



Harmony at Arlington LLC.  
7417 204th St NE, Arlington, WA 98223  
PLN# GIM 1084  
1<sup>st</sup> Submittal: June 2024

**Stormwater Site Plan Report  
for  
Harmony at Arlington**

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**06/11/2024**

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# Section 1 – Summary and Minimum Requirements

## 1.1 Project Description

Harmony at Arlington, a proposed townhome community will reside on a 3.21-*acre* lot in the City of Arlington. The development is located on Parcel Number 310511-003-040-00 and bears the address 7417 204th St NE, Arlington, WA 98223. The development will contain 2.33-*acres* impervious surface of which 1.16-*acres* will be pollution generating and 1.17-*acres* will be non-pollution generating impervious surface.

The project will utilize bioretention swales for stormwater mitigation of driveway, aisle, and parking. Swales will be located around the perimeter for stormwater infiltration. Stormwater will sheet flow to the nearest swale. Stormwater generated from the rooftops will be directed to downspouts and collection system. The roof drain collection system will be excavated to native sand soils and backfilled with clean rock. The site will fully infiltrate 100% of the stormwater runoff model.

The development of the parcel will conform to the requirements set forth in Arlington Municipal Code (AMC).

## 1.2 Project Data Summary:

Existing and proposed project areas are presented in Table 2 for determination of stormwater management requirements based on prescribed thresholds as outlined in the AMC 13.28.

## 1.3 Construction Activities

The site has been used for single-family residence but has changed uses and land coverage many times through the years. The site has been vacant for at least a dozen years now.

The site is relatively flat and fill will be brought into the site to match the neighboring developments grades. Minimal excavation will occur except for utility and stormwater management installations. Gravel base and asphalt will be imported to create the parking, roadway, and driveways. Organic strippings stockpiled on site will be used for soil amendments.

Project disturbance area is 3.35-*acres*. A separate document titled **Construction Stormwater Pollution Prevention Plan for Harmony at Arlington** will detail construction methods for eliminating pollution.

**Table 1 – Project Location Data**

<b>Project Data:</b>	
Applicant	Harmony at Arlington LLC.
Project Name	Harmony at Arlington
Project T.S.R. Location	SW 1/4 of Section 11, Township 31 N, Range 5 W
Project Address	7417 204th St NE, Arlington, WA 98223
Parcel ID(s)	310511-003-040-00
Watershed	Mainstem Stillaguamish
WRIA number	5
Basin	Stillaguamish
Sub-Basin	Portage Creek

**Table 2 - Project Theshhold Data Summary**

<b>Project Data:</b>	
Project Name	Harmony at Arlington
<b>Existing Conditions:</b>	
Total Site Area	140,025 sf (3.21ac)
<b>Proposed Activity:</b>	
Proposed Activity	Townhomes
Proposed Clearing Area (Total)	146,070 sf (3.35 ac)
Proposed Grading Area (Total)	146,070 sf (3.35 ac)
Proposed New NPGIS (Total)	50,808 sf (1.17 ac)
Proposed New PGIS (Total)	50,755 sf (1.16 ac)
Proposed Replaced Impervious Area	0 sf (0.0000 ac)
Native Vegetation convert to Lawn	0 sf (0.0000 ac)
Native Vegetation convert to Pasture	0 sf (0.0000 ac)
Total New Impervious Area (Total)	<b>101,563 sf (2.33 ac)</b>
Proposed Disturbance Area	<b>146,070 sf (3.35 ac)</b>
<b>Project Qualification:</b>	
Development Type	<b>New Development</b>
Minimum Requirements	<b>1 thru 10</b>

## 1.4 Minimum Requirements and Thresholds

The project qualifies as new development under Volume I, Chapter 2 of the 2019 DOE Stormwater Management Manual for Western Washington (SMMWW). The SMMWW is specified as the governing document for stormwater management per AMC 13.28.150. This specifies compliance with Minimum Requirements 1-10 of the SMMWW.

Harmony at Arlington requires a full stormwater site plan and compliance with the minimum requirements set forth in the SMMWW.

A full construction SWPPP is required. The SWPPP is provided as a separate stand-alone document titled **Construction Stormwater Pollution Prevention Plan for Harmony at Arlington**

### Minimum Requirements

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems and Outfalls
5. On-site Stormwater Management
6. Runoff Treatment
7. Flow Control
8. Wetlands Protection
9. Operation and Maintenance

Minimum Requirements are addressed sequentially in this document.

## Section 2 - MR-1: PREPARE STORMWATER SITE PLAN

### 2.1 Existing Site Conditions

#### 2.1.1 Site Location

The project is located in the southwest quarter of Section 11 in Township 31 North, Range 5 West. The site's address is 7417 204th St NE, Arlington, WA 98223.

The location of the site is shown in Figure 1 below. The parcel is located at the address of 7417 204th St NE, Arlington, WA 98223 behind Starbucks and the Bartell Drugstore at the corner of 204<sup>th</sup> St and Highway 9. The project is located in the Stillaguamish watershed (WRIA-5), in the Portage Creek Sub-Basin.

#### 2.1.2 Site Description

The site has a total area of 140,025-square feet (3.21-acres). The property is zoned Commercial Corridor and its current use is listed as 'Vacant.

#### 2.1.3 Vegetative Cover

The development area is predominately pasture or unvegetated. Some trees are located along the north side of the parcel. An aerial photo can be seen in Section 11.1 as Figure 2.

#### 2.1.4 Topography

The pre-developed existing topography both onsite and offsite was evaluated using LiDAR generated surfaces. The average slope as indicated by the LiDAR model is 0.8% through the parcel. A berm appears to have been constructed along the north edge of the parcel adjacent to the stream corridor. No structures will be placed along this berm but a open space path will be placed along the top edge for residents. The site slopes to the west with a low point along the west boundary line towards the north corner. The banks and edges of this stream corridor have been built up over the years by neighboring parcels as well. The dike along the stream corridor is not consistent between parcels and in some cases prevents surface flow from reaching the stream.

The site topography is generally flat within the development area.

#### 2.1.5 Critical Areas

Portage Creek is located to the north of the site within Parcel A of the Binding Site Plan. Parcel A will be dedicated to the City of Arlington. There are no known wetlands or critical areas within the development area.

An existing conditions map is presented in Figure 2.

## 2.1.6 Soils

The NRCS Soil mappings for the site consist of Norma loam. NRCS aerial photograph of the soil mappings can be seen in Figure 3.

Norma loam and soils with a weathered layer represents “B/D” type hydrologic soils that range in depth from about 0 to 60 *inches*. Below that is recessional outwash sand. Extensive grading appears to have occurred in the past so surface soils may vary greatly from the NRCS mappings.

Analysis of the site indicates a silty sand and silty gravel layers underlain by fine to coarse sand with silt. This is typical of geologic studies of the site area which define the site as the Marysville Sand Member consisting of well-drained outwash sand.

