BACKGROUND ON THE LID DRAFT CHAPTER: Methodology for the Stormwater Detention Volume Reductions, Native Vegetation Retention, and Maximum Impervious Surface Standards Table

The standards for minimum stormwater detention volume reductions in the low impact development (LID) table were developed based on a combination of soil infiltration rates, assumptions about the average densities in various rural, urban, commercial, and industrial settings, and the results of stormwater modeling scenarios using Western Washington Hydrology Model (WWHM) software.

The initial standard evaluated was Department of Ecology's 65/10/0 rule for allowing full dispersion of developed project runoff. The 65/10/0 standard was meant to apply to rural settings where the standards include: a minimum of 65% vegetation preserved or replanted, a maximum of 10% impervious surface coverage, and 0% effective impervious surface coverage. During preliminary conversations between AHBL, the Puget Sound Partnership (PSP), Washington State University Extension, and Department of Ecology it was determined that the 65/10/0 rule was likely an unattainable goal in most urban development scenarios. Therefore, the project team worked to develop a sliding scale of stormwater management goals with the understanding that the minimum LID standards must balance urban density requirements mandated under the Growth Management Act (GMA), while minimizing the impacts of stormwater runoff to receiving waters.

The project team consensus was that maintaining a percentage of the development site in native open space should be a primary goal of LID projects. The minimum native vegetation retention and maximum impervious surface standards in the table were developed by reviewing existing coverage limitations in a variety of jurisdictions for different zone designations and by assuming reasonable additional requirements for an LID project taking into account typical lots in a variety of rural, commercial, and industrial zones.

The reduction in conventional detention storage volumes required for a project was developed by modeling several development scenarios using WWHM and applying assumptions intended to mimic a typical development. The modeling was done for both commercial and residential developments with varying densities. In order to calculate detention volume reduction, it is necessary to calculate the required detention storage volume for a conventionally designed project. Therefore, a second table was developed to give the designer assumed conventional surface areas for modeling. This second table was developed based on similar impervious surface tables found within several adopted stormwater management manuals. The project goals were further defined by assuming different average site soil infiltration rates and determining how that affected reductions in detention volume that could be obtained through reasonable LID implementation (i.e., implementation of commonly used LID techniques such as bioretention and pervious pavement). The following section details several of the project scenarios and assumptions that were modeled for the development of the LID tables. All modeling was conducted using guidance from Chapter 7 of the *LID Technical Guidance Manual*

for Puget Sound, 2005 and Appendix III-C of the *Stormwater Management Manual for Western Washington*, 2005.

Modeling Scenarios/Assumptions/Detention Volume Reductions

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4 DU/ACRE (gross)

Total Site Area = 435,600 sf (10.000 ac)

Native Growth Area = 152,460 sf (3.500 ac)

Dispersed Area = 27,240 sf (0.625 ac)

Total Area Input to Model = 255,900 sf (5.875 ac)

Road Area = 28,424 sf (0.653 ac)

(24 foot impervious road with 2-40' radius cul-de-sacs)

Public Sidewalk = 6,400 sf (0.147 ac)

(Pervious surface modeled as 3,200 sf impervious and 3,200 sf landscape)

Driveways

24(18'x24') + 16(18'x29') = 18,720 sf

(Pervious surface modeled as 9,360 sf impervious and 9,360 sf landscape)

Private Walkways & Patio

34(300 sf) + 40 (30'x3') = 13,800 sf

(Patios from 6 lots assumed to be fully dispersed in native growth area. Pervious surface modeled as 6,900 sf impervious and 6,900 sf landscape)

Roof Area

34(1,650 sf) = 56,100 sf

(Roof Area from Lots 12 – 17 assumed to be fully dispersed in native growth area

Swale Area

685 lf – 16(27') for driveways + 172 for center of c.d.s.= 425 lf

Swale is assumed 4 ft bottom width with 3:1 side slopes and a total depth of 18 inches and a max design depth of 9 inches. Swale is lined with a minimum of 2 feet of engineered soil mix.

Center of c.d.s. bottom radius if 10.5' with area of 346 sf equivalent to 86 lf of swale with 4' bottom width. Two c.d.s. results in total additional swale length of 172 lf.

