Preliminary Drainage Report

Monroe Apartments

2322.14525.01

Prepared for

JDA West, LLC

88 Kearney Street, Suite 1770

San Francisco, California 94108

July 15, 2019

Prepared for	JDA West, LLC
Project Name	Preliminary Drainage Report
Job Number	2322.14525.01
Date	July 15, 2019

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Name	Title	Date	Revision	Reviewer
Kevin Russell	WR Project Manager	07/15/19	-	Jerome Klima

Executive Summary

The proposed Monroe Apartment Development is located at the intersection of SE 37th Avenue and SE Monroe Street in Milwaukie, Oregon (See Figure 1-1 Vicinity Map. The development will construct 234 garden style apartment units and associated parking lot, garages, internal drive aisles, and landscaping with pedestrian circulation. Frontage improvements on SE Monroe Street and SE 37th Avenue will be included with this proposal. The runoff mitigations from these improvements will be provided through the existing and proposed City stormwater systems.

Stormwater Management Standards

The proposed storm design will meet the requirements of the City of Milwaukie as listed in the *Public Works Standards* dated February 2015. The City of Milwaukie follows the current City of Portland's *Stormwater Management Manual* for water quality facility design.

Water Quality

The project will discharge into a proposed City stormwater facility that will be located across SE Oak Street from the subject site. The City Stormwater facility is planned to be constructed in congruence with the Meek Street Pipe installation project.

Water quality treatment will occur through a lined vegetated basin. These facilities are shallow landscaped depressions that collect and treat stormwater runoff through vegetation and soil media. They provide pollution reduction and flow attenuation to reduce hydraulic impacts from urban developments. Specific elements are incorporated into the design to increase the effectiveness of this stormwater facility type. Design elements include trapped catch basins to remove coarse sediment, soil media to provide stormwater filtration, and vegetation to will provide plant uptake.

The basins are designed using the City of Portland Presumptive Approach Calculator (PAC). The stormwater facilities were designed to the standards below:

- Water Quality: 50% of the cumulative rainfall from the 2-year storm event. (Using a continuous rainfall/runoff model).

Water Quantity

Water quantity control will occur within the proposed lined and vegetated basins. A control structure will be placed within the facility to control releases to the proposed City stormwater facility. Infiltration is not proposed on the site due to the existence of contaminated soils.

- City of Milwaukie = Match existing flow rate to proposed flow from the 2 through 25-year storm event.

Conveyance

The proposed conveyance system will be designed using the 100-year storm event in the final Drainage Report.

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1 Project Overview

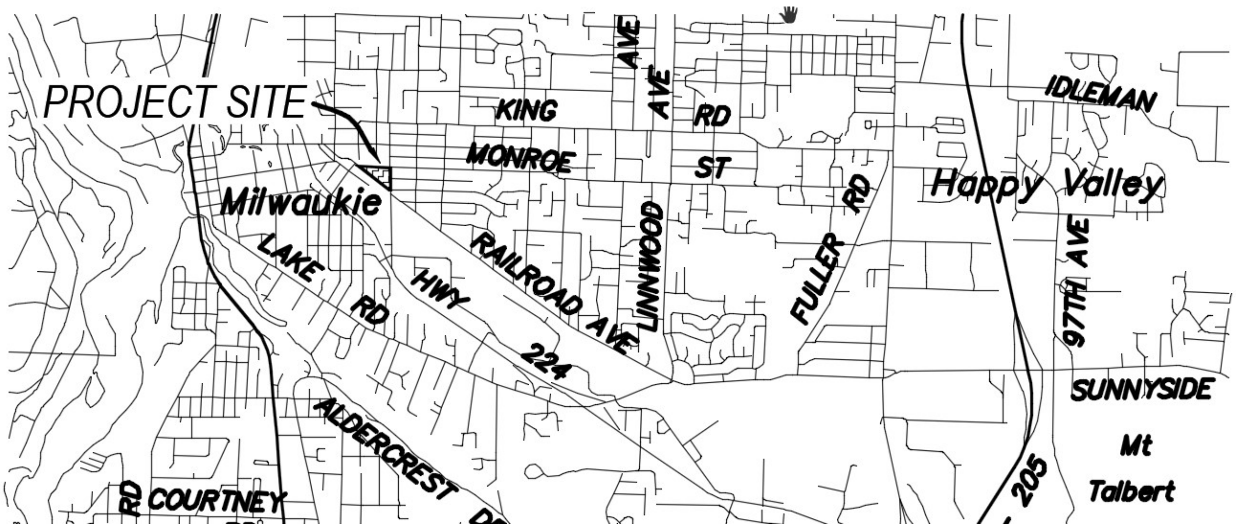
1.1 Project Overview

The proposed Monroe Apartment Development is located at the intersection of SE 37th Avenue and SE Monroe Street in Milwaukie, Oregon (See Figure 1-1 Vicinity Map. The development will construct 234 garden style apartment units and associated parking lot, garages, internal drive aisles, and landscaping with pedestrian circulation.

1.2 Location

The proposed project is located at the intersection of SE 37th Avenue and SE Monroe Street in Milwaukie, Oregon (See Figure 1-1 Vicinity Map).

Figure 1-1 Vicinity Map



1.3 Methodology

The proposed storm design will meet the requirements of the City of Milwaukie as listed in the *Public Works Standards* dated February 2015. The City of Milwaukie follows the current City of Portland's *Stormwater Management Manual* for water quality facility design.

2 Existing Conditions

2.1 Topography

The existing site contains open space area and a contaminated soils area that is covered in gravel. Fill material was placed over the contaminated soils in the past. The areas of open space and contaminated soils are on separate parcels. The highest elevation point of the site is at the southwest corner of the intersection of SE Monroe Street and SE 37th Avenue. From the high point the site slopes generally from northeast to southwest at slopes between 2% and 30% Steeper slopes occur in the northeast region of the site The highest elevation within the project area is 127; located along the northeast property corner. The lowest elevation of 100 is located in the northwest and south portions of the property.

2.2 Climate

The site is in Milwaukie, Oregon and is located approximately 65 miles inland from the Pacific Ocean. There is a gradual change in seasons with defined seasonal characteristics. Average daily temperatures range from 36°F to 83°F. Record temperatures recorded for this region of the state are -3°F and 107°F. Average annual rainfall recorded in this area is 42-inches. Average annual snowfall is approximately 1-inches between December and February.

2.3 Site Geology

The underlying soil types on the site, as classified by the United States Department of Agriculture Soil Survey of Clackamas County, Oregon are identified in Table 2-1 (See Technical Appendix: Hydrologic Soils Map - Clackamas County).

Table 2-1 Soil Characteristics

Soil Type	Hydrologic Group
Woodburn Silt Loam	C

The site is classified as Woodburn Silt Loam. Therefore, the entire site has been assigned a soil Group C. Group C soils typically have low infiltration rates when thoroughly saturated. Infiltration is not allowed on-site, because of the existence of contaminated soils.

Groundwater is anticipated to be between 6 and 16 feet below ground surface, However, due to groundwater fluctuations, these results may vary during the time of construction.

2.4 Curve Number

The curve number represents runoff potential from the soil. The major factors for determining the curve number values are hydrologic soil group, cover type, hydrologic condition and antecedent runoff condition. The pervious curve numbers of 86 were used for grassy open space under hydrologic soil group C and 96 for gravel.

2.5 Time of Concentration

The time of concentration (T_C) as described in NEH-4 Chapter 15 is defined in two ways; the time for runoff to travel from the furthermost point of the watershed to the point in question, and the time from the end of excess rainfall to the point of inflection on the trailing limb of the unit hydrograph. Time of concentration can be estimated from the following formulas. The time of concentration was calculated to be 13 minutes. (See Technical Appendix: Time of Concentration Calculation).

Sheet Flow

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

T_t =	Travel Time (hours)	n =	Manning's "n" of slope
L =	Length of flow (ft)	P_2 =	2-Year, 24-hour rainfall (in)
s =	Slope (ft / ft)		

Shallow Concentrated Flow

$$T_t = \frac{L}{3600V}$$

T_t =	Travel Time (hours)	L =	Flow Length (ft)
V =	Average Velocity (ft / s)	3600 =	seconds / hour

2.6 Hydrology

Stormwater runoff from the site sheet flows from the northeast to the southwest. Catch basins collect the runoff from the Monroe Street roadway and the east portion of SE 37th Avenue. A portion of SE 37th Avenue drains directly on to the site, due to there being no curb and gutter on SE 37th Avenue to pick it up.

2.7 Basin Area

Impervious and pervious surface areas for the existing conditions are shown in Table 2-2. One of the parcels on site is consisted of grassy open space. The other parcel on the site where the contaminated soils exist is covered in gravel. (See Technical Appendix: Figure 1 – Existing Basin Delineation).

Table 2-2 Existing Basin Areas

Basin	Impervious Area (ac)	Pervious Area (ac)	Total Area (ac)
Existing On-site	2.515	4.716	7.231

3 Proposed Conditions

3.1 Curve Number

The curve numbers of 98 representing impervious area was used at the site as represented in the PAC. The pervious curve numbers of 86 representing Open Space in Good Condition was used at the site. (See Technical Appendix: Table 2-2a – Technical Release 55-Urban Hydrology for Small Watersheds).

3.2 Time of Concentration

A time of concentration of 5 minutes was used for the delineated basin.

3.3 Hydrology

Stormwater runoff from the proposed on-site improvements will be routed to the single proposed lined and vegetated basin on-site. This basin is proposed to be located at the proposed lowest point on-site which is located in the northwest corner across SE Oak Street from the proposed City stormwater facility. The frontage improvements on Monroe Street will be captured and collected into the new City stormwater conveyance system that is proposed with the construction of the new City stormwater facility. Runoff from the frontage improvements on SE 37th Avenue will be captured by the existing City stormwater system.

