarly routed.~~

~~Within the model, route the runoff into the gravel trench by grabbing the gravel trench icon and placing it below the tributary “basin” area. Be sure to include the surface area of the bioretention area in the tributary “basin” area. Run the model to produce the effluent runoff file from the theoretical gravel trench. For projects subject to the flow control standard, compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. A conveyance system should be designed to route all overflows from the bioretention areas to centralized treatment facilities, and to flow control facilities if flow control applies to the project.~~

~~*C.10.3 Modeling of Multiple Bioretention facilities*~~

~~Where multiple bioretention facilities are scattered throughout a development, it may be possible to cumulatively represent a group of them that have similar characteristics as one large bioretention facility serving the cumulative area tributary to those facilities. For this to be a reasonable representation, the design of each bioretention facility in the group should be similar (e.g., same depth of soil, same depth of surface ponded water, roughly the same ratio of impervious area to bioretention volume). In addition, the group should have similar (0.5x to 1.5x the average) controlling infiltration rates (i.e., either the long-term rate of the bioretention soil, or the initial rate of the underlying soil) that can be averaged as a single rate.~~

~~**C.11 WWHM Instructions for Estimating Runoff Losses in Road Base Material Volumes that are Below Surrounding Grade**~~

~~*Introduction*~~

~~This section applies to roads or parking lots that have been constructed with a permeable pavement and whose underlying base materials extend below the surrounding grade of land. The over-excavated volume can temporarily store water before it infiltrates or overflows to the surrounding ground surface. This section describes design criteria and modeling approaches for such designs.~~

~~*Pre-requisite*~~

~~Before using this guidance to estimate infiltration losses, the designer should have sufficient information to know whether adequate depth to a seasonal high ground water table, or other infiltration barrier (such as bedrock) is available. The minimum depth necessary is 3 feet as measured from the bottom of the base materials.~~

~~*C.11.1 Instructions for Roads on Zero to 2% Grade*~~

~~For road projects whose base materials extend below the surrounding grade, the below grade volume of base materials may be modeled in WWHM as a Gravel trench/bed with a set infiltration rate. The pervious pavement area is entered as a basin with an equivalent amount of impervious area that is routed to the gravel trench/bed. If an underdrain is installed at the bottom of the base materials, the pavement is modeled as impervious surface without a gravel trench.~~

~~First, place a “basin” icon in the “Schematic” grid. Enter the appropriate pre-developed and post-developed descriptions of your project site (or threshold discharge area of the project site). Assume that your pervious pavement surfaces are impervious surfaces. By placing a~~

~~Gravel trench/bed icon below the basin icon in the Schematic grid, we are routing the runoff from the road and any other tributary area into the below grade volume that is represented by the Gravel trench/bed.~~

~~Enter the dimensions of the Gravel trench/bed: the length of the base materials that are below grade (parallel to the road); the width of the below grade material volume; and the depth. The available storage is the void volume in the gravel base layer below the pervious pavement. Enter the void ratio for the gravel base in the Layer 1 field. For example, for a project with a gravel base of 32% porosity, enter 0.32 for the Layer 1 porosity. If the below grade base course has perforated drainage pipes elevated above the bottom of the base course, but below the elevation of the surrounding ground surface, the "Layer 1 Thickness" is the distance from the invert of the lowest pipe to the bottom of the base course.~~

~~Also in WWHM3, the Gravel trench/bed facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So for the "Riser Height", enter a value slightly smaller than the effective depth of the base materials (say 0.1 ft below the Effective Total Depth); and for the "Riser Diameter" enter a large value (say 10,000 inches) to ensure that there is ample capacity should overflows from the trench occur.~~

~~For all infiltration facilities, WWHM3 has a button that asks, "Use Wetted Surface Area?" The answer should remain "NO."~~

~~Using one of the procedures explained in Book 1, Chapter 4, estimate the initial measured (a.k.a., short-term) infiltration rate of the native soils beneath the base materials. Enter that into the "measured infiltration rate" field. For the Infiltration Reduction Factor, enter 0.5.~~