8.5'x425' = 3,612 sf pond area

13'x425' – 3,612 sf = 1,913 sf pasture

Detention Pond Area

10,890 sf (0.250 ac) pond

Remaining Landscape Area

255,900 sf – (28,424 + 6,400 + 18,720 + 13,800 + 56,100 + 5,525 + 10,890) = 116,041 sf (2.664 ac)

Assume 25% of the area is pasture for soil rehabilitation.

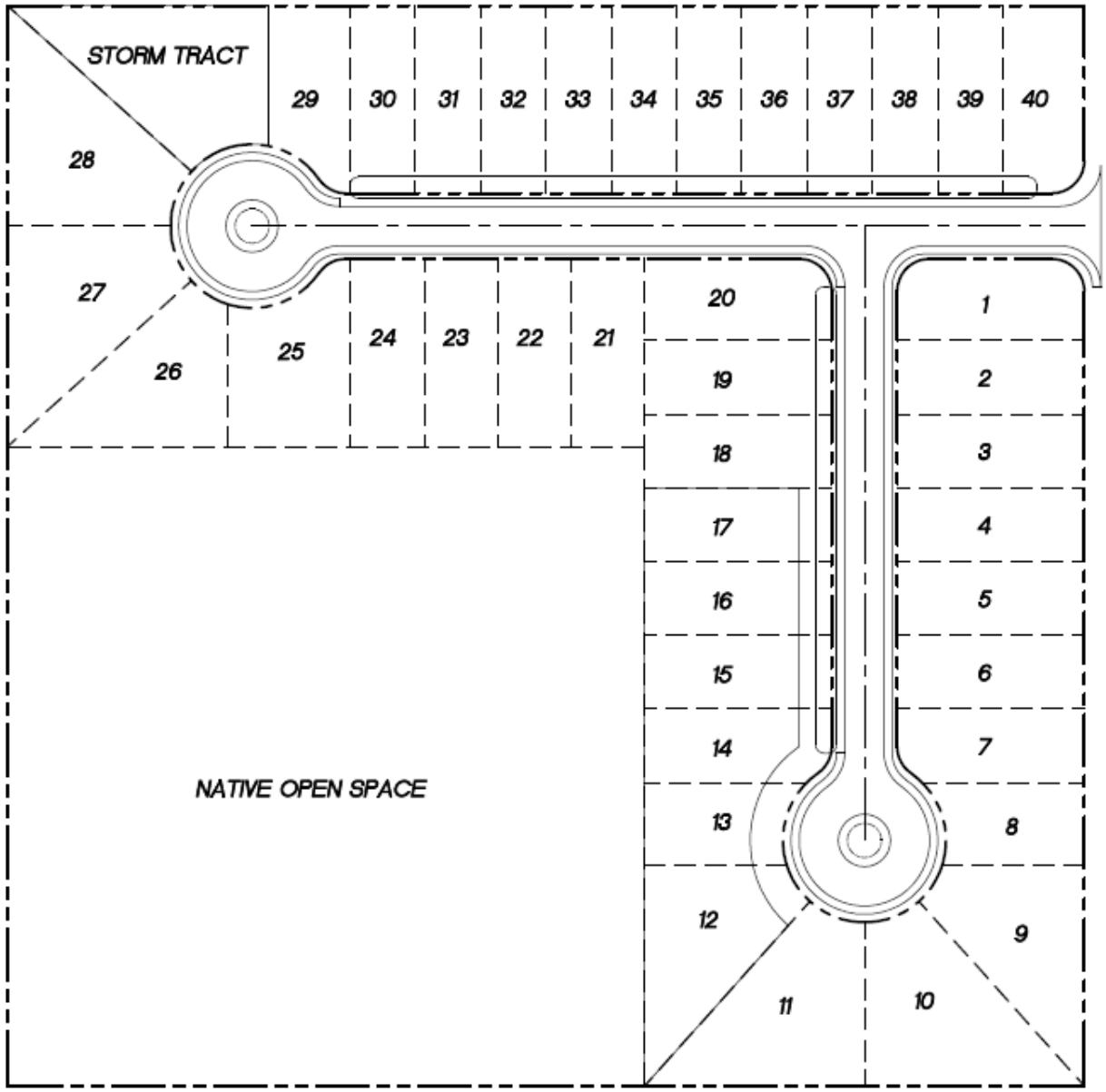
WWHM Inputs

	Impervious (ac)	Landscape (ac)	Pasture (ac)	Pond (ac)	Forest (ac)	Total (ac)
Pre-LID	-	-	-	-	5.875	5.875
Post-LID	2.387	2.445	0.710	0.333	-	5.875
Pre-Conventional	-	-	-	-	10.000	10.000
Post-Conventional	3.885	5.365	-	0.750	-	10.000