3.4 Basin Area

Impervious and pervious surface areas for proposed on-site conditions are shown in Table 3-1. The site is 53% impervious in proposed conditions. (See Technical Appendix: Figure 2 – proposed Basin Delineation).

Table 3-1 Proposed Basin Areas

Basin	Impervious Area, ac	Pervious Area, ac	Total Area, ac
On-site Basin	3.840	3.391	7.231

4 Hydrologic and Hydraulic Analysis

4.1 Design Guidelines

The proposed storm design will meet the requirements of the City of Milwaukie as listed in the *Public Works Standards* dated February 2015. Section 2.0013 describes the allowable flow determination methods including the selected Unity Hydrograph Method.

4.2 Hydrologic Method

The Santa Barbara Urban Hydrograph (SBUH) was used for this analysis. The SBUH method is based on the curve number (CN) approach, and uses the Natural Resources Conservation Service's (NRCS) equations for computing soil absorption and precipitation excess.The SBUH method converts the incremental runoff depths into instantaneous hydrographs, which are then routed through an imaginary reservoir with a time delay equal to the basin time of concentration.

A HydroCAD model was used for hydrology and hydraulics analysis and is an approved method of analysis by the City of Milwaukie.

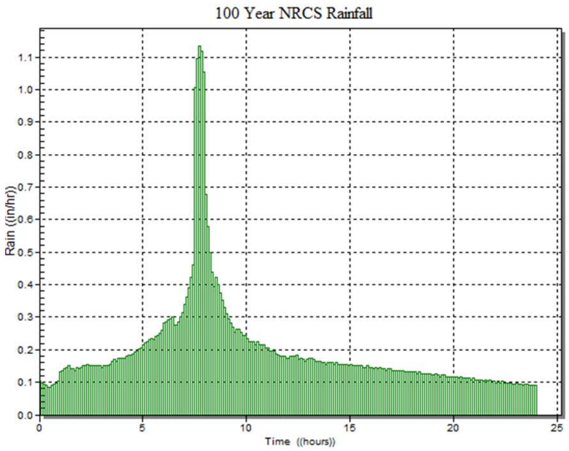
4.3 Design Storm

The rainfall distribution to be used within the City of Milwaukie jurisdiction is the design storm of 24-hour duration based on the standard Type 1A rainfall distribution. Table 4-1 shows total precipitation depths for different storm events. The NRCS Distribution for a type 1A 24-hour rainfall distribution for a 100-year storm event is shown in Figure 4-1.

Table 4-1 Precipitation Depth

Recurrence interval (years)	Total Precipitation Depth (in)
2	2.40
5	3.30
10	3.50
25	4.00
100	4.70

Figure 4-1 100-Year Type 1A Rainfall Distribution



4.4 Basin Runoff

Table 4-2 lists the runoff rates for existing and proposed conditions for the site during the 2, 5, 10, and 25-year storm events. (See Technical Appendix: Existing and Proposed Hydrographs).

Table 4-2 Runoff Rates

Recurrence Interval (years)	Existing* Peak Runoff Rate (cfs)	Proposed* Peak Runoff Rate (cfs)
2	2.187	2.059
5	3.625	3.106
10	3.952	3.279
25	4.776	3.694

*Existing and proposed peak runoff rates are calculated for entire site.

5 Conveyance Analysis

5.1 Design Guidelines

The analysis and design criteria described in this section will follow the City of Milwaukie's *Public Works Standards.* The manual requires storm drainage system and facilities be designed to convey the 100-year storm event.

5.2 System Capacity

The proposed conveyance system will be designed to convey and contain the peak runoff from a 100-year design storm.

5.3 System Performance

A complete conveyance analysis will be completed in the final Drainage Report.

6 Water Quality & Quantity

6.1 Design Guidelines

The proposed water quality and quantity facilities were designed per the City of Milwaukie requirements as listed in the *Public Works Standards* dated February 2015. The City of Milwaukie follows the current City of Portland's *Stormwater Management Manual* for water quality facility design. The City of Milwaukie requires the proposed discharge rate for the 2, 5, 10, and 25-year events to be that of the existing discharge rate.

6.2 Water Quality and Quantity Facilities

The project will discharge into a proposed City stormwater facility that will be located across SE Oak Street from the subject site. The City Stormwater facility is planned to be constructed in congruence with the Meek Street Pipe installation project.

Water quality treatment will occur through a lined vegetated basin. These facilities are shallow landscaped depressions that collect and treat stormwater runoff through vegetation and soil media. They provide pollution reduction and flow attenuation to reduce hydraulic impacts from urban developments. Specific elements are incorporated into the design to increase the effectiveness of this stormwater facility type. Design elements include trapped catch basins to remove coarse sediment, soil media to provide stormwater filtration, and vegetation to will provide plant uptake.

Water quantity control will occur within the proposed lined and vegetated basins. A control structure will be placed within the facility to control releases to the proposed City stormwater facility. Infiltration is not proposed on the site due to the existence of contaminated soils.

- City of Milwaukie = Match existing flow rate to proposed flow from the 2 through 25-year storm event.

The detention portion of the basins are designed using HydroCAD. Treatment area was calculated using the City of Portland Presumptive Approach Calculator (PAC).

Basins are designed to incorporate the following criteria:

- Water Depth: Varies
- Drain Rock Depth: 6 to 18 inches
- Growing Medium Depth: 18 inches
- Minimum Freeboard: 2 inches
- Perforated Pipe Under Drain
- Minimum Orifice Size: 1 inch

7 Floodplain Analysis

The project site is not within a floodplain.

8 Operation & Maintenance

Maintenance of water quality and quantity facilities is very important to ensure they operate as designed. Inadequate maintenance can be attributed to premature failures of these facilities. Stormwater facilities for the site will be maintained and operated privately by the property owners.

The owners must insure the water quality systems efficiently perform their function of removing petroleum hydrocarbons, sediments, metals, bacteria and nutrients from stormwater runoff and that the water quantity system performs their function of regulating the rate and volume of stormwater runoff leaving the property.

The Operation and Maintenance Plan will be provided with the final drainage report

9 Summary

The proposed water quality and quantity facility design follows the City of Milwaukie's *Public Works Standards* dated February 2015. The City of Milwaukie follows the current City of Portland's *Stormwater Management Manual* for water quality facility design. The City of Milwaukie requires the proposed discharge rate for the 2, 5, 10, and 25-year events to be that of the existing discharge rate for detention..

Technical Appendix

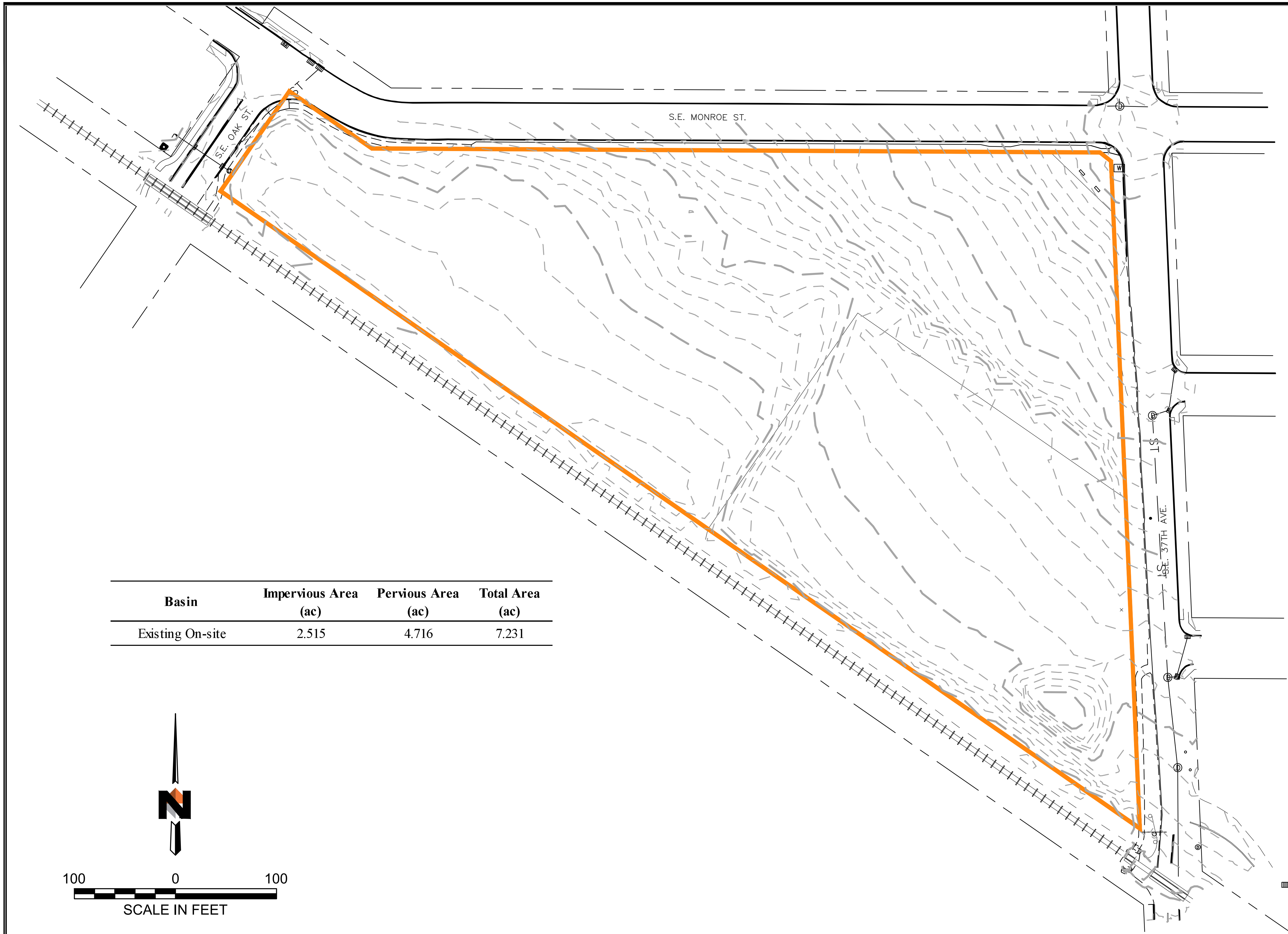
Technical Appendix

- Figure 1 – Existing Basin Delineation
- Figure 2 – Proposed Basin Delineation

- Hydrologic Soil Map – Clackamas County
- Table 2-2c – Runoff Curve Numbers for Other Agricultural Lands
- Table 2-2a – Runoff Curve Numbers for Urban Areas
- Time of Concentration
- HydroCAD Detention Calculations
- PAC Report
- Geotechnical Study – Johnson Development Associates, Aspect Consulting, December 22, 2017.