~~Run the model to produce the overflow runoff file from the gravel trench. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. Design the road base materials to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.~~

~~C.11.2 Instructions for Roads on Grades above 2%~~

~~Road base material volumes that are below the surrounding grade and that are on a slope can be modeled as a gravel trench with an infiltration rate and a nominal depth. Represent the below grade volume as the gravel trench. Grab the gravel trench icon and place it below the "basin" icon so that the computer model routes all of the runoff into the gravel trench.~~

~~The dimensions of the gravel trench are: the length (parallel to and beneath the road) of the base materials that are below grade; the width of the below grade base materials; and an Effective Total Depth of 1 inch. In WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So, enter 0.04 ft (½ inch) for the "Riser Height" and a large Riser Diameter (say 1000 inches) to ensure that there is no head build up.~~

~~*Note:* If a drainage pipe is embedded and elevated in the below grade base materials, the pipe should only have perforations on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space. If a drainage pipe is placed at the bottom of the base material, the pavement is modeled as an impervious surface without any gravel trench.~~

~~Estimate the infiltration rate of the native soils beneath the base materials. See the previous Section (Instructions for Roads on Zero to 2% Grade) for estimating options and for how to enter infiltration rates and infiltration reduction factors for the gravel trench. In the "Material Layers" field, enter ½ inch for Layer 1 Thickness and its appropriate porosity. For all infiltration facilities, WWHM3 has a button that asks, "Use Wetted Surface Area?" The answer should remain "NO."~~

~~Run the model to produce the effluent runoff file from the gravel trench (base materials). Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. The road base materials should be designed to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.~~

~~*C.11.3 Instructions for Roads on a Slope with Internal Dams within the Base Materials that are Below Grade*~~

~~In this option, a series of infiltration basins is created by placing relatively impermeable barriers across the below grade base materials at intervals downslope. The barriers inhibit the free flow of water down the grade of the base materials. The barriers must not extend to the elevation of the surrounding ground. Provide a space sufficient to pass water from upgradient to lower gradient basins without causing flows to surface out the sides of the base materials that are above grade.~~

~~Each stretch of trench (cell) that is separated by barriers can be modeled as a gravel trench. This is done by placing the "Gravel trench/bed" icons in series in WWHM. For each cell,~~