Results

	0.05 in/hr	0.10 in/hr	0.30 in/hr	1.00 in/hr
Conventional (ac-ft)	2.902	2.902	2.902	2.902
LID (ac-ft)	1.460	1.353	1.067	0.599
% Reduction	49.69%	53.38%	63.23%	79.36%

The drawing below is meant to be a very rough schematic of site and storm features. This drawing reflects a concept site with assumptions made on layout and topography. As such, the drawing was not modified or fine tuned for each site scenario modeled.



6 DU/ACRE (gross)

Total Site Area = 435,600 sf (10.000 ac)

Native Growth Area = 87,120 sf (2.000 ac)

Dispersed Area = 21,730 sf (0.499 ac)

Total Area Input to Model = 326,750 sf (7.501 ac)

Road Area = 29,384 sf (0.675 ac)

(24 foot impervious road with 2-40' radius cul-de-sacs)

Public Sidewalk = 6,602 sf (0.147 ac)

(Pervious surface therefore modeled as 3,301 sf impervious and 3,301 sf landscape)

Driveways

35(18'x24') + 25(18'x29') = 28,170 sf

(Pervious surface therefore modeled as 14,085 sf impervious and 14,085 sf landscape)

Private Walkways & Patio

50(300 sf) + 60 (30'x3') = 20,400 sf

(Patios from 10 lots assumed to be fully dispersed in native growth area. Pervious surface therefore modeled as 10,200 sf impervious and 10,200 sf landscape)

Roof Area

45(1,200 sf) = 54,000 sf

(Roof Area from 15 lots assumed to be fully dispersed in native growth area

Swale Area

725 lf – 25(27') for driveways + 116 for center of c.d.s. + 100 for rain garden= 266 lf

Swale is assumed 6 ft bottom width with 3:1 side slopes and a total depth of 18 inches and a max design depth of 9 inches. Swale is lined with a minimum of 2 feet of engineered soil mix.

Center of c.d.s. bottom radius if 10.5' with area of 346 sf equivalent to 58 lf of swale with 6' bottom width. Two c.d.s. results in total additional swale length of 116 lf.

Add rain garden prior to detention pond. Assume 600 sf bottom area, equivalent to 100 lf of swale.

Detention Pond Area

16335 sf (0.375 ac) pond

Remaining Landscape Area

326,750 sf – (29,384 + 6,602 + 28,170 + 20,400 + 54,000 + 15,720) = 172,474 sf (3.959 ac)

Assume 25% of the area is pasture for soil rehabilitation.