A geotechnical report by PBS indicates medium to coarse sand at a depth of about 1-2 feet to 7.5 feet below grade. (PBS Engineering & Environmental, 2024) Groundwater elevation is deep, exceeds 9-feet BGS. A PIT test was conducted in test pits 1 and 2. Soils were consistent throughout the site. Long-term infiltration rate with correction is 12.0 inches/hour. For systems utilizing bioretention, the siltation correction factor could be eliminated and long-term rates increased. However, the bioretention soils are limited to 12-inches/hour and increasing the rate beyond this would not provide any measurable effect. Long-term infiltration rate of 12-inches/hour will be used for a conservative stormwater design across the site.

## 2.1.7 Existing Basin Analysis

The project falls within the Stillaguamish Basin that is a portion of the Mainstem Stillaguamish Watershed. The project falls within the Portage Creek Sub-Basin. The development area lies in what is colloquially called the Marysville Trough. The trough runs north to south and encompasses flat terrain west of Highway 9 and East of the Lakewood/Tulalip areas. The site is situated in the northwestern extent of this system.

It is assumed and highly likely that the entirety of this area is drained through groundwater and the groundwater gradient to the Portage Creek stream system. No discrete drainage systems drain the site but surface flow is to the west – northwest. The site will drain to Portage Creek on the north side of the site but may require a subsurface route to reach the creek. The creek channels have been built up with what appears to be berms or dikes in an uncoordinated effort between landowners. It is not known if this is the result of clearing activities on individual parcels or if there is flooding concerns historic property owners were trying to alleviate. It is presumed that this is the result of clearing activities only. Portage Creek drains to the Stillaguamish River before reaching Puget Sound.

There are no known drainage issues immediately downstream of the parcel.

There are no known flooding or erosion concerns adjacent to the site.

## 2.1.8 Upstream Analysis

There is no large expansive upstream area to the development site. The area is relatively flat. Small portions of run-on may occur from the site perimeter and Highway 9 sheet flow. Upstream areas are routed through Portage Creek in the north.

## 2.1.9 Existing Drainage

The site topography trends westward. Due to the presence of outwash soils, surface runoff is not expected to occur. There appears to be no existing discrete drainage systems on-site or offsite.

## 2.1.10 Downstream Analysis

The site will largely infiltrate all stormwater except for extremely large storms following storm events that overwhelm an already saturated groundwater system. The following is a theoretical assessment of the drainage pathways assuming surface runoff occurs and recognizing the built-up berms downstream from the site preventing stormwater to reach the creek.

The site drains to the sites west boundary along the northern portion of the west parcel line. The low point along this west point is at roughly 119.60-feet MSL. Overflow from the sites bioretention cells will be directed to this downstream property following the natural, pre-existing path. This route will be armored with rip-rap in the event of emergency overflow.

Beyond this low point, stormwater will flow westward into the site to a confined low point that is disconnected from any downstream path. Stormwater will need to pond before overtopping and draining to Portage Creek to the northwest. Portage Creek flows west before reaching the Stillaguamish River. See Figure 4.

There are no known drainage issues immediately downstream.

The project is not expected to alter hydrology to Portage Creek while discernibly posing no altered hydrology to the Stillaguamish River/Puget Sound.

## Section 3 – MR-2: Stormwater Pollution Prevention Plan

### 3.1 Storm Water Pollution Prevention Plan

A Storm Water Pollution Prevention Plan (SWPPP) has been prepared for this project and presented as a separate document titled “**Stormwater Pollution Prevention Plan for Harmony at Arlington**”, 10-Jun-2024

## Section 4 - MR-3: Source Control of Pollution

Per the 2019 SMWW Volume-I, Ch-2.5.3, source control BMPs are required for all development projects for the intended purpose to prevent stormwater from coming in contact with pollutants. The activities and the associated source control BMPs are listed in Volume-IV of the manual. These are primarily commercial industrial developments that involve significant pollutant generation potential. The proposed stormwater facilities addressed in this report manage stormwater generated from passenger vehicle parking and non-pollution generating rooftop from residential development. No source control BMPs apply to these facilities controlling stormwater from these surfaces.

No Volume-IV source control BMPs are specified.

For construction activities, source control BMPs prescribed in Volume-II are specified and described in the construction SWPPP per MR#2.

## **Section 5 - MR-4: Preserve Natural Drainage Systems and Outfalls**

All drainage courses are to be preserved to the maximum extent feasible. All outfalls will remain in their current locations. Natural drainage patterns as they once existed shall be retained. Pre-developed conditions experience a sheet flow drainage pattern to the sites western boundary and infiltration. The developed site is designed to direct flows to maintain the hydrology at the same boundary while fully infiltrating stormwater flows. Stormwater flows that exceed the infiltrative capacity of soils will be under emergency conditions and will discharge to the low point along the west side of the site.

## Section 6 - MR-5: On-site Stormwater Management

Minimum Requirement #5 specifies requirements for on-site stormwater BMPs. This requirement mandates that on-site stormwater runoff be infiltrated, dispersed, and/or retained to the maximum extent feasible without causing flooding or erosion impacts. Projects triggering Minimum Requirements 1 through 5 must use On-site stormwater management BMPs from List #1 for all surfaces or demonstrate compliance with the LID Performance Standard. Projects triggering Minimum Requirements 1 through 9 must meet the requirements of Table 2.5.1 in Vol. 1 of the 2019 SMMWW. Table 2.5.1 specifies the requirements for new or redevelopment depending on UGA and parcel size to meet the requirements of the LID Performance Standard and/or List #2. List #1 and List #2 specify stormwater BMPs in order of preference. The first BMP determined feasible is required.

This project trigger MR's 1-9. This project is within the City's UGA. This project is required to adhere to the LID Performance Standard or List #2 per Table 2.5.1.

List #1 and #2 contain appropriate BMPs to mitigate a particular developed surface. The surfaces included in the list are Lawn and Landscaped Areas, Roofs, and other hard surfaces (road/driveway/parking).

Lawn/Landscape is required to utilize BMP T5.13, Post-Construction Soil Quality and Depth.

Roofs are required to employ BMP T5.30 Full Dispersion or Downspout Infiltration, Rain Gardens or Bioretention, BMP T5.10A Downspout Dispersion Systems, or perforated stub-out connections. The first feasible BMP in this list must be used.

Other Hard surfaces (Roads, Driveways, Parking Lots, Etc.) must utilize BMP T5.30 Full Dispersion, BMP T5.15 Permeable Pavement, Bioretention, Sheet Flow Dispersion, or Concentrated Flow Dispersion. The first feasible BMP in this list must be used.

Roofs will not be able to provide BMP T5.30 Full Dispersion. Full Dispersion requires 100 *foot* flow paths within native areas. The project will not be able to maintain 65% open space while also complying with the Growth Management Act and the City's comprehensive plan. There is not adequate space for the Full Dispersion requirements while meeting other facets of code. Roofs will be routed to Downspout Infiltration facilities which is the next feasible alternative (BMP T5.10A).