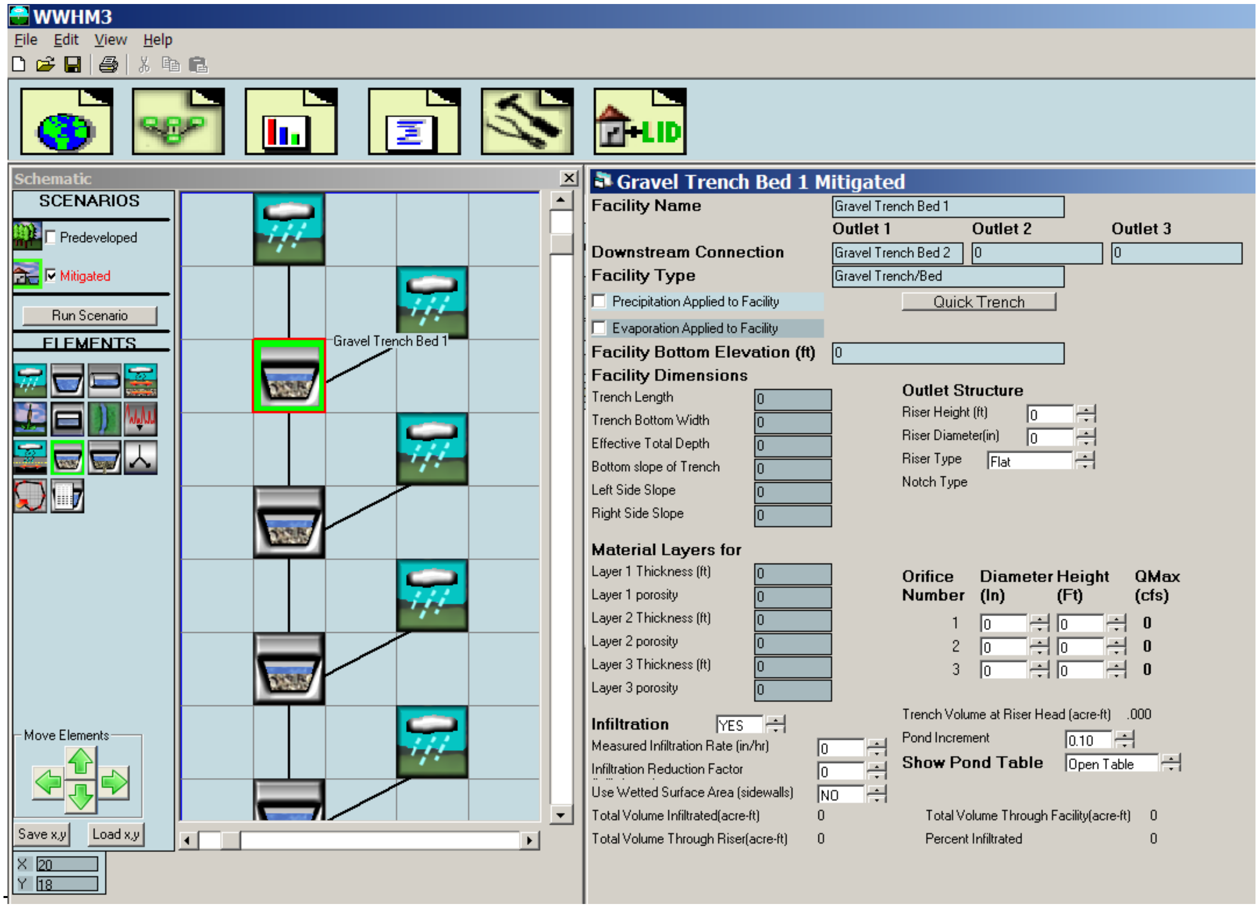
~~determine the average depth of water within the cell (Average Cell Depth) at which the barrier at the lower end will be overtopped.~~

~~Specify the dimensions of each cell of the below-grade base materials using the “Gravel trench/bed” dimension fields for: the “Trench Length” (length of the cell parallel to the road); the “Trench Bottom Width”(width of the bottom of the base material); and the Effective Total Depth (the Average Cell Depth as determined above).~~

~~Also in WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. For each trench cell, the available storage is the void space within the Average Cell Depth. WWHM calculates the storage/void volume of the trench cell using the porosity values entered in the “Layer porosity” fields. The value for the “~~***~~Riser Height~~***~~” should be slightly below the “Effective Total Depth” (say by about 1/8” to ¼”). For the~~ ***~~Riser diameter~~***~~, enter a large number (say 10,000 inches) to ensure that there is ample capacity should overflows from the below-grade trench occur.~~

~~Each cell should have its own tributary drainage area that includes the road above it, any project site pervious areas whose runoff drains onto and through the road, and any off-site areas. Each drainage area is represented with a “basin” icon.~~

~~Below is the computer graphic representation of a series of Gravel trench/beds and the Basins that flow into them.~~



☐ Predeveloped
☑ Mitigated

X 20
Y 18

Gravel Trench Bed 1 Mitigated

Facility Name: Gravel Trench Bed 1

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	Gravel Trench Bed 2	0	0

Facility Type: Gravel Trench/Bed

☐ Precipitation Applied to Facility
☐ Evaporation Applied to Facility

Facility Bottom Elevation (ft): 0

Facility Dimensions

Trench Length	0
Trench Bottom Width	0
Effective Total Depth	0
Bottom slope of Trench	0
Left Side Slope	0
Right Side Slope	0

Outlet Structure

Riser Height (ft): 0
Riser Diameter(in): 0
Riser Type: Flat
Notch Type

Material Layers for

Layer 1 Thickness (ft)	0
Layer 1 porosity	0
Layer 2 Thickness (ft)	0
Layer 2 porosity	0
Layer 3 Thickness (ft)	0
Layer 3 porosity	0