References

Public Works Standards, City of Milwaukie, February 2015.
Stormwater Management Manual, City of Portland, August 2016.



Basin	Impervious Area (ac)	Pervious Area (ac)	Total Area (ac)
Existing On-site	2.515	4.716	7.231

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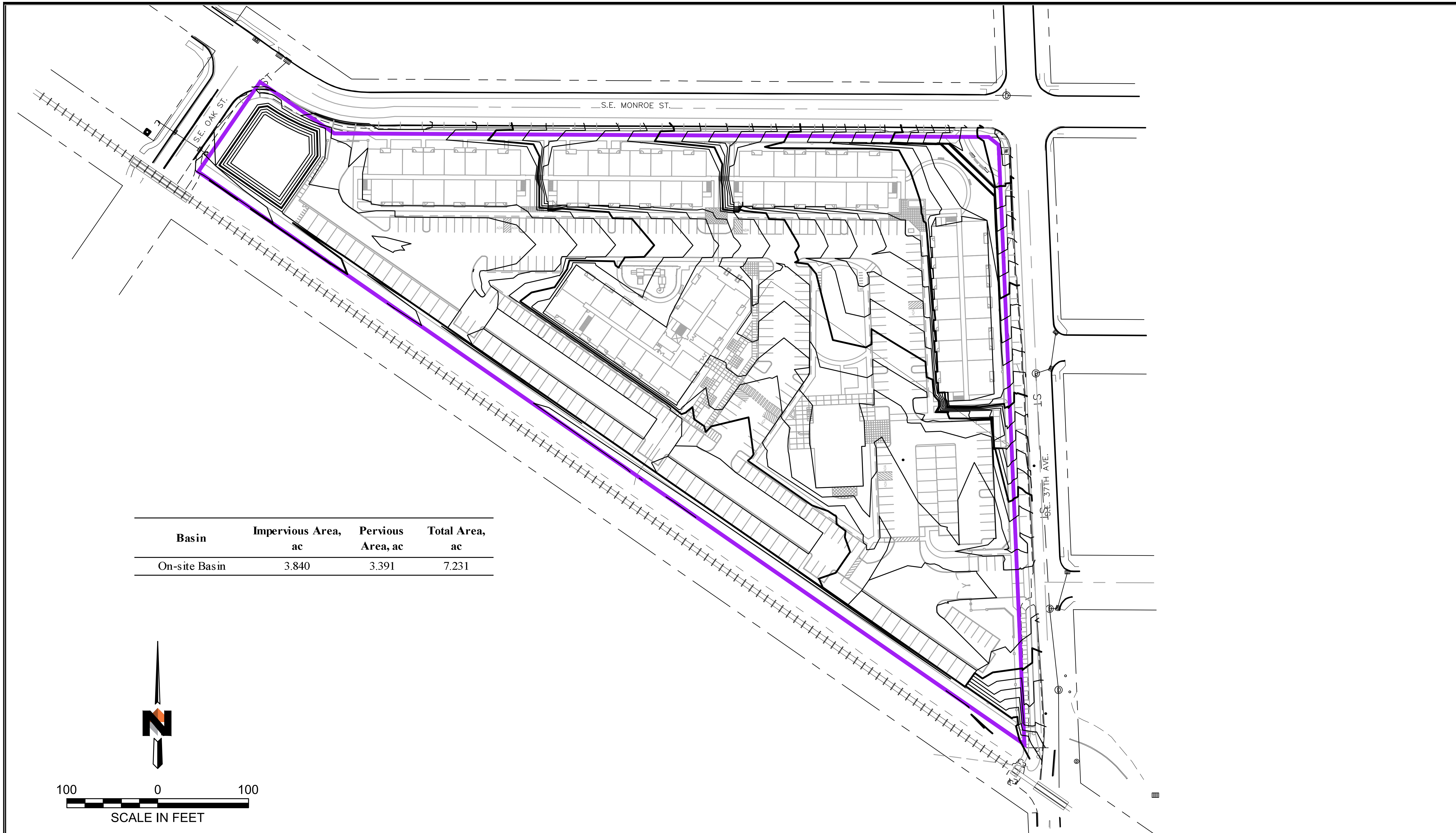
SE MONROE STREET MULTIFAMILY DEVELOPMENT
PRELIMINARY EXISTING BASIN MAP
MILWAUKIE, OR

PROJECT	14525-01
DATE	07/20/2019

FIGURE 1 OF 2

\\BIL-FS\BIL-projects\22\14525-01\40Study\Drain\Exhibit\Extg Basin.dwg PLOT DATE 2019-7-17 15:44 SAVED DATE 2019-07-17 15:43 USER: jklima



Basin	Impervious Area, ac	Pervious Area, ac	Total Area, ac
On-site Basin	3.840	3.391	7.231

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SE MONROE STREET MULTIFAMILY DEVELOPMENT
PRELIMINARY PROPOSED BASIN MAP
MILWAUKIE, OR

PROJECT 14525-01
DATE 07/20/2019

FIGURE 2 OF 2


122° 37' 45" W
122° 37' 23" W
45° 26' 44" N
45° 26' 33" N
529000
529050
529100
529150
529200
529250
529300
529350
529400
529450
5032510
5032460
5032410
5032360
5032310
5032260
5032210
Se Monroe St
Se Jefferson St
Se 37th Ave
Se Oak St
Milwaukie Marketplace Parking
53B
91B
224
Soil Map may not be valid at this scale.
Map Scale: 1:2,220 if printed on A landscape (11" x 8.5") sheet.
N
0
30
60
120
180
Meters
0
100
200
400
600
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Clackamas County Area, Oregon
Survey Area Data: Version 14, Sep 18, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 26, 2014—Sep 5, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
53B	Latourell loam, 3 to 8 percent slopes	B	0.0	0.0%
91B	Woodburn silt loam, 3 to 8 percent slopes	C	9.9	100.0%
Totals for Area of Interest			**9.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

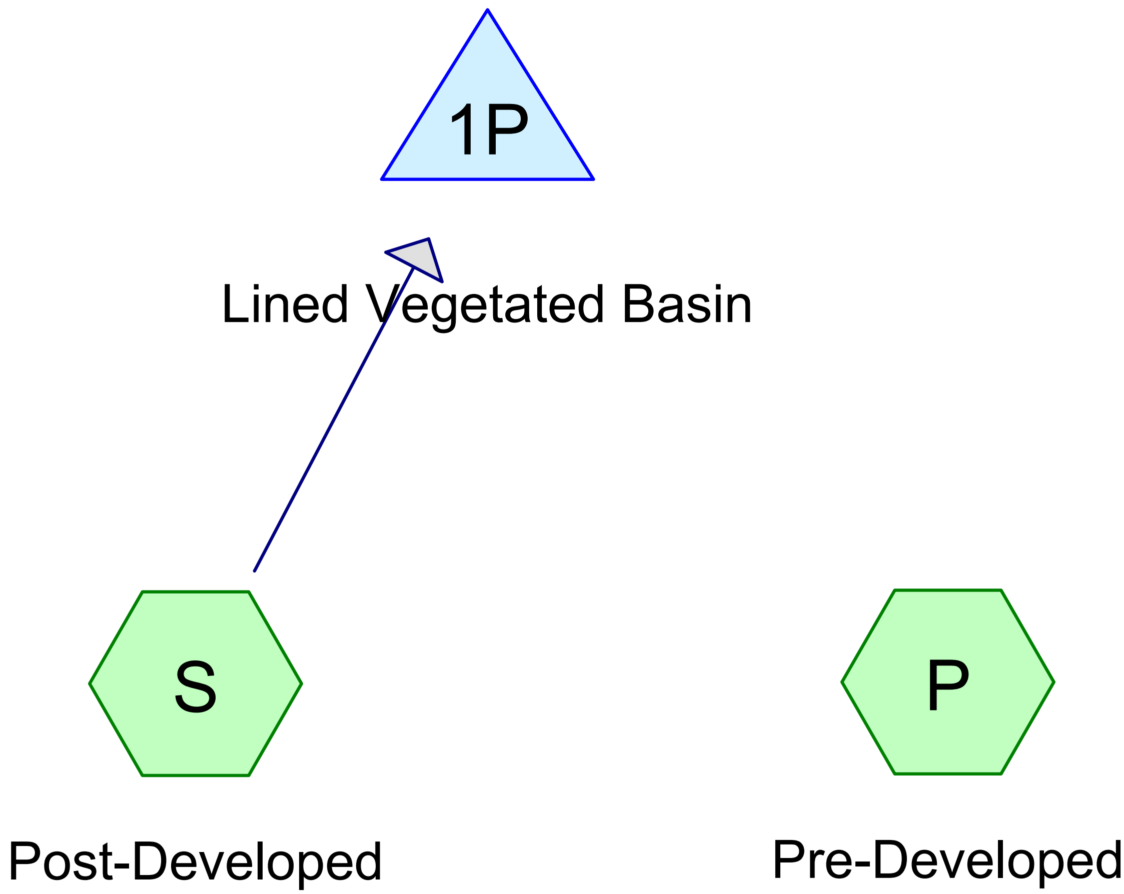
Cover description: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