Driveways and parking will be routed to Bioretention areas. Bioretention used to meet MR #5 will be designed in accordance with BMP T7.30 per Page 7-3 of Vol. V of the 2019 SMMWW. Bioretention under BMP T7.30 is to be designed per the parameters of BMP T5.14 for infeasibility and design criteria as well as hydrologic modeling credits. Stormwater is released to the bioretention cells through sheet flow or a conveyance system.

A site plan showing the stormwater management and development can be seen in Figure 5.

## Section 7 - MR-6: Runoff Treatment

Minimum Requirement #6 specifies the requirements for providing runoff treatment. The threshold for requiring a treatment BMP is 5,000 *square feet* of PGIS (Pollution Generating Impervious Surface) or a total of more than  $\frac{3}{4}$  of an acre of PGPS (Pollution Generating Pervious Surface).

This project is expected to generate 50,755 *square feet* (1.16 *acres*) of PGIS based on road and driveway areas, therefore treatment facility BMPs are required for this project.

Runoff treatment facility selection is outlined in Vol. I, Ch. 4.2, Step V of the 2019 SMMWW. Step V outlines the treatment facility selection flow chart based on the intended use of a project. Treatment selection is based on if the site is a high-use site, if the downstream receiving waters are phosphorous sensitive, and/or if the site is required to provide enhanced treatment. The definitions of high-use, phosphorous control, and enhanced treatment can be found in Step V in Section 4.2 of the 2019 SMMWW.

The project is not a high use site.

The project is not required to treat for phosphorous.

Enhanced treatment is not required for the project.

Basic treatment is required per Vol. I, Ch. 2 & 4 of the 2019 SMMWW.

Enhanced and Basic treatment is provided through the use of a bioretention facility per Vol. III Section 3.3.12 of the 2019 SMMWW. The bioretention specified will provide enhanced treatment. The bio-cell treats stormwater through the infiltration of stormwater through soils and their ability to absorb pollutants. Soils have a CEC of greater than 5 meg/100g to a depth of 12 *inches*. On-site soils are suitable for use. See Vol III. Section 3.3.12 of the 2019 SMMWW for specific soil design criteria.

### Road, Driveway, and Parking Area

The project has PGIS areas exceeding the threshold for simple treatment BMPs. Therefore, the development is required to employ basic treatment for its respective road, driveway, and parking areas.

The project utilizes bioretention swales for treatment. The bioretention swales mitigate polluted stormwater through physical, chemical, and biological treatment processes. The treatment process reduces pollutant loads to downstream receiving waters. Pretreatment (flow entrance and presettling) is controlled by 5/8" clean chip located adjacent to the edge of asphalt along its entire length to prevent channelization of storm inflow. Stormwater then percolates through compost amended soils and plantings to obtain treatment. Stormwater flows through this part of the cell at a rate of 12.0 *inches/hour*. Infiltration is accounted for below the bio-cell at a long-term adjusted rate of 12 *inches/hour*. This infiltration rate accounts for stormwater that will rehydrate and restore pre-developed groundwater channels and accurately reflect the built condition. The total percolated runoff through the bio-cell's amended soils is well over the 91% total runoff volume treatment requirement, at 100%. See Section 12.6

## Section 8 - MR-7: Flow Control

### 8.1 Flow Control

Minimum Requirement #7 specifies the requirements for runoff flow control. The threshold for requiring Minimum Requirement #7 is 5,000 *square feet* of impervious surface. Flow control shall be provided if the project creates more than 10,000 *square feet* of effective impervious area in a threshold discharge area, converts  $\frac{3}{4}$  of an acre or more of native vegetation to lawn, 2.5 *acres* or more native vegetation is converted to pasture, or a combination of impervious and converted pervious surfaces cause a 0.1 *cfs* increase in the 100-year flow frequency from a continuous simulation runoff model.

The project exceeds this requirement and is required to provide flow control.

A total of 700 *square feet* of bioretention swale is proposed for stormwater facilities for the PGIS. The bioretention swale varies in width at its base and is surrounded by 3:1 slopes that rise 1.0 *feet*. The swale consists of 0.5 *feet* of ponded water depth and 0.5 *feet* of freeboard. The swale is constructed using 1.5 *feet* of amended soils. Sand may be made up of the existing onsite soils. A rate of 12 *inches/hour* is measured below the facilities and it should be confirmed during construction that stormwater BMPs make a continuous connection with these soils.

The bioretention swale design and construction specification follows 2019 DOE SMMWW BMP T7.30. The bioretention swale infiltrates 100% of stormwater design for the impervious areas draining to them. Bioretention swales are located adjacent to the majority of PGIS inputs throughout the site. The site is graded with the highest elevations in the east and the lowest in the west following the predeveloped topography. The bioretention swales step through the site from east to west. Overflow is directed to each bioretention swale on site through overflow risers to equalize distribution throughout before releasing to the downstream emergency system. The emergency system is not expected to be triggered unless complete failure of the system and subsurface soils occur or back-to-back storms exceeding the 100-year design storm happen.

Rooftops on site are routed to an infiltration trench. The infiltration trench is designed to be 2 *foot* thick, 2 *feet* wide and 1,525 *feet* long. The infiltration trench system is designed in accordance with BMP T5.10A for medium sand. Medium Sand soils may accept rooftop at a rate of 1,000sf per 30-lf of trench draining to them. Therefore, 1,525sf of trench is required to fully infiltrate the rooftops. The trench system will be dispersed throughout the site forming a broad infiltration field to further mitigate stormwater by LID processes. The perimeter building drain and conveyance system which would normally carry stormwater to a 'regional' facility will be composed of perforated storm pipe and backfilled with clean rock. Infiltration will take place at the source from each connection.

Downspouts will incorporate screen filters and baffles prior to discharging to the gravel filled trench. Hydrologic Analysis was conducted using the latest version of the WWHM software. Software reports are in Section 12.6. Supplementary information for the continuous simulation models is presented in Section 12.4. A site plan showing the location of bioretention swale can be seen in Section 11.1.

## Section 9 - MR-8: Wetlands Protection

There is no detention or treatment in critical areas. There are no known wetlands on-site or downstream from the site. Wetlands shall not be disturbed by the project. Protective and mitigation measures are employed through the construction stormwater pollution prevention plans.

## Section 10 - **MR-9: Operation and Maintenance**

Minimum Requirement #9 contains requirements for inspection, operation and maintenance of stormwater facilities and BMPs. Specific maintenance standards and requirements are outlined in Volume V of the 2019 SMMWW. The 2019 SMMWW requires the regular maintenance and inspection of drainage facilities.