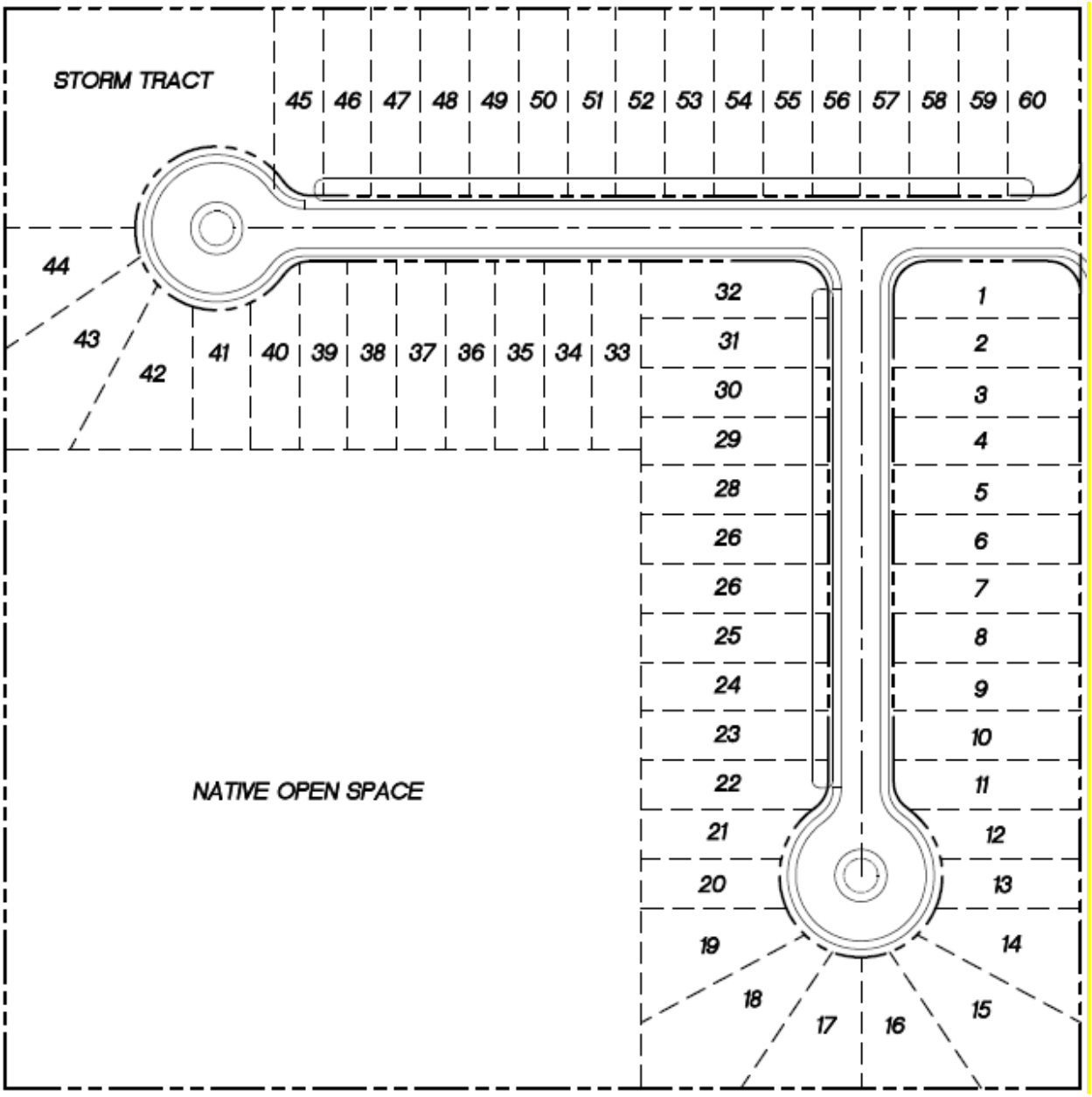
WWHM Inputs

	Impervious (ac)	Landscape (ac)	Pasture (ac)	Pond (ac)	Forest (ac)	Total (ac)
Pre-LID	-	-	-	-	7.501	7.501
Post-LID	2.547	3.589	0.990	0.375	-	7.501
Pre-Conventional	-	-	-	-	10.000	10.000
Post-Conventional	5.000	5.000	-	-	-	10.000

Results

	0.05 in/hr	0.10 in/hr	0.30 in/hr	1.00 in/hr
Conventional (ac-ft)	3.062	3.062	3.062	3.062
LID (ac-ft)	1.862	1.813	1.585	1.108
% Reduction	39.19%	40.79%	48.23%	63.81%

The drawing below is meant to be a very rough schematic of the site and storm features. This drawing reflects a concept site, as many assumptions were made on layout and topography. As such, the drawing is not scaled or fine tuned for each site scenario modeled.