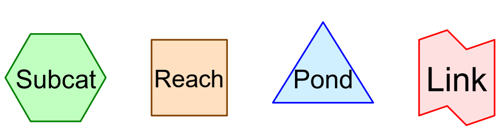
1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Time of Concentration

SUBJECT	Time of Concentration - Monroe Apartments				
PROJECT NO.	2322.14525.01	**BY**	KSR	**DATE**	7/17/2019

	Existing	
SHEET FLOW		
INPUT	**VALUE**	
Surface Description	**Type**	**5**
	Grass (short prairie)	
Manning's "n"	**0.15**	
Flow Length, L (<300 ft)	**300**	ft
2-Yr 24 Hour Rainfall, P_2	**2.6**	in
Land Slope, s	**0.13**	ft/ft
OUTPUT		
Travel Time	0.21	hr
SHALLOW CONCENTRATED FLOW		
INPUT	**VALUE**	
Surface Description	**Unpaved**	
Flow Length, L	**159**	ft
Watercourse Slope*, s	**0.05**	ft/ft
OUTPUT		
Average Velocity, V	3.61	ft/s
Travel Time	0.012	hr
SHALLOW CONCENTRATED FLOW		
INPUT	**VALUE**	
Surface Description	**Unpaved**	
Flow Length, L	**0**	ft
Watercourse Slope*, s	**0.01**	ft/ft
OUTPUT		
Average Velocity, V	1.61	ft/s
Travel Time	0.000	hr
Watershed or Subarea T_c =	**0.22**	**hr**
Watershed or Subarea T_c =	**13**	**minutes**





Routing Diagram for Detention Pond - Monroe Street Apartments
Prepared by DOWL, Printed 7/17/2019

Area Listing (selected nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
147,712	86	<50% Grass cover, Poor, HSG C (S)
109,553	96	Gravel surface, HSG C (P)
167,270	98	Impervious (S)
205,429	86	Open Space (P)
629,965	**91**	**TOTAL AREA**

Summary for Subcatchment P: Pre-Developed

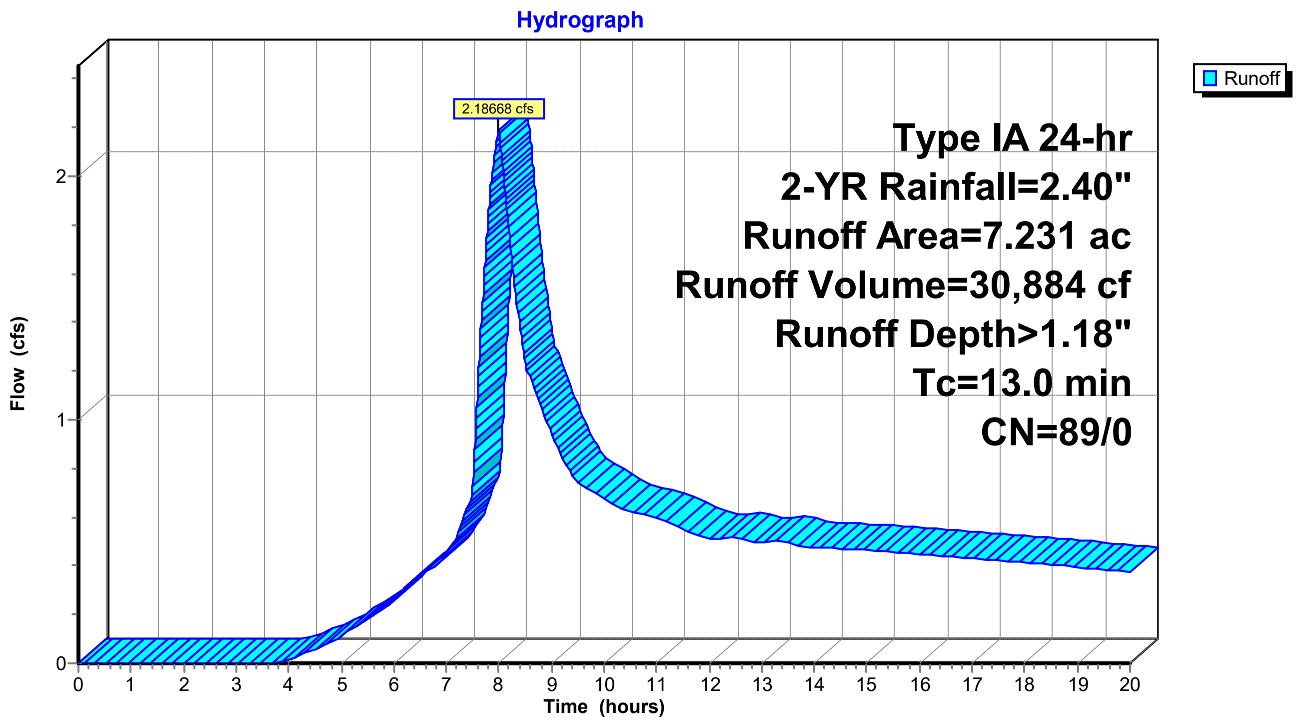
Runoff = 2.18668 cfs @ 8.00 hrs, Volume= 30,884 cf, Depth> 1.18"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 2-YR Rainfall=2.40"

	Area (ac)	CN	Description
	2.515	96	Gravel surface, HSG C
*	4.716	86	Open Space
	7.231	89	Weighted Average
	7.231	89	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0					**Direct Entry,**

Subcatchment P: Pre-Developed



Summary for Subcatchment S: Post-Developed

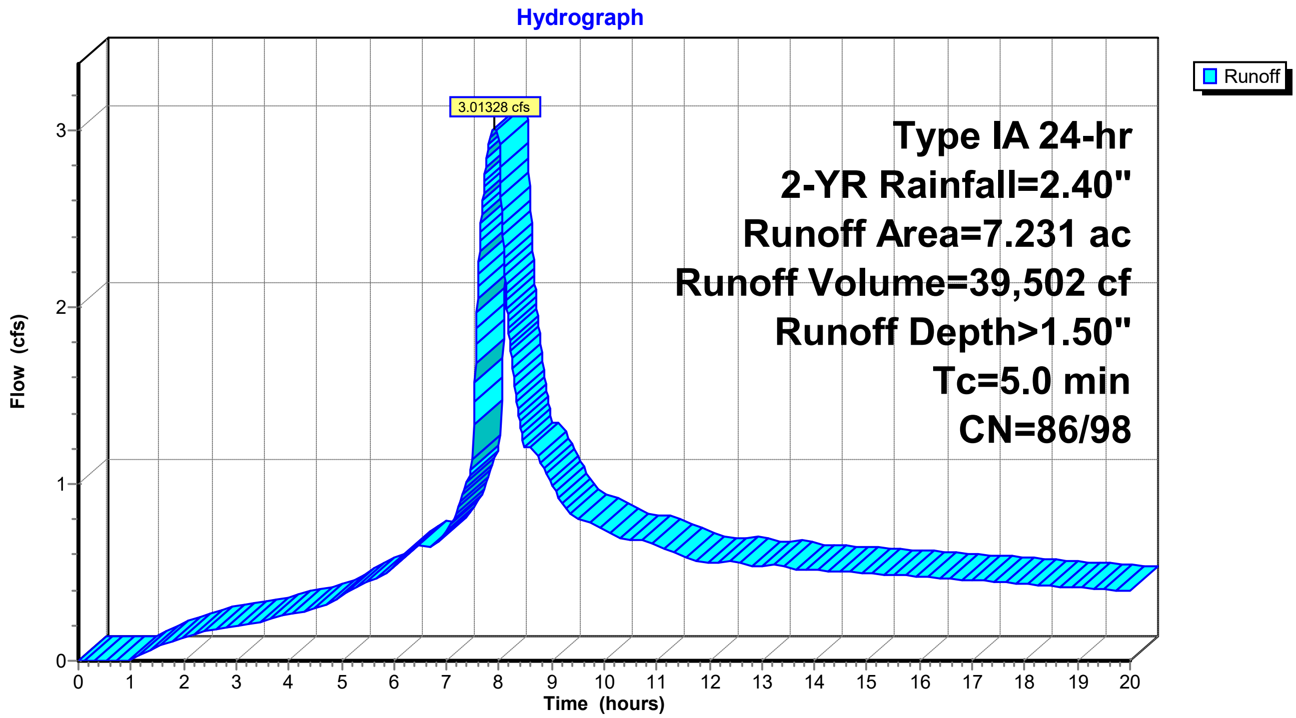
Runoff = 3.01328 cfs @ 7.91 hrs, Volume= 39,502 cf, Depth> 1.50"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 2-YR Rainfall=2.40"