Orifice Number	Diameter (In)	Height (Ft)	QMax (cfs)
1	0	0	0
2	0	0	0
3	0	0	0

Infiltration: YES

Measured Infiltration Rate (in/hr): 0
Infiltration Reduction Factor: 0
Use Wetted Surface Area (sidewalls): NO
Total Volume Infiltrated(acre-ft): 0
Total Volume Through Riser(acre-ft): 0

Trench Volume at Riser Head (acre-ft): .000
Pond Increment: 0.10
Show Pond Table: Open Table

Total Volume Through Facility(acre-ft): 0
Percent Infiltrated: 0

~~It is possible to represent a series of cells as one infiltration basin (using a single gravel trench icon) if the cells all have similar length and width dimensions, slope, and Average Cell Depth. A single "basin" icon is also used to represent all of the drainage area into the series of cells.~~

~~On the Gravel Trench screen under "Infiltration", there is a field that asks the following "Use Wetted Surface Area?" By default, it is set to "NO". It should stay "NO" if the below-grade base material trench has sidewalls steeper than 2 horizontal to 1 vertical.~~

~~Using the procedures explained above for roads on zero grade, estimate the infiltration rate of the native soils beneath the trench. Also as explained above, enter the appropriate values into the "Measured Infiltration Rate" and "Infiltration Reduction Factor" boxes.~~

~~Run the model to produce the effluent runoff file from the below grade trench of base materials. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved size a downstream retention or detention facility (using the WWHM standard procedures) and locate~~

~~it in the field. Design the road base materials to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.~~

~~Part 2:~~ Summary of WWHM 2012 Representation of LID BMPs

Note: BMP numbering given in this appendix corresponds to numbers in this manual. In some cases, the numbering differs from those given in the SMMWW.

Downspout Dispersion – BMP T5.10C

Where BMP T5.10C – Downspout Dispersion - is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, and the vegetated flow path is at least 50 feet, the connected roof area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple downspout dispersions in a project site. If such guidance is not forthcoming, in situations where multiple downspout dispersions will occur, Clark County allows the roof area to be modeled as a landscaped area (where the 50-foot flowpath requirement is met) or as 50% impervious ~~landscape~~/50% lawn (where a gravel trench is used to disperse into a vegetated area with a 25 to 50 foot flowpath) so that the project schematic in WWHM becomes manageable.

Concentrated Flow Dispersion – BMP T5.11

Where BMP T5.11- Concentrated Flow Dispersion - is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, and the vegetated flow path is at least 50 feet, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple concentrated flow dispersions in a project site. If such guidance is not forthcoming, in situations where multiple concentrated flow dispersions will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Sheet Flow Dispersion – BMP T5.12

Where BMPT5.12 – Sheet Flow Dispersion - is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple sheet flow dispersions in a project site. If such guidance is not forthcoming, in situations where multiple sheet flow dispersions will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Post-Construction Soil Quality and Depth – BMP T5.13

Enter area as field ~~pasture~~.

Bioretention – BMP T5.14B

Use new bioretention element for each type: cell, swale, or planter box.

The equations used by the elements are intended to simulate the wetting and drying of soil as well as how the soils function once they are saturated. This group of LID elements uses the modified Green Ampt equation to compute the surface infiltration into the amended soil. The water then moves through the top amended soil layer at the computed rate, determined by Darcy’s and Van Genuchten’s equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), the model determines when water will begin to infiltrate into the second soil layer (lower layer). This occurs when the matric head is less than the gravity head in the first layer (top layer). The second layer is intended to prevent loss of the amended soil layer. As the second layer approaches field capacity, the water begins to move into the third layer – the gravel underlayer. For each layer, the user inputs the depth of the layer and the type of soil.

For the Ecology-recommended soil specifications for each layer in the design criteria for bioretention, the model will automatically assign pre-determined appropriate values for parameters that determine water movement through that soil. These include: wilting point, minimum hydraulic conductivity, maximum saturated hydraulic conductivity, and Van Genuchten number.