The Operations and Maintenance manual has been prepared for this project and presented as a separate document titled **“Operations and Maintenance manual for Harmony at Arlington”, 10-Jun-2024.**

# Section 11 - Support Data

## 11.1 Maps & Figures

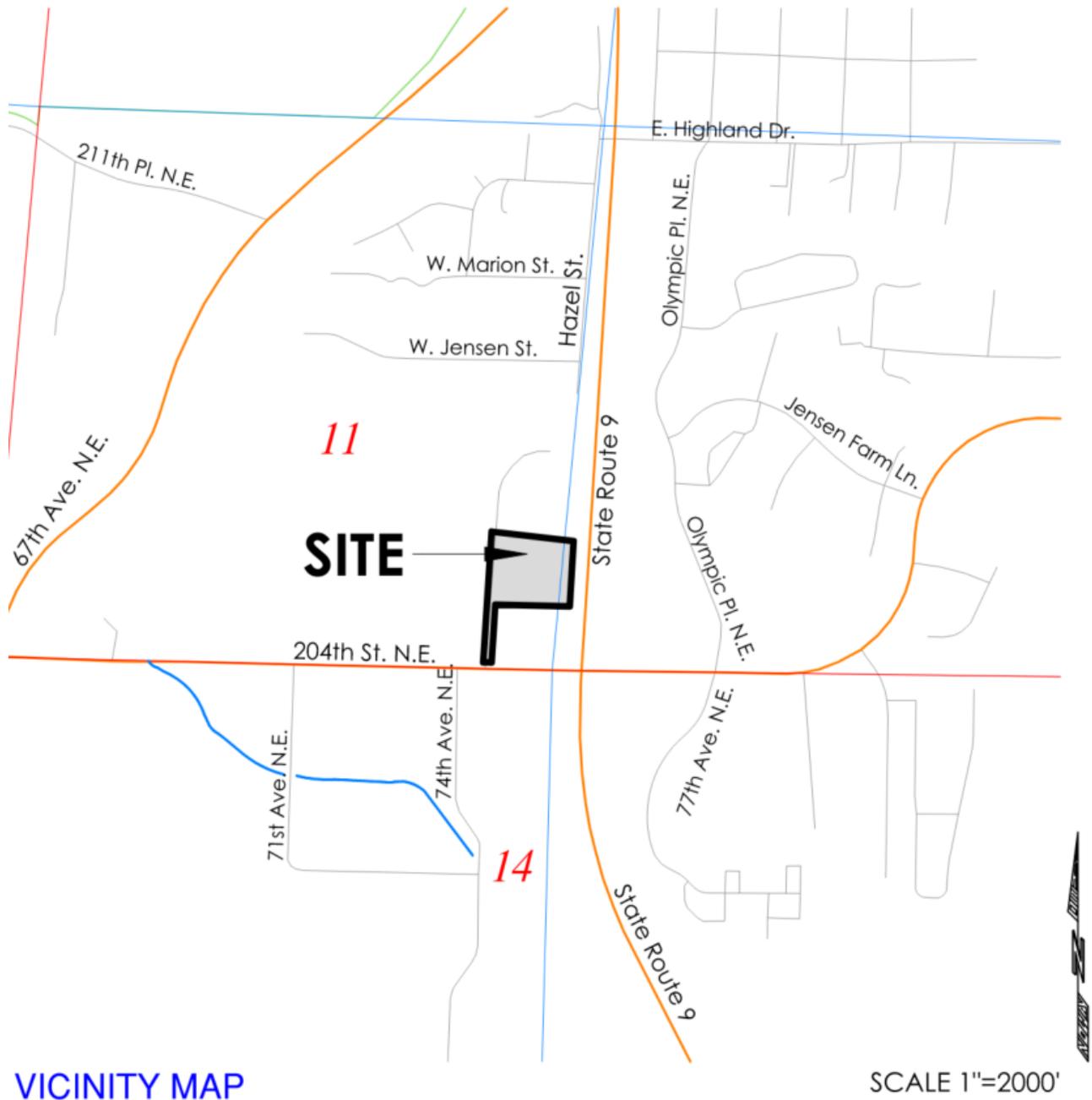


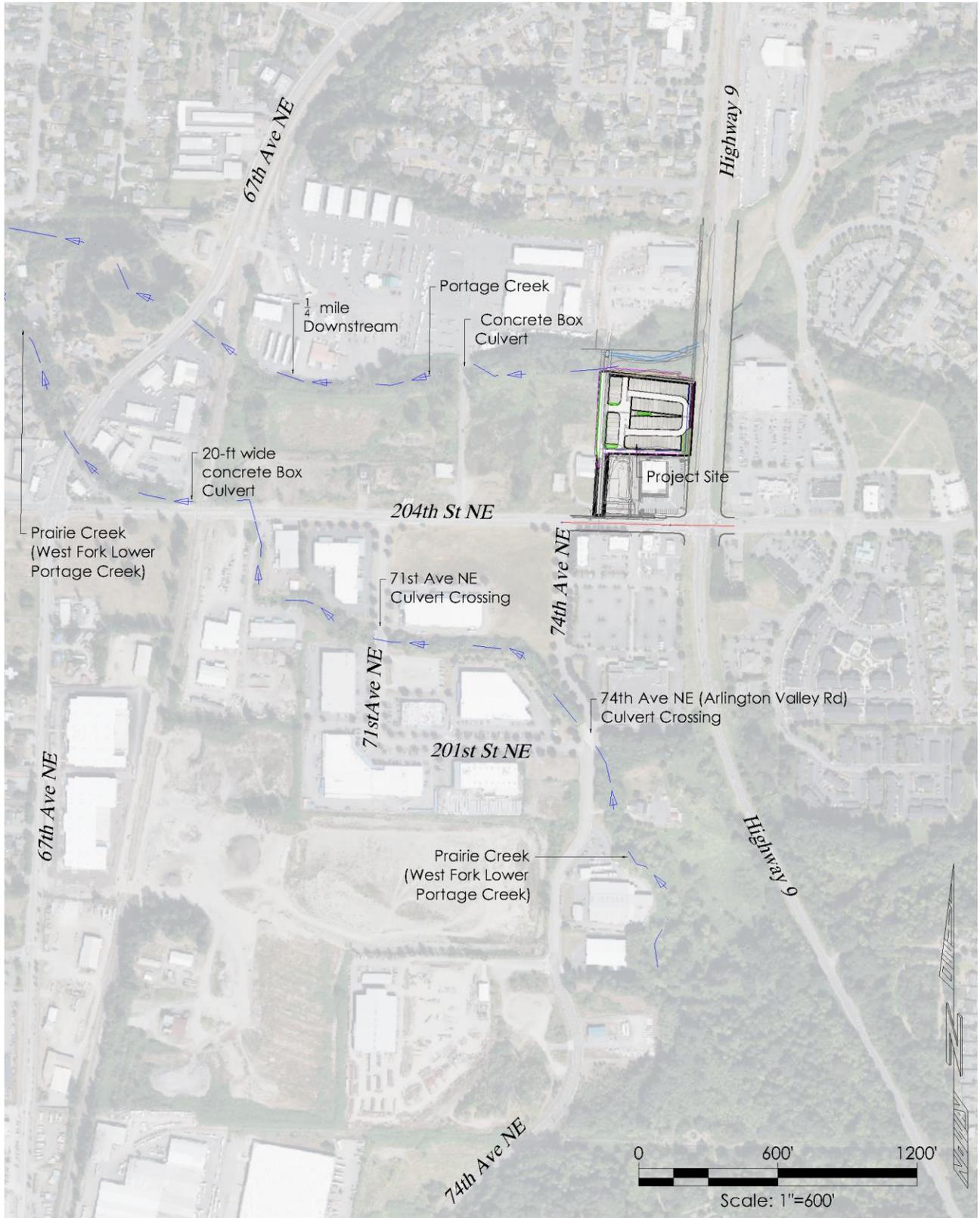
Figure 1 - Vicinity Map



**Figure 2 - Existing Conditions**



**Figure 3 - NRCS Soil Map (Not to Scale)**



**Figure 4 - Downstream Analysis**



**Figure 5 - Site Plan**

## Section 12 **Support Data**

This appendix contains the following support data as applicable to this report:

- Soils Data
- Reference Documents
- Topographic Data
- Continuous Simulation Modeling
- Software Output

## 12.1 Soils

The following data was extracted from Web Soil Survey, National Cooperative Soil Survey:

**Table 3 - Soil Table**

### 39—Norma loam

#### Map Unit Setting

*National map unit symbol: 2hyx*  
*Elevation: 0 to 1,000 feet*  
*Mean annual precipitation: 35 to 60 inches*  
*Mean annual air temperature: 48 to 52 degrees F*  
*Frost-free period: 150 to 200 days*  
*Farmland classification: Prime farmland if drained*

#### Map Unit Composition

*Norma, undrained, and similar soils: 85 percent*  
*Minor components: 15 percent*  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Norma, Undrained

##### Setting

*Landform: Drainageways, depressions*  
*Parent material: Alluvium*

##### Typical profile

*H1 - 0 to 10 inches: ashy loam*  
*H2 - 10 to 28 inches: sandy loam*  
*H3 - 28 to 60 inches: sandy loam*

##### Properties and qualities

*Slope: 0 to 3 percent*  
*Depth to restrictive feature: More than 80 inches*  
*Drainage class: Poorly drained*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)*  
*Depth to water table: About 0 inches*  
*Frequency of flooding: None*  
*Frequency of ponding: Frequent*  
*Available water supply, 0 to 60 inches: Moderate (about 9.0 inches)*

##### Interpretive groups

*Land capability classification (irrigated): None specified*  
*Land capability classification (nonirrigated): 5w*  
*Hydrologic Soil Group: B/D*  
*Ecological site: F002XA007WA - Puget Lowlands Wet Forest*  
*Forage suitability group: Wet Soils (G002XN102WA)*  
*Other vegetative classification: Wet Soils (G002XN102WA)*  
*Hydric soil rating: Yes*

#### Minor Components

##### Norma, drained

*Percent of map unit: 5 percent*  
*Landform: Depressions*  
*Other vegetative classification: Seasonally Wet Soils (G002XN202WA)*  
*Hydric soil rating: Yes*

##### Terric medisaprists, undrained

*Percent of map unit: 5 percent*

*Landform: Depressions*

*Other vegetative classification: Wet Soils (G002XN102WA)*

*Hydric soil rating: Yes*

**Bellingham, undrained**

*Percent of map unit: 5 percent*

*Landform: Depressions*

*Other vegetative classification: Wet Soils (G002XN102WA)*

*Hydric soil rating: Yes*

## Data Source Information

**Natural Resources Conservation Service**

Web Soil Survey, National Cooperative Soil Survey

7/23/2014

Soil Survey Area: Arlington, Washington (Snohomish County)

## 12.2 Reference Documents

Department of Ecology. (2005). Surface Water Management Manual for Western Washington. WA: Department of Ecology.

Federal Emergency Management Agency. (1999, November 8). Flood Insurance Rate Map Number 392 of 1575. *Snohomish County, Washington and Incorporated Areas*, Panel 1061 of 1575. Arlington, Washington.

PBS Engineering & Environmental. (2024). *Geotechnical Engineering Report - Harmony at Arlington*. Portland: PBS.

Puget Sound Action Team. (2005, January). Low Impact Development Technical Guidance Manual for Puget Sound. *Publication No. PSAT 05-03*. Washington: Washington State University - Pierce County Extension.

Puget Sound LIDAR Consortium. (2003, April). LIDAR Bare Earth DEM File. q47121h24be.e00. Snohomish County, Washington. Retrieved May 2013, from <http://pugetsoundlidar.ess.washington.edu/index.htm>

## 12.3 Topographic Data

- Snohomish County 2005 LiDAR survey was used to augment the existing site topography and the downstream and surrounding areas. Citation: LiDAR Bare Earth DEM Files: be\_48122b22.zip. Available: Puget Sound LiDAR Consortium, Seattle, WA
- Modeled coordinate system: Lateral - Washington State Plan Plane - North, FIPS 4601; Vertical – NAVD 88

## **12.4 Continuous Simulation Modeling**

### **12.4.1 Continuous Simulation Background**

HSPF based continuous simulation modeling was used to evaluate the hydrologic performances of the pre-developed and developed sub-basins in order to accurately assess flow rates.

The currently adopted continuous simulation models use the HSPF (Hydraulic Simulation Program in FORTRAN) software engine. The HSPF model uses a robust and detail accounting of the 'water budget', including evaporation, evapotranspiration, interception, interflow, and groundwater. The modeling accounts for and assesses land segment areas that include vegetation or impervious cover, soil types, and slopes. The modeling also utilizes over 50 years of continuous rainfall data (precipitation) and evaporation data for the area. The HSPF continuous modeling is considered the best available science for hydrologic analysis.

## **12.5 Modeling Methodology**

HSPF modeling was managed via the Western Washington Hydrology Model (WWHM) interface program. The current professional version of WWHM by Clearcreek Solutions, Inc., WWHM-2012 was used. The current data precipitation and evaporation set provided by DOE with the WWHM-2012 software interface was used that includes quantized data in 15-minute time steps from October 1948 to October 2009.

The WWHM program comes packaged with generic, well considered HSPF modeling parameters. These settings allow for the modeling of the majority of the topological conditions found in the Puget Sound area. Where conditions fall reasonably outside the range of the default HSPF parameters, adjustments should be made to more accurately reflect those conditions. These are generally limited to the pervious land segments (IMPLNDS) and are mostly limited to slopes (SLSUR), infiltration rates (INFILT), and length of flow path (LSUR). For this project, HSPF parameters were not adjusted to reflect site conditions.

### **12.5.1 Existing Conditions**

The surface vegetative cover is assumed forested with a flat slope. The NRCS soil maps indicate Lynnwood soils throughout the project area. For hydrologic modeling, Lynnwood soils are A type soils. Note: the predeveloped scenario for the site is included but not required since the project is complying with 100% infiltration. The comparison of predeveloped flows is for discharges to downstream conveyances. The existing site is pasture. Outside of the disturbance area, there is no land conversion.