	Area (ac)	CN	Description
*	3.840	98	Impervious
	3.391	86	<50% Grass cover, Poor, HSG C
	7.231	92	Weighted Average
	3.391	86	46.90% Pervious Area
	3.840	98	53.10% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment S: Post-Developed



Summary for Pond 1P: Lined Vegetated Basin

Inflow Area = 314,982 sf, 53.10% Impervious, Inflow Depth > 1.50" for 2-YR event
Inflow = 3.01328 cfs @ 7.91 hrs, Volume= 39,502 cf
Outflow = 2.05942 cfs @ 8.13 hrs, Volume= 38,897 cf, Atten= 32%, Lag= 13.3 min
Primary = 2.05942 cfs @ 8.13 hrs, Volume= 38,897 cf

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Peak Elev= 97.62' @ 8.13 hrs Surf.Area= 5,366 sf Storage= 3,115 cf

Plug-Flow detention time= 22.8 min calculated for 38,877 cf (98% of inflow)
Center-of-Mass det. time= 14.3 min (653.3 - 639.0)

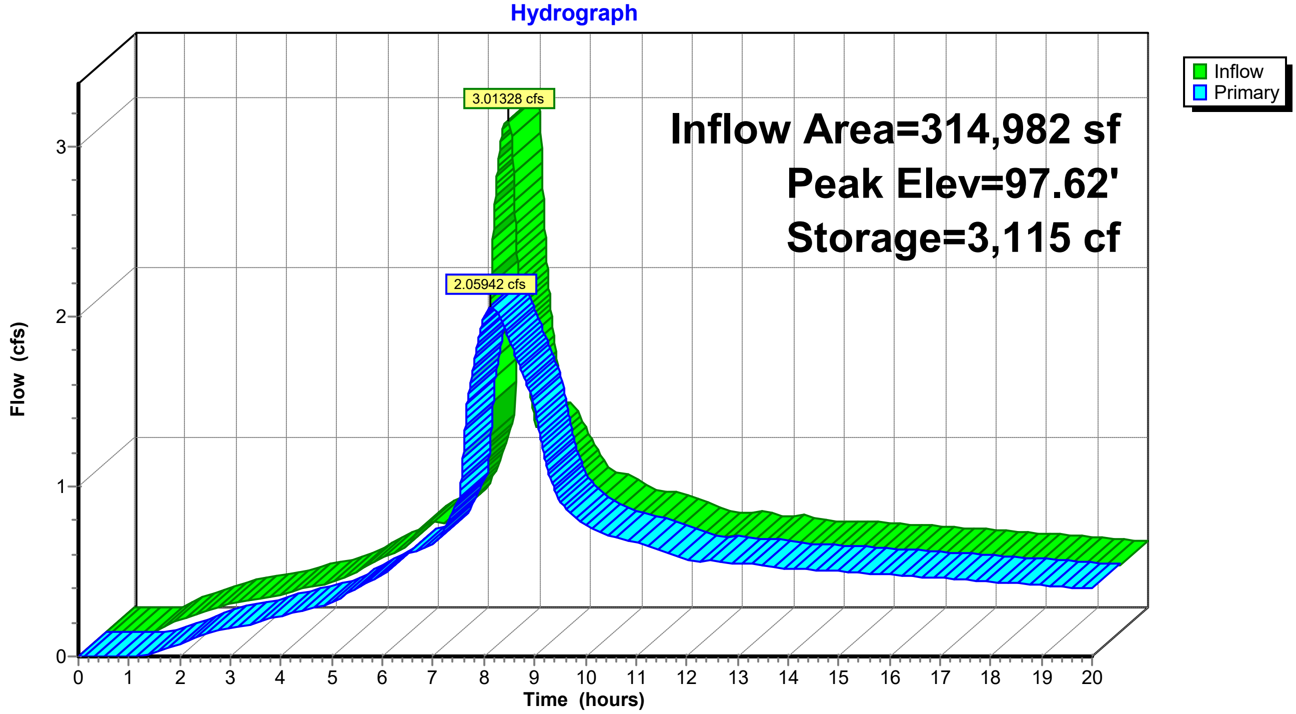
Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	26,623 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	0	0.0	0	0
97.01	4,850	100.0	24	24
98.00	5,695	100.0	5,220	5,244
99.00	6,611	100.0	6,153	11,397
100.00	7,595	100.0	7,103	18,500
101.00	8,650	100.0	8,123	26,623

Device	Routing	Invert	Outlet Devices
#1	Primary	97.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	97.65'	**6.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=2.05961 cfs @ 8.13 hrs HW=97.62' (Free Discharge)
—**1=Orifice/Grate** (Orifice Controls 2.05961 cfs @ 3.78 fps)
—**2=Orifice/Grate** (Controls 0.00000 cfs)

Pond 1P: Lined Vegetated Basin



Summary for Subcatchment P: Pre-Developed

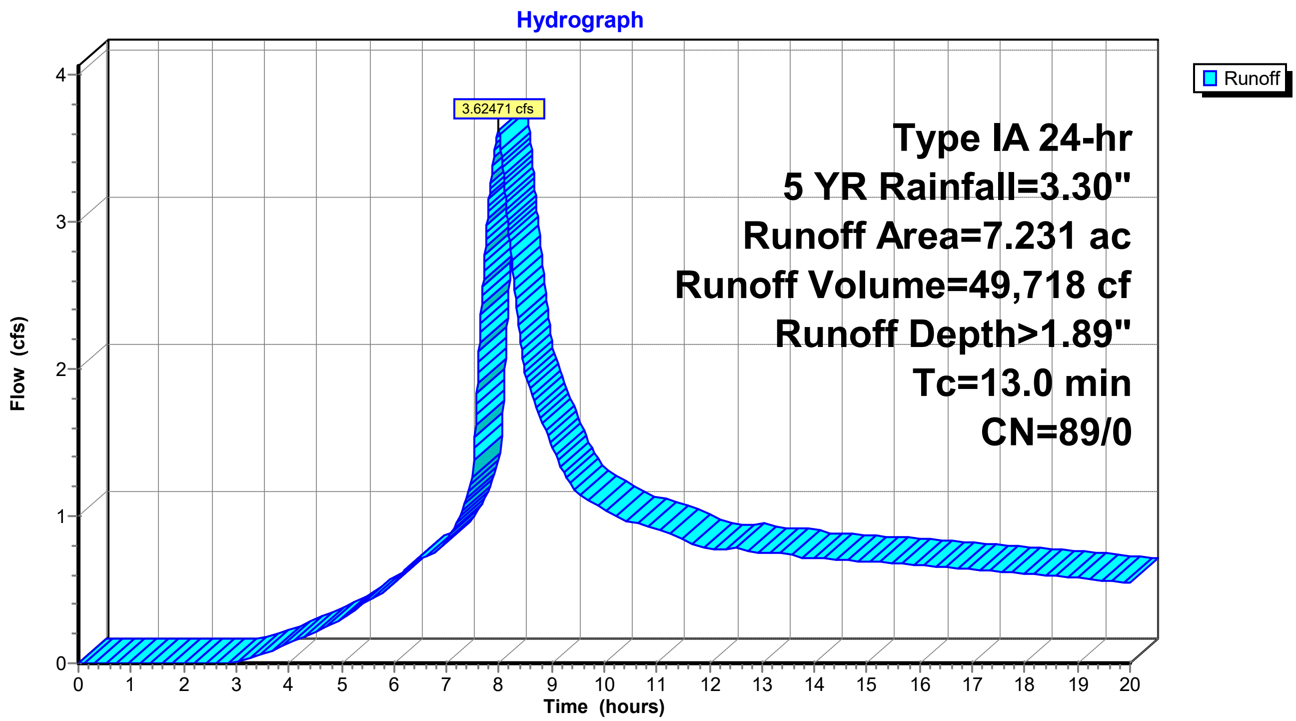
Runoff = 3.62471 cfs @ 8.00 hrs, Volume= 49,718 cf, Depth> 1.89"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 5 YR Rainfall=3.30"

	Area (ac)	CN	Description
	2.515	96	Gravel surface, HSG C
*	4.716	86	Open Space
	7.231	89	Weighted Average
	7.231	89	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0					**Direct Entry,**