If a user opts to use soils that deviate from the recommended specifications, the default parameter values do not apply. The user will have to use the Gravel Trench element to represent the bioretention facility~~. and follow the procedures identified for WWHM3 in Part 1 of this appendix~~.

For Bioretention with underlying perforated drain pipes that discharge to the surface, the only volume available for storage (and modeled as storage as explained herein) is the void space within the aggregate bedding layer below the invert of the drain pipe. Use 40% void space for the Type 26 mineral aggregate specified in BMP T5.14B in Book 2.

Using the procedures explained in Book 1, Section 2.3 and the test methods described in Book 1, Section 2.3.1.4, estimate the initial measured (a.k.a. short-term) infiltration rate of the native soils beneath the bioretention soil and any base materials. Because these soils are protected from fouling, not correction factor will be applied.

Permeable Pavements – BMP T5.15

Use new porous pavement element.

User specifies pavement thickness & porosity, aggregate base material thickness & porosity, maximum allowed ponding depth & infiltration rate into native soil. For grades greater than 2%, see additional guidance.

Vegetated Roofs – BMP T5.17

Use new green roof element

User specifies media thickness, vegetation type, roof slope, and length of drainage.

Impervious Reverse Slope Sidewalks – BMP T5.18

Use the lateral flow elements to send the impervious area runoff onto the lawn/landscape area that will be used for dispersion.

Ecology may develop guidance for representing multiple impervious reverse slope sidewalks in a project site. If such guidance is not forthcoming, in situations where multiple impervious reverse slop sidewalks will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Minimal Excavation Foundations – BMP T5.19

- Where residential roof runoff is dispersed on the up gradient side of a structure in accordance with the design criteria and guidelines in BMP T5.10C, the tributary roof area may be modeled as pasture on the native soil.
- In "step forming," the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards. Where "step forming" is used on a slope, the square footage of roof that can be modeled as pasture must be reduced to account for lost soils. The following equation (suggested by Rick Gagliano of Pin Foundations, Inc.) can be used to reduce the roof area that can be modeled as pasture.

$$A_1 - \frac{dC(.5)}{dP} \text{ X } A_1 = A_2$$

A_1 = roof area draining to up gradient side of structure

dC = depth of cuts into the soil profile

dP = permeable depth of soil (The A horizon plus an additional few inches of the B horizon where roots permeate into ample pore space of soil).

A_2 = roof area that can be modeled as pasture on the native soil. The rest of the roof is modeled as impervious surface unless it is dispersed in accordance with the next bullet.

- If roof runoff is dispersed down gradient of the structure in accordance with the design criteria and guidelines in BMP T5.10C, AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in BMP T5.13, the tributary roof areas should be modeled as a lateral flow impervious area. This is done in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

  Ecology may develop guidance for representing multiple downspout dispersions in a project site. If such guidance is not forthcoming, in situations where multiple downspout (down gradient) dispersions will occur, Ecology may allow the roof area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Full dispersion – BMP T5.30

If BMP design criteria in Book 2 are followed, the area draining to the BMP is not entered into the runoff model.

Full downspout infiltration – BMP T5.10A and BMP T5.10B

If BMP design criteria in Book 2 are followed, the area draining to the BMP is not entered into the runoff model.

Rainwater Harvesting – BMP T5.20

If BMP design criteria in Book 2 are followed, the area draining to the BMP is not entered into the runoff model.

Newly planted trees – BMP T5.16

If BMP design criteria in Book 2 are followed, the total impervious/hard surface areas entered into the runoff model may be reduced by an amount indicated in the criteria for the BMP in Book 2.

Retained trees – BMP T5.16

If BMP design criteria in Book 2 are followed, the total impervious/hard surface areas entered into the runoff model may be reduced by an amount indicated in the criteria for the BMP in Book 2.

Perforated Stub-out Connection – BMP T5.10D

Any flow reduction is variable and unpredictable. No computer modeling techniques are allowed that would predict any reduction in flow rates and volumes from the connected area.