Commercial

Total Site Area = 87,120 sf (2.000 ac)

Native Growth Area = 8,712 sf (0.200 ac)

Total Area Input to Model = 78,408 sf (1.800 ac)

Roof Area = 15,200 sf (0.349 ac)

Sidewalk = 4,050 sf (0.093 ac)

(Pervious surface therefore modeled as 2,025 sf impervious and 2,025 sf landscape)

Pavement Area = 32,737 sf (0.752 ac)

Swale Bottom Area = 4,400 sf

(equivalent to 8'x550' swale, 6,050 sf pond 2,200 sf pasture)

Detention Pond Area = 6,000 sf

Remaining Landscape Area

78,408 sf – (15,200 + 4,050 + 32,737 + 6,050+ 2,200 + 6,000) = 12,171 sf

WWHM Inputs

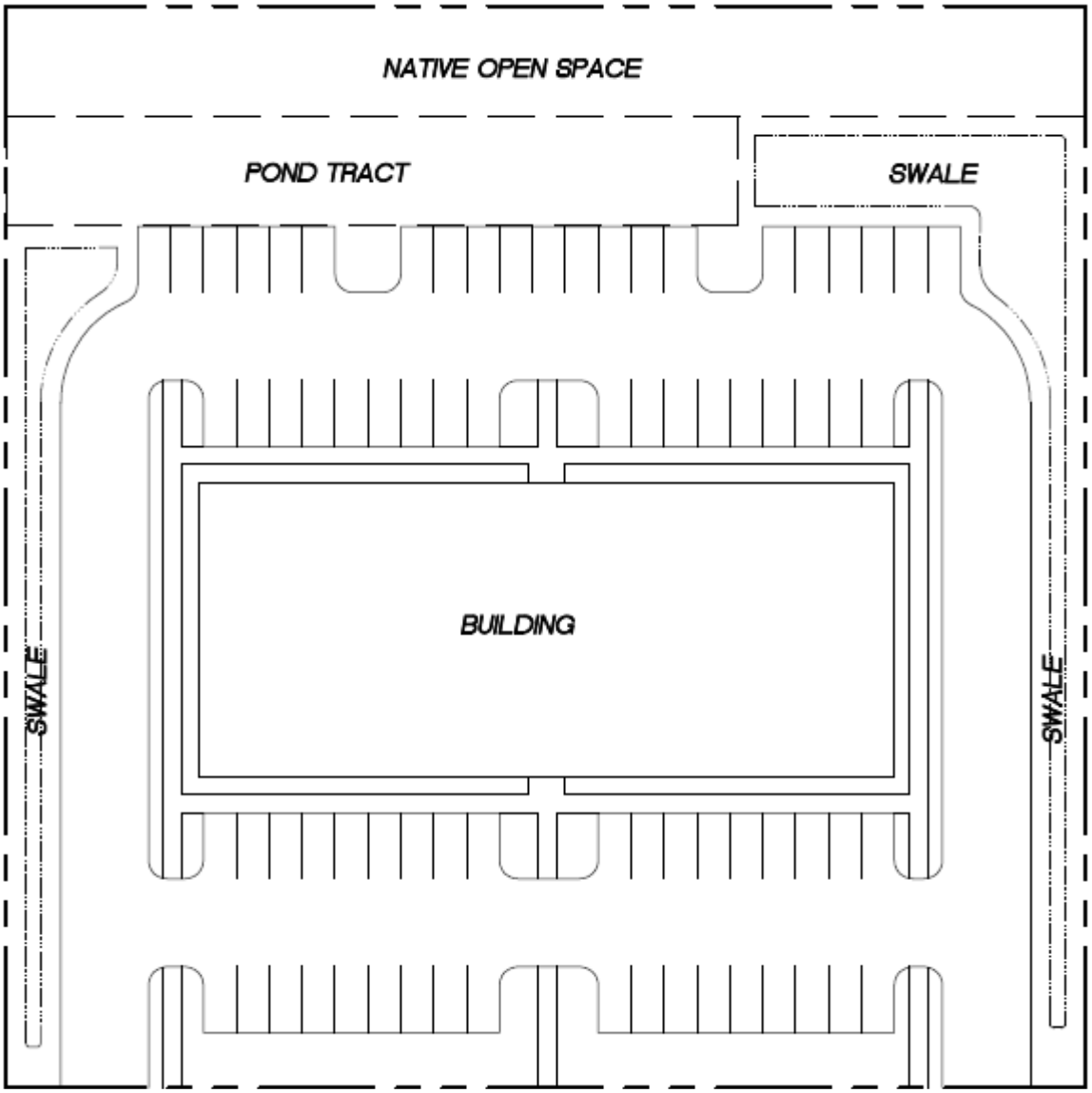
	Impervious (ac)	Landscape (ac)	Pasture (ac)	Pond (ac) [1]	Forest (ac)	Total (ac)
Pre-LID	-	-	-	-	1.800	1.800
Post-LID	1.147	0.326	0.050	0.277	-	1.800
Pre-Conventional	-	-	-	-	2.000	2.000
Post-Conventional	1.295	0.555	-	.15.	-	2.000