Subcatchment P: Pre-Developed



Summary for Subcatchment S: Post-Developed

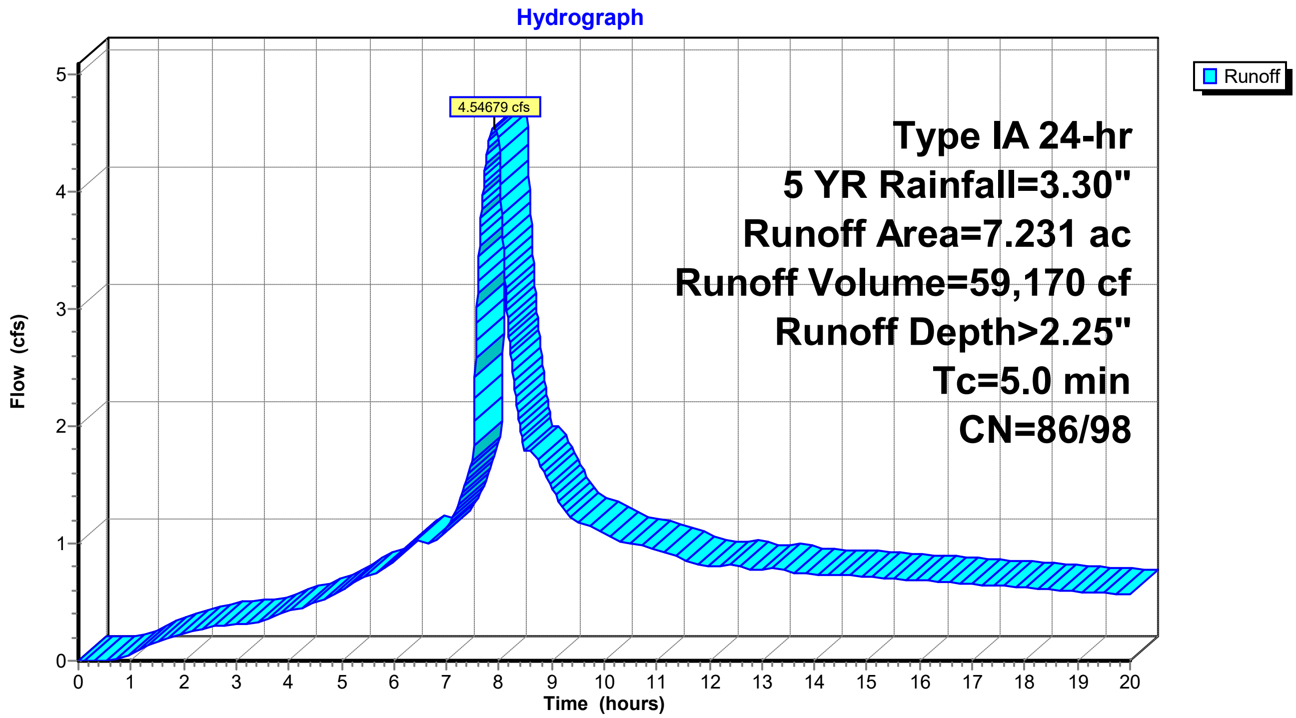
Runoff = 4.54679 cfs @ 7.90 hrs, Volume= 59,170 cf, Depth> 2.25"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 5 YR Rainfall=3.30"

	Area (ac)	CN	Description
*	3.840	98	Impervious
	3.391	86	<50% Grass cover, Poor, HSG C
	7.231	92	Weighted Average
	3.391	86	46.90% Pervious Area
	3.840	98	53.10% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment S: Post-Developed



Summary for Pond 1P: Lined Vegetated Basin

Inflow Area = 314,982 sf, 53.10% Impervious, Inflow Depth > 2.25" for 5 YR event
Inflow = 4.54679 cfs @ 7.90 hrs, Volume= 59,170 cf
Outflow = 3.10561 cfs @ 8.13 hrs, Volume= 58,390 cf, Atten= 32%, Lag= 13.7 min
Primary = 3.10561 cfs @ 8.13 hrs, Volume= 58,390 cf

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Peak Elev= 97.96' @ 8.13 hrs Surf.Area= 5,663 sf Storage= 5,033 cf

Plug-Flow detention time= 22.1 min calculated for 58,390 cf (99% of inflow)
Center-of-Mass det. time= 14.6 min (643.4 - 628.8)

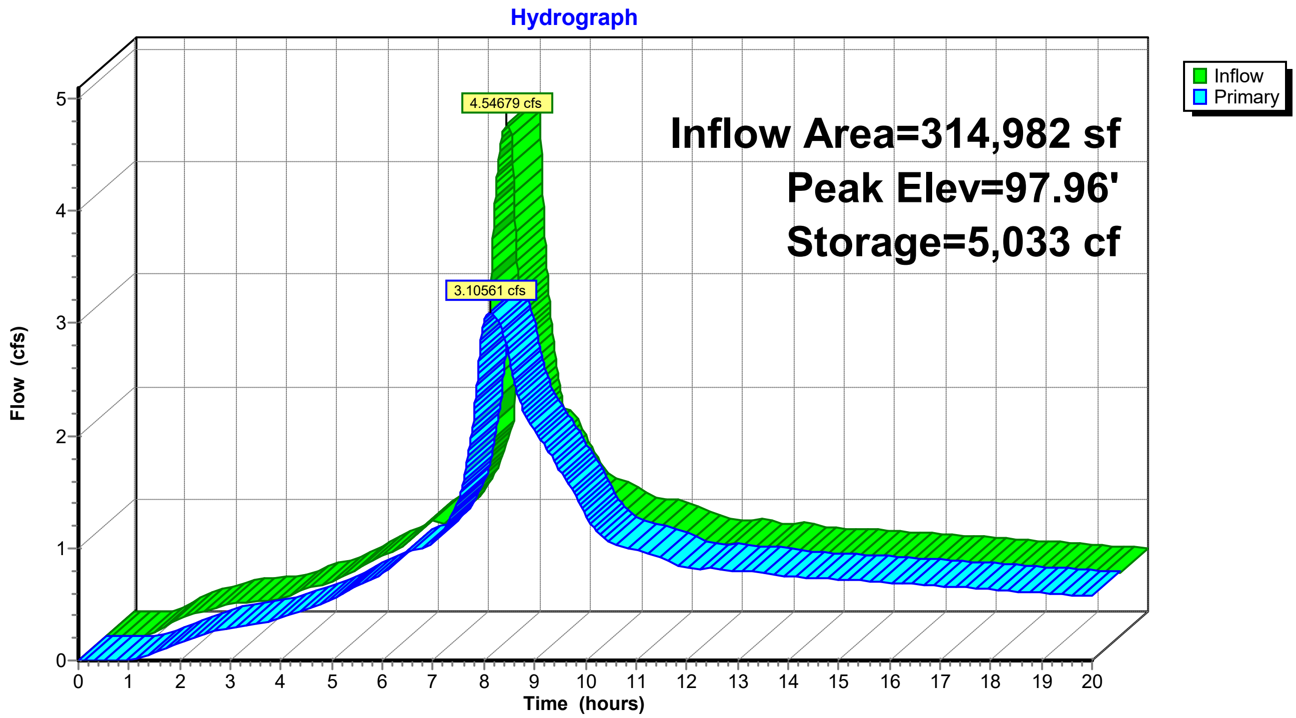
Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	26,623 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	0	0.0	0	0
97.01	4,850	100.0	24	24
98.00	5,695	100.0	5,220	5,244
99.00	6,611	100.0	6,153	11,397
100.00	7,595	100.0	7,103	18,500
101.00	8,650	100.0	8,123	26,623

Device	Routing	Invert	Outlet Devices
#1	Primary	97.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	97.65'	**6.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=3.10566 cfs @ 8.13 hrs HW=97.96' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 2.57688 cfs @ 4.72 fps)
└─**2=Orifice/Grate** (Orifice Controls 0.52878 cfs @ 2.69 fps)

Pond 1P: Lined Vegetated Basin



Summary for Subcatchment P: Pre-Developed

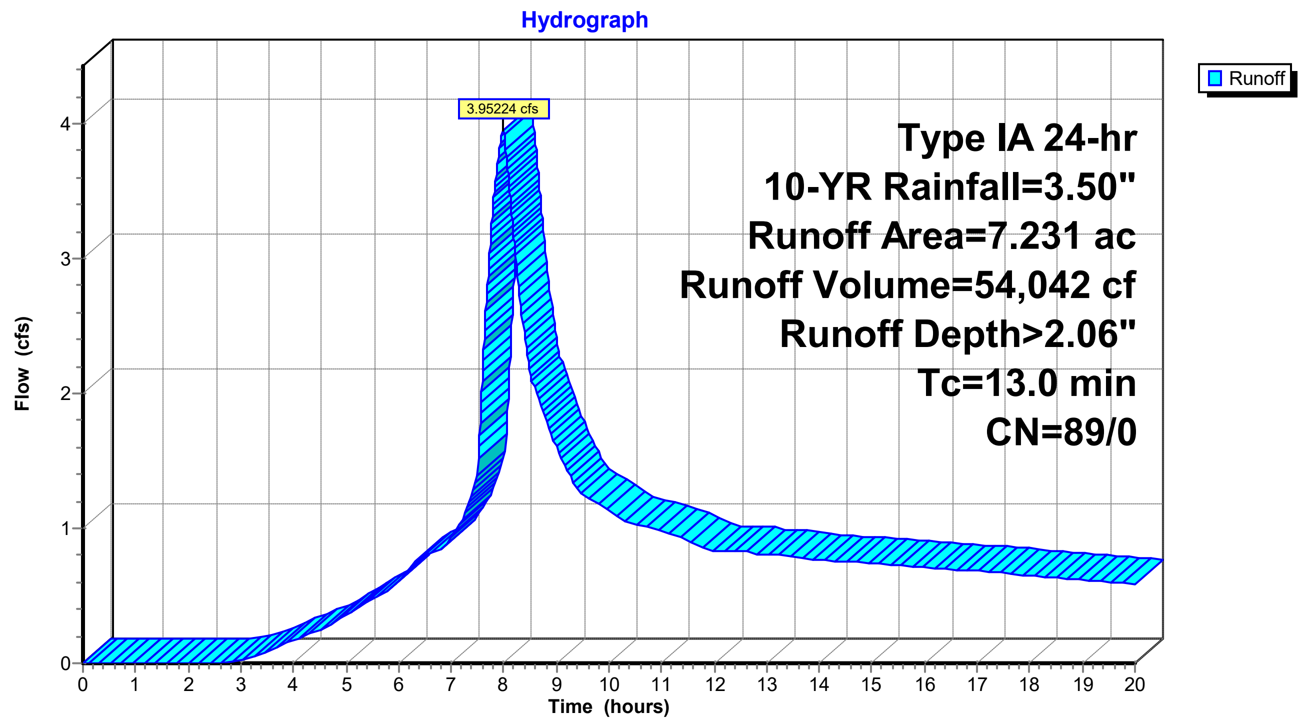
Runoff = 3.95224 cfs @ 8.00 hrs, Volume= 54,042 cf, Depth> 2.06"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 10-YR Rainfall=3.50"