### **12.5.2 Developed Conditions**

The site is flat and grading will consist of stripping existing soils. Roof and driveway area will be added to the developed site. These areas are accounted for and used in the WWHM program. The

remaining area of the site will be used for stormwater management. The stormwater bioretention cells will be excavated down below the sealed surface layer to allow stormwater to readily infiltrate. The bio-swale areas are accounted for in the WWHM bio-retention element and are therefore discounted from the basin area. The preceding section contains input and output of parameters relevant to the existing and developed site to achieve 100% infiltration meeting current DOE standards. CAS areas are modeled as pasture as allowed and recommended by DOE.

## 12.6 Software Output

WWHM2012  
PROJECT REPORT

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**Project Name:** Prelim SPA  
**Site Name:** Harmony at Arlington  
**Site Address:**  
**City** : Arlington  
**Report Date:** 5/14/2024  
**Gage** : Everett  
**Data Start** : 1948/10/01  
**Data End** : 2009/09/30  
**Precip Scale:** 1.20  
**Version Date:** 2023/03/31  
**Version** : 4.2.19

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**Low Flow Threshold for POC 1** : 50 Percent of the 2 Year

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**High Flow Threshold for POC 1:** 50 year

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### PREDEVELOPED LAND USE

**Name** : Basin 1  
**Bypass:** No  
**GroundWater:** No

<u>Pervious Land Use</u>	<u>acre</u>
A B, Forest, Flat	3.03
<b>Pervious Total</b>	<b>3.03</b>

<u>Impervious Land Use</u>	<u>acre</u>
<b>Impervious Total</b>	<b>0</b>

**Basin Total** 3.03

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### Element Flows To:

Surface	Interflow	Groundwater
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### MITIGATED LAND USE

**Name** : Basin 1  
**Bypass:** No  
**GroundWater:** No

<u>Pervious Land Use</u>	<u>acre</u>
C, Pasture, Flat	.71
<b>Pervious Total</b>	<b>0.71</b>

<u>Impervious Land Use</u>	<u>acre</u>
DRIVEWAYS FLAT	0.93
SIDEWALKS FLAT	0.22
<b>Impervious Total</b>	<b>1.15</b>

Basin Total

1.86

Element Flows To:

<b>Surface</b>		<b>Interflow</b>		<b>Groundwater</b>
Surface retention	1	Surface retention	1	

**Name** : Bioretention 1  
**Bottom Length:** 700.00 ft.  
**Bottom Width:** 1.00 ft.  
**Material thickness of first layer:** 1.5  
**Material type for first layer:** SMMWW 12 in/hr  
**Material thickness of second layer:** 0.5  
**Material type for second layer:** Sand  
**Material thickness of third layer:** 0.5  
**Material type for third layer:** GRAVEL  
**Infiltration On**  
**Infiltration rate:** 12  
**Infiltration safety factor:** 1  
**Wetted surface area On**  
**Total Volume Infiltrated (ac-ft.):** 276.882  
**Total Volume Through Riser (ac-ft.):** 0.012  
**Total Volume Through Facility (ac-ft.):** 276.894  
**Percent Infiltrated:** 100  
**Total Precip Applied to Facility:** 1.945  
**Total Evap From Facility:** 1.401  
**Underdrain not used**  
**Discharge Structure**  
**Riser Height:** 0.5 ft.  
**Riser Diameter:** 12 in.

Element Flows To:

<b>Outlet 1</b>		<b>Outlet 2</b>
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Bioretention 1 Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.0161	0.0000	0.0000	0.0000
0.0385	0.0161	0.0003	0.0000	0.0000
0.0769	0.0161	0.0006	0.0000	0.0000
0.1154	0.0161	0.0008	0.0000	0.0000
0.1538	0.0161	0.0011	0.0000	0.0000
0.1923	0.0161	0.0014	0.0000	0.0000
0.2308	0.0161	0.0017	0.0000	0.0000
0.2692	0.0161	0.0020	0.0000	0.0000
0.3077	0.0161	0.0023	0.0000	0.0000
0.3462	0.0161	0.0025	0.0000	0.0012
0.3846	0.0161	0.0028	0.0000	0.0018
0.4231	0.0161	0.0031	0.0000	0.0025
0.4615	0.0161	0.0034	0.0000	0.0035
0.5000	0.0161	0.0037	0.0000	0.0047
0.5385	0.0161	0.0040	0.0000	0.0060
0.5769	0.0161	0.0042	0.0000	0.0060
0.6154	0.0161	0.0045	0.0000	0.0076
0.6538	0.0161	0.0048	0.0000	0.0095
0.6923	0.0161	0.0051	0.0000	0.0107
0.7308	0.0161	0.0054	0.0000	0.0115

0.7692	0.0161	0.0057	0.0000	0.0139
0.8077	0.0161	0.0059	0.0000	0.0165
0.8462	0.0161	0.0062	0.0000	0.0173
0.8846	0.0161	0.0065	0.0000	0.0194
0.9231	0.0161	0.0068	0.0000	0.0226
0.9615	0.0161	0.0071	0.0000	0.0258
1.0000	0.0161	0.0073	0.0000	0.0261
1.0385	0.0161	0.0076	0.0000	0.0300
1.0769	0.0161	0.0079	0.0000	0.0341
1.1154	0.0161	0.0082	0.0000	0.0365
1.1538	0.0161	0.0085	0.0000	0.0386
1.1923	0.0161	0.0088	0.0000	0.0434
1.2308	0.0161	0.0090	0.0000	0.0485
1.2692	0.0161	0.0093	0.0000	0.0495
1.3077	0.0161	0.0096	0.0000	0.0540
1.3462	0.0161	0.0099	0.0000	0.0599
1.3846	0.0161	0.0102	0.0000	0.0651
1.4231	0.0161	0.0105	0.0000	0.0662
1.4615	0.0161	0.0107	0.0000	0.0728
1.5000	0.0161	0.0110	0.0000	0.0798
1.5385	0.0161	0.0112	0.0000	0.0832
1.5769	0.0161	0.0115	0.0000	0.0872
1.6154	0.0161	0.0117	0.0000	0.0950
1.6538	0.0161	0.0120	0.0000	0.1032
1.6923	0.0161	0.0122	0.0000	0.1040
1.7308	0.0161	0.0125	0.0000	0.1118
1.7692	0.0161	0.0127	0.0000	0.1133
1.8077	0.0161	0.0130	0.0000	0.1208
1.8462	0.0161	0.0132	0.0000	0.1274
1.8846	0.0161	0.0135	0.0000	0.1302
1.9231	0.0161	0.0137	0.0000	0.1400
1.9615	0.0161	0.0140	0.0000	0.1503
2.0000	0.0161	0.0142	0.0000	0.1503
2.0385	0.0161	0.0145	0.0000	0.1503
2.0769	0.0161	0.0147	0.0000	0.1503
2.1154	0.0161	0.0150	0.0000	0.1944
2.1538	0.0161	0.0152	0.0000	0.1944
2.1923	0.0161	0.0155	0.0000	0.1944
2.2308	0.0161	0.0157	0.0000	0.1944
2.2692	0.0161	0.0160	0.0000	0.1944
2.3077	0.0161	0.0163	0.0000	0.1944
2.3462	0.0161	0.0165	0.0000	0.1944
2.3846	0.0161	0.0168	0.0000	0.1944
2.4231	0.0161	0.0170	0.0000	0.1944
2.4615	0.0161	0.0173	0.0000	0.1944
2.5000	0.0161	0.0175	0.0000	0.1944
2.5000	0.0161	0.0175	0.0000	0.1944