1: The post-LID pond area is larger than the post-Conventional pond area because the swale area was input into an older version of WWHM as pond area, as shown in the swale assumptions above, in addition to the conventional detention pond that is required. At the time that this modeling was performed, the live storage area of the swales needed to be designated as pond area in the basin description. The current WWHM3 model allows the swale areas to be defined as a detention facility that provides infiltration and receives direct precipitation and evapotranspiration. Therefore, the swale areas do not need to be included as ponds in the basin description, resulting in a smaller defined pond area in the LID scenario.

Results

	0.05 in/hr	0.10 in/hr	0.30 in/hr	1.00 in/hr
Conventional (ac-ft)	0.795	0.795	0.795	0.795
LID (ac-ft)	0.496	0.381	0.168	0.000
% Reduction	37.61%	52.01%	78.87%	100%

The pond is eliminated in the 1 inch per hour scenario resulting in a swale equivalent length of 1000 feet. The rough site plan below depicts the scenario for 0.3 in/hr and below. The drawing is meant to be a very rough schematic of the site and storm features. This drawing reflects a concept site, as many assumptions were made on layout and topography. As such, the drawing is not modified or fine tuned for each site scenario modeled. The model that the rough schematic is based on, was derived from a single swale length for the 0.05 through 0.3 in/hr. A pond was not needed for the 1.00 in/hr, and it was therefore removed from the assumptions and swale was added where the pond was assumed for the other scenarios.


NATIVE OPEN SPACE
POND TRACT
SWALE
BUILDING
SWALE
SWALE

Commercial Project #2

The following is an analysis of Low Impact Design techniques for a typical strip-mall type commercial development. The proposed site plan is based on an actual commercial development in Pierce County. The following assumptions were used:

- The Western Washington Hydrology Model (WWHM) was used to predict stormwater runoff rates and volumes.
- The site is assumed to be located in Kirkland.
- Site soils are assumed to be till with a long term design infiltration rate of 0.25 inches per hour.
- Pervious pavements are modeled as 50% impervious surface and 50% grass.
- Green roofs are modeled as 50% impervious and 50% grass.
- Detention is provided via an underground vault within the pavement area.
- Existing conditions are modeled as forest.
- Proposed conditions are based on the attached site plan. The areas are summarized in the table below.

Surface Type	Area (acre)
Building Roof Area	0.156
Sidewalk Area	0.043
Asphalt/Concrete Area	0.467
Landscape Area	0.254
Total Area	0.920
% Impervious	72.39%

Five scenarios were modeled; the following is a description of each scenario:

Scenario #1 – This scenario assumes standard asphalt and concrete pavements drained to a conventional conveyance system.

Scenario #2 – Perimeter landscaped areas are depressed to function as rain gardens (bio-retention). A bottom surface area of 1500 square feet is assumed with a maximum surface ponding depth of 6-inches. The rain gardens are lined with 18-inches of treatment soil with a void ratio of 40% resulting in a total effective storage depth of (0.4x18") + 6" = 13.2 inches (1.1 feet)

Scenario #3 – Pervious pavements are used for driving and parking surfaces. The sidewalk around the building is impervious concrete. No bio-retention is provided.

Scenario #4 – This scenario is a combination of #2 and #3.

Scenario #5 – Is the same as #4 with the addition of a green roof.

The following table summarizes required detention volumes for each scenario.

Scenario	Detention Volume (cf)	% Reduction
#1	13,035	n/a
#2	7,795	40.20%
#3	9,576	26.54%
#4	4,713	63.84%
#5	4,758	63.50%

Scenario #5 appears to show that the detention volume reduction benefit of the green roof for this particular site plan is minimal, and within the error range for the model.

Treatment requirements were not analyzed.

The drawing below is meant to be a very rough schematic of the site and storm features. This drawing reflects a concept site, as many assumptions were made on layout and topography. As such the drawing is not scaled or fine tuned for each site scenario modeled.