	Area (ac)	CN	Description
	2.515	96	Gravel surface, HSG C
*	4.716	86	Open Space
	7.231	89	Weighted Average
	7.231	89	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0					**Direct Entry,**

Subcatchment P: Pre-Developed



Summary for Subcatchment S: Post-Developed

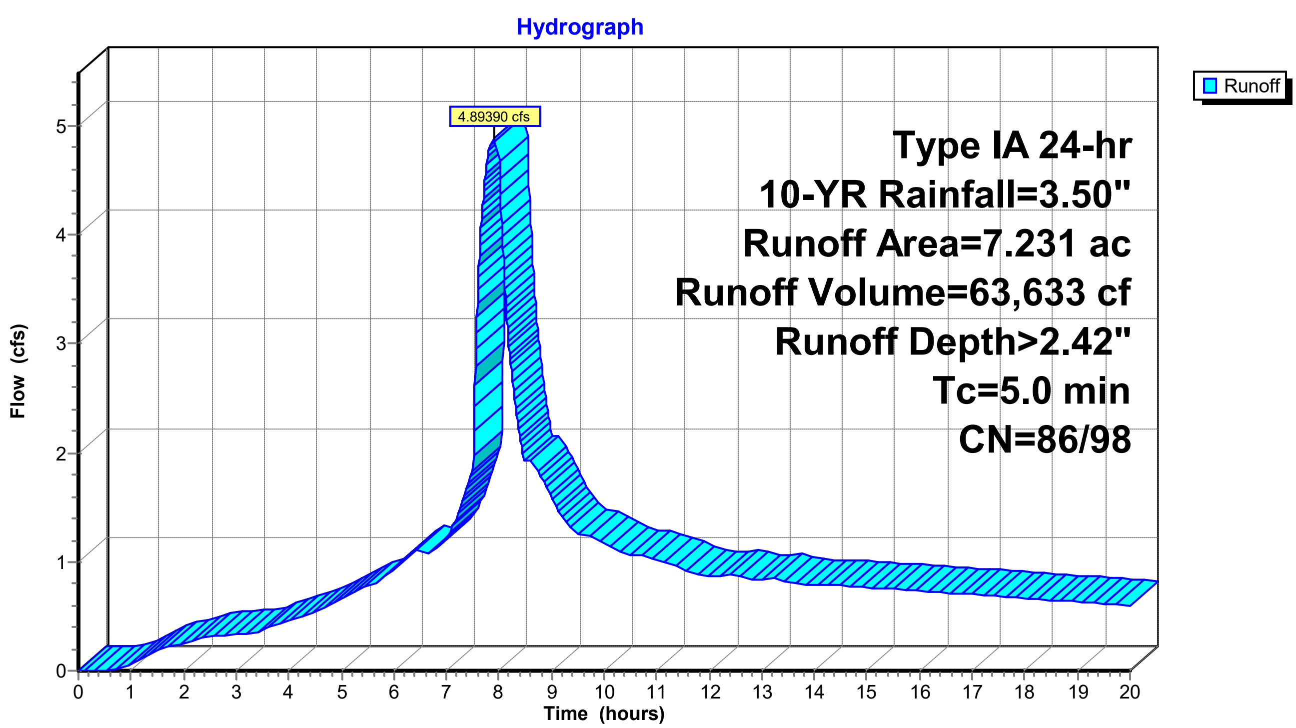
Runoff = 4.89390 cfs @ 7.90 hrs, Volume= 63,633 cf, Depth> 2.42"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 10-YR Rainfall=3.50"

	Area (ac)	CN	Description
*	3.840	98	Impervious
	3.391	86	<50% Grass cover, Poor, HSG C
	7.231	92	Weighted Average
	3.391	86	46.90% Pervious Area
	3.840	98	53.10% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment S: Post-Developed



Summary for Pond 1P: Lined Vegetated Basin

Inflow Area =	314,982 sf, 53.10% Impervious,	Inflow Depth > 2.42"	for 10-YR event
Inflow =	4.89390 cfs @ 7.90 hrs,	Volume=	63,633 cf
Outflow =	3.27854 cfs @ 8.14 hrs,	Volume=	62,818 cf, Atten= 33%, Lag= 14.3 min
Primary =	3.27854 cfs @ 8.14 hrs,	Volume=	62,818 cf

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Peak Elev= 98.04' @ 8.14 hrs Surf.Area= 5,736 sf Storage= 5,501 cf

Plug-Flow detention time= 22.0 min calculated for 62,786 cf (99% of inflow)
Center-of-Mass det. time= 14.8 min (641.7 - 627.0)

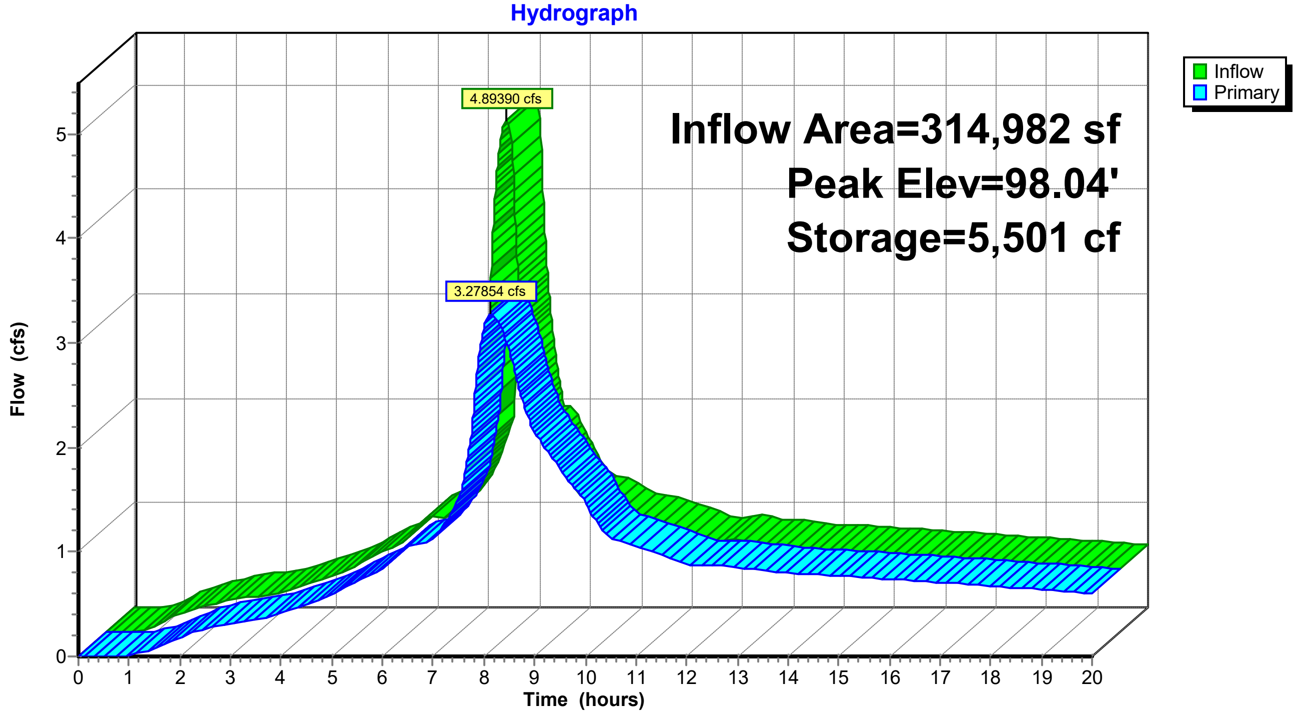
Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	26,623 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	0	0.0	0	0
97.01	4,850	100.0	24	24
98.00	5,695	100.0	5,220	5,244
99.00	6,611	100.0	6,153	11,397
100.00	7,595	100.0	7,103	18,500
101.00	8,650	100.0	8,123	26,623

Device	Routing	Invert	Outlet Devices
#1	Primary	97.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	97.65'	**6.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=3.27866 cfs @ 8.14 hrs HW=98.04' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 2.68452 cfs @ 4.92 fps)
└─**2=Orifice/Grate** (Orifice Controls 0.59414 cfs @ 3.03 fps)