**Surface retention 1 Hydraulic Table**

<u>Stage(feet)</u>	<u>Area(ac.)</u>	<u>Volume(ac-ft.)</u>	<u>Discharge(cfs)</u>	<u>To Amended(cfs)</u>	<u>Wetted Surface</u>
2.5000	0.0161	0.0175	0.0000	0.2394	0.0450
2.5385	0.0198	0.0182	0.0000	0.2394	0.0899
2.5769	0.0235	0.0191	0.0000	0.2990	0.1349
2.6154	0.0272	0.0200	0.0000	0.3547	0.1800
2.6538	0.0309	0.0212	0.0000	0.4128	0.2250
2.6923	0.0347	0.0224	0.0000	0.4733	0.2701
2.7308	0.0384	0.0238	0.0000	0.5361	0.3153
2.7692	0.0421	0.0254	0.0000	0.6012	0.3604

2.8077	0.0459	0.0271	0.0000	0.6687	0.4056
2.8462	0.0496	0.0289	0.0000	0.7052	0.4508
2.8846	0.0533	0.0309	0.0000	0.7168	0.4961
2.9231	0.0571	0.0330	0.0000	0.7284	0.5414
2.9615	0.0608	0.0353	0.0000	0.7399	0.5867
3.0000	0.0646	0.0377	0.0000	0.7515	0.6320
3.0385	0.0683	0.0402	0.0800	0.7631	0.6774
3.0769	0.0721	0.0429	0.2257	0.7746	0.7228
3.1154	0.0758	0.0458	0.4122	0.7862	0.7682
3.1538	0.0796	0.0488	0.6273	0.7977	0.8136
3.1923	0.0833	0.0519	0.8600	0.8093	0.8591
3.2308	0.0871	0.0552	1.0991	0.8209	0.9046
3.2692	0.0908	0.0586	1.3333	0.8324	0.9502
3.3077	0.0946	0.0622	1.5516	0.8440	0.9957
3.3462	0.0984	0.0659	1.7445	0.8555	1.0414
3.3846	0.1021	0.0697	1.9054	0.8671	1.0870
3.4231	0.1059	0.0737	2.0318	0.8787	1.1326
3.4615	0.1097	0.0779	2.1274	0.8902	1.1783
3.5000	0.1135	0.0822	2.2033	0.9018	1.1783

---

**Name** : Surface retention 1

**Element Flows To:**

<b>Outlet 1</b>	<b>Outlet 2</b>
Bioretention 1	

---

**Name** : Basin 2

**Bypass:** No

**GroundWater:** No

<u>Pervious Land Use</u>	<u>acre</u>
Pervious Total	0
<u>Impervious Land Use</u>	<u>acre</u>
ROOF TOPS FLAT	1.17
Impervious Total	1.17
Basin Total	1.17

---

**Element Flows To:**

<b>Surface</b>	<b>Interflow</b>	<b>Groundwater</b>
Gravel Trench Bed 1	Gravel Trench Bed 1	

---

**Name** : Gravel Trench Bed 1

**Bottom Length:** 1500.00 ft.

**Bottom Width:** 2.00 ft.

**Trench bottom slope 1:** 0.01 To 1

**Trench left side slope 0:** 0.01 To 1

**Trench right side slope 2:** 0.01 To 1

**Material thickness of first layer:** 1.5

**Pour Space of material for first layer:** 0.4

**Material thickness of second layer:** 0

**Pour Space of material for second layer:** 0

**Material thickness of third layer:** 0

**Pour Space of material for third layer:** 0

**Infiltration On**  
**Infiltration rate:** 12  
**Infiltration safety factor:** 1  
**Wetted surface area On**  
**Total Volume Infiltrated (ac-ft.):** 225.468  
**Total Volume Through Riser (ac-ft.):** 0.018  
**Total Volume Through Facility (ac-ft.):** 225.486  
**Percent Infiltrated:** 99.99  
**Total Precip Applied to Facility:** 0  
**Total Evap From Facility:** 0  
**Discharge Structure**  
**Riser Height:** 1 ft.  
**Riser Diameter:** 12 in.

**Element Flows To:**  
**Outlet 1**                      **Outlet 2**

---

**Gravel Trench Bed Hydraulic Table**

<u>Stage(feet)</u>	<u>Area(ac.)</u>	<u>Volume(ac-ft.)</u>	<u>Discharge(cfs)</u>	<u>Infilt(cfs)</u>
0.0000	0.068	0.000	0.000	0.000
0.0167	0.068	0.000	0.000	0.833
0.0333	0.068	0.000	0.000	0.833
0.0500	0.068	0.001	0.000	0.833
0.0667	0.068	0.001	0.000	0.833
0.0833	0.068	0.002	0.000	0.834
0.1000	0.068	0.002	0.000	0.834
0.1167	0.069	0.003	0.000	0.834
0.1333	0.069	0.003	0.000	0.834
0.1500	0.069	0.004	0.000	0.834
0.1667	0.069	0.004	0.000	0.834
0.1833	0.069	0.005	0.000	0.834
0.2000	0.069	0.005	0.000	0.835
0.2167	0.069	0.006	0.000	0.835
0.2333	0.069	0.006	0.000	0.835
0.2500	0.069	0.006	0.000	0.835
0.2667	0.069	0.007	0.000	0.835
0.2833	0.069	0.007	0.000	0.835
0.3000	0.069	0.008	0.000	0.835
0.3167	0.069	0.008	0.000	0.836
0.3333	0.069	0.009	0.000	0.836
0.3500	0.069	0.009	0.000	0.836
0.3667	0.069	0.010	0.000	0.836
0.3833	0.069	0.010	0.000	0.836
0.4000	0.069	0.011	0.000	0.836
0.4167	0.069	0.011	0.000	0.836
0.4333	0.069	0.012	0.000	0.836
0.4500	0.069	0.012	0.000	0.837
0.4667	0.069	0.012	0.000	0.837
0.4833	0.069	0.013	0.000	0.837
0.5000	0.069	0.013	0.000	0.837
0.5167	0.069	0.014	0.000	0.837
0.5333	0.069	0.014	0.000	0.837
0.5500	0.069	0.015	0.000	0.837
0.5667	0.069	0.015	0.000	0.838
0.5833	0.069	0.016	0.000	0.838
0.6000	0.069	0.016	0.000	0.838
0.6167	0.069	0.017	0.000	0.838

0.6333	0.069	0.017	0.000	0.838
0.6500	0.069	0.018	0.000	0.838
0.6667	0.069	0.018	0.000	0.838
0.6833	0.069	0.018	0.000	0.839
0.7000	0.069	0.019	0.000	0.839
0.7167	0.069	0.019	0.000	0.839
0.7333	0.069	0.020	0.000	0.839
0.7500	0.069	0.020	0.000	0.839
0.7667	0.069	0.021	0.000	0.839
0.7833	0.069	0.021	0.000	0.839
0.8000	0.069	0.022	0.000	0.840
0.8167	0.069	0.022	0.000	0.840
0.8333	0.069	0.023	0.000	0.840
0.8500	0.069	0.023	0.000	0.840
0.8667	0.069	0.024	0.000	0.840
0.8833	0.069	0.024	0.000	0.840
0.9000	0.069	0.024	0.000	0.840
0.9167	0.069	0.025	0.000	0.841
0.9333	0.069	0.025	0.000	0.841
0.9500	0.069	0.026	0.000	0.841
0.9667	0.069	0.026	0.000	0.841
0.9833	0.069	0.027	0.000	0.841
1.0000	0.069	0.027	0.000	0.841
1.0167	0.069	0.028	0.022	0.841
1.0333	0.069	0.028	0.064	0.842
1.0500	0.069	0.029	0.118	0.842
1.0667	0.069	0.029	0.182	0.842
1.0833	0.069	0.030	0.254	0.842
1.1000	0.069	0.030	0.333	0.842
1.1167	0.069	0.030	0.418	0.842
1.1333	0.069	0.031	0.509	0.842
1.1500	0.069	0.031	0.604	0.842
1.1667	0.069	0.032	0.703	0.843
1.1833	0.069	0.032	0.804	0.843
1.2000	0.069	0.033	0.907	0.843
1.2167	0.069	0.033	1.011	0.843
1.2333	0.069	0.034	1.115	0.843
1.2500	0.069	0.034	1.217	0.843
1.2667	0.069	0.035	1.318	0.843
1.2833	0.069	0.035	1.415	0.844
1.3000	0.069	0.036	1.509	0.844
1.3167	0.069	0.036	1.599	0.844
1.3333	0.069	0.037	1.683	0.844
1.3500	0.069	0.037	1.762	0.844
1.3667	0.069	0.037	1.834	0.844
1.3833	0.069	0.038	1.900	0.844
1.4000	0.069	0.038	1.960	0.845
1.4167	0.069	0.039	2.013	0.845
1.4333	0.069	0.039	2.060	0.845
1.4500	0.069	0.040	2.101	0.845
1.4667	0.069	0.040	2.138	0.845
1.4833	0.069	0.041	2.171	0.845
1.5000	0.069	0.041	2.203	0.845

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**ANALYSIS RESULTS**

Stream Protection Duration

Predeveloped Landuse Totals for POC #1

Total Pervious Area:3.03

Total Impervious Area:0

Mitigated Landuse Totals for POC #1

Total Pervious Area:0.71

Total Impervious Area:2.32

Flow Frequency Return Periods for Predeveloped. POC #1

<u>Return Period</u>	<u>Flow(cfs)</u>
2 year	0.003478
5 year	0.007543
10 year	0.0121
25 year	0.021132
50 year	0.031227
100 year	0.045296

Flow Frequency Return Periods for Mitigated. POC #1

<u>Return Period</u>	<u>Flow(cfs)</u>
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Stream Protection Duration

POC #1

The Facility PASSED

The Facility **PASSED.**

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0017	2355	4	0	Pass
0.0020	1326	4	0	Pass
0.0023	434	4	0	Pass
0.0026	112	4	3	Pass
0.0029	102	4	3	Pass
0.0032	89	4	4	Pass
0.0035	77	4	5	Pass
0.0038	66	4	6	Pass
0.0041	61	4	6	Pass
0.0044	58	4	6	Pass
0.0047	54	4	7	Pass
0.0050	50	4	8	Pass
0.0053	49	4	8	Pass
0.0056	47	4	8	Pass
0.0059	43	4	9	Pass
0.0062	40	4	10	Pass
0.0065	36	4	11	Pass
0.0068	36	4	11	Pass
0.0071	32	4	12	Pass
0.0074	31	4	12	Pass
0.0077	31	4	12	Pass
0.0080	29	4	13	Pass

0.0083	29	4	13	Pass
0.0086	27	4	14	Pass
0.0089	26	4	15	Pass
0.0092	26	4	15	Pass
0.0095	26	4	15	Pass
0.0098	25	4	16	Pass
0.0101	23	4	17	Pass
0.0104	23	4	17	Pass
0.0107	23	4	17	Pass
0.0110	23	4	17	Pass
0.0113	23	4	17	Pass
0.0116	21	4	19	Pass
0.0119	19	4	21	Pass
0.0122	18	4	22	Pass
0.0125	17	4	23	Pass
0.0128	16	4	25	Pass
0.0131	16	4	25	Pass
0.0134	15	4	26	Pass
0.0137	15	4	26	Pass
0.0140	14	4	28	Pass
0.0142	13	4	30	Pass
0.0145	13	4	30	Pass
0.0148	13	4	30	Pass
0.0151	13	4	30	Pass
0.0154	13	4	30	Pass
0.0157	13	4	30	Pass
0.0160	13	4	30	Pass
0.0163	13	4	30	Pass
0.0166	13	4	30	Pass
0.0169	11	4	36	Pass
0.0172	11	4	36	Pass
0.0175	11	4	36	Pass
0.0178	11	4	36	Pass
0.0181	11	4	36	Pass
0.0184	11	4	36	Pass
0.0187	11	4	36	Pass
0.0190	11	4	36	Pass
0.0193	11	4	36	Pass
0.0196	11	4	36	Pass
0.0199	11	4	36	Pass
0.0202	11	4	36	Pass
0.0205	11	4	36	Pass
0.0208	10	4	40	Pass
0.0211	10	4	40	Pass
0.0214	9	4	44	Pass
0.0217	9	4	44	Pass
0.0220	8	3	37	Pass
0.0223	8	3	37	Pass
0.0226	8	3	37	Pass
0.0229	8	3	37	Pass
0.0232	8	3	37	Pass
0.0235	8	3	37	Pass
0.0238	8	3	37	Pass
0.0241	8	3	37	Pass
0.0244	8	3	37	Pass
0.0247	8	3	37	Pass
0.0250	8	3	37	Pass
0.0253	8	3	37	Pass

0.0256	8	3	37	Pass
0.0259	8	3	37	Pass
0.0262	8	3	37	Pass
0.0265	7	3	42	Pass
0.0268	7	3	42	Pass
0.0271	7	3	42	Pass
0.0274	7	3	42	Pass
0.0277	6	3	50	Pass
0.0280	6	3	50	Pass
0.0282	6	3	50	Pass
0.0285	6	3	50	Pass
0.0288	6	3	50	Pass
0.0291	6	3	50	Pass
0.0294	6	3	50	Pass
0.0297	6	3	50	Pass
0.0300	6	3	50	Pass
0.0303	6	3	50	Pass
0.0306	6	3	50	Pass
0.0309	5	3	60	Pass
0.0312	5	3	60	Pass

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**Perlnd and Implnd Changes**

No changes have been made.

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