Pond 1P: Lined Vegetated Basin



Summary for Subcatchment P: Pre-Developed

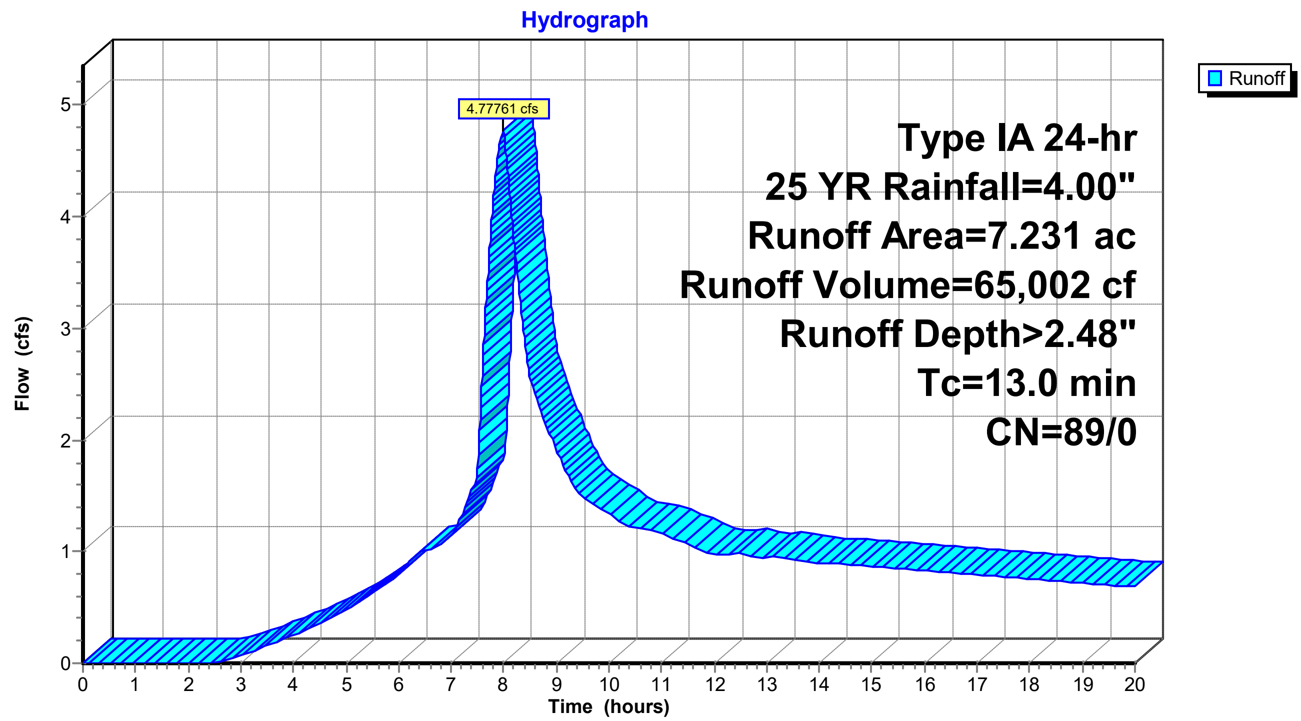
Runoff = 4.77761 cfs @ 8.00 hrs, Volume= 65,002 cf, Depth> 2.48"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 25 YR Rainfall=4.00"

	Area (ac)	CN	Description
	2.515	96	Gravel surface, HSG C
*	4.716	86	Open Space
	7.231	89	Weighted Average
	7.231	89	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0					**Direct Entry,**

Subcatchment P: Pre-Developed



Summary for Subcatchment S: Post-Developed

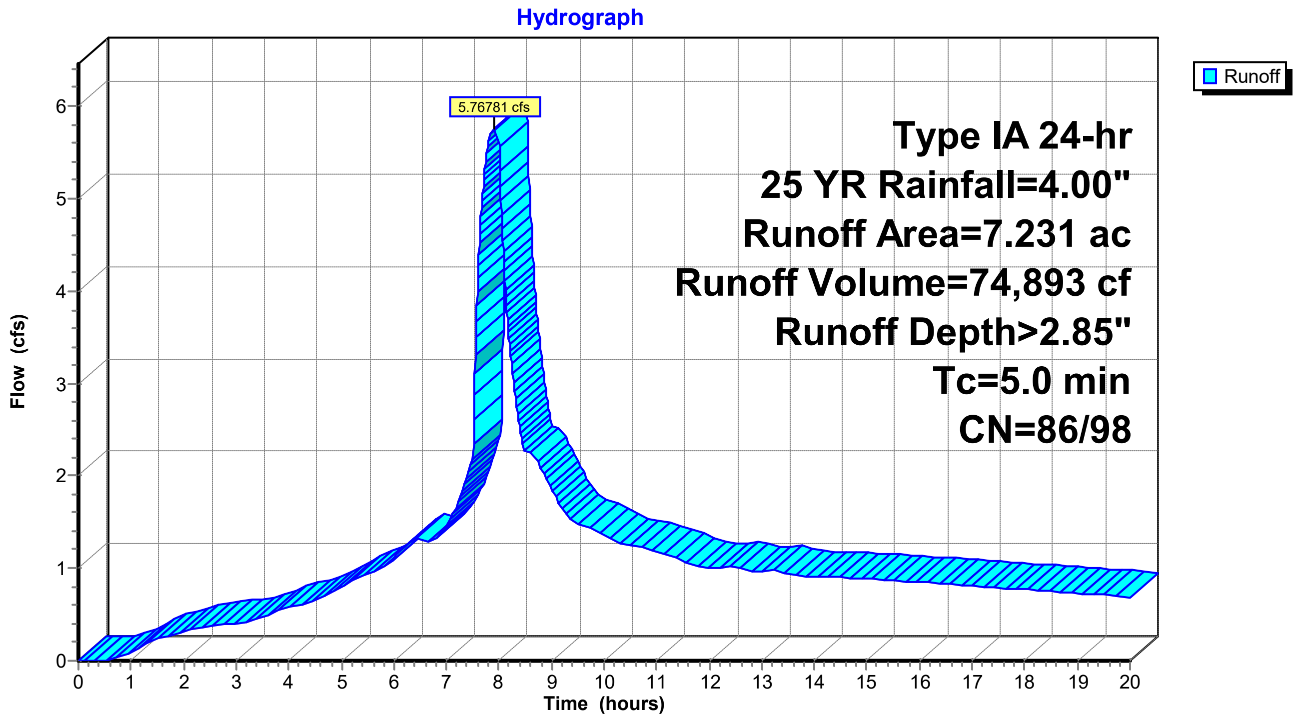
Runoff = 5.76781 cfs @ 7.90 hrs, Volume= 74,893 cf, Depth> 2.85"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Type IA 24-hr 25 YR Rainfall=4.00"

	Area (ac)	CN	Description
*	3.840	98	Impervious
	3.391	86	<50% Grass cover, Poor, HSG C
	7.231	92	Weighted Average
	3.391	86	46.90% Pervious Area
	3.840	98	53.10% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment S: Post-Developed



Summary for Pond 1P: Lined Vegetated Basin

Inflow Area = 314,982 sf, 53.10% Impervious, Inflow Depth > 2.85" for 25 YR event
Inflow = 5.76781 cfs @ 7.90 hrs, Volume= 74,893 cf
Outflow = 3.69411 cfs @ 8.16 hrs, Volume= 73,991 cf, Atten= 36%, Lag= 15.7 min
Primary = 3.69411 cfs @ 8.16 hrs, Volume= 73,991 cf

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.01 hrs
Peak Elev= 98.26' @ 8.16 hrs Surf.Area= 5,937 sf Storage= 6,783 cf

Plug-Flow detention time= 22.2 min calculated for 73,954 cf (99% of inflow)
Center-of-Mass det. time= 15.3 min (638.1 - 622.8)

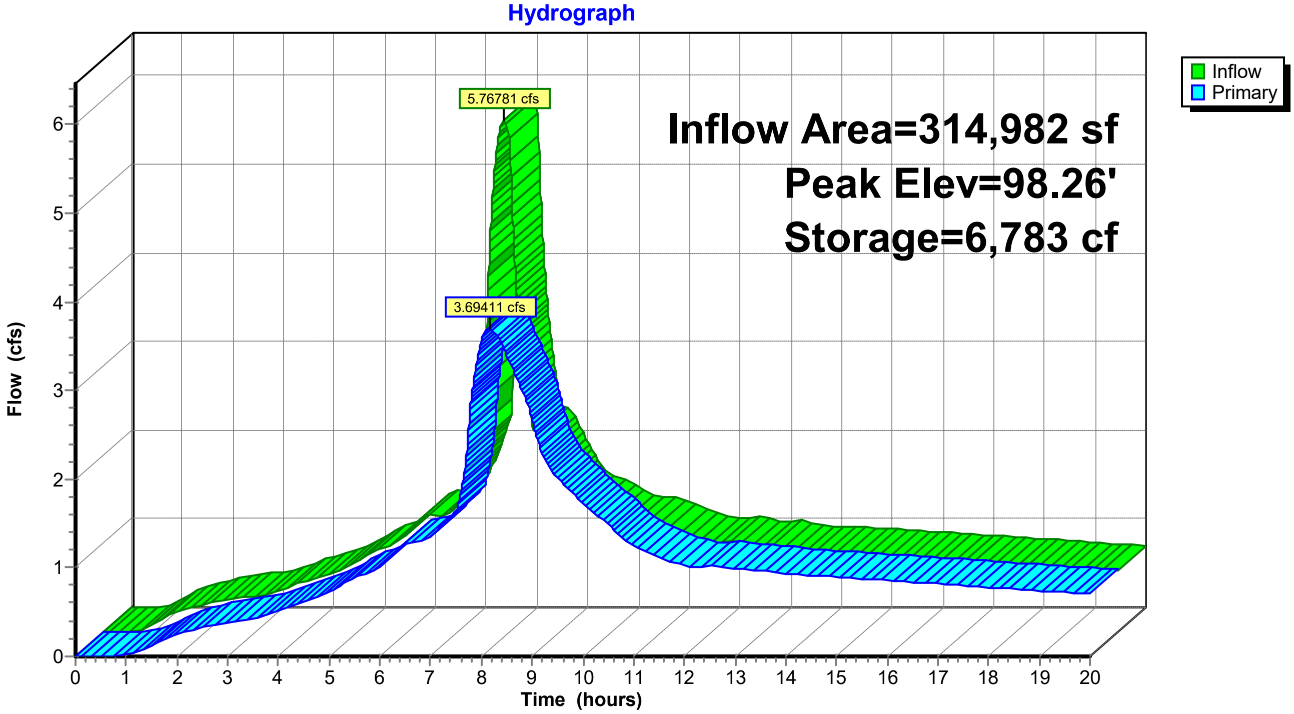
Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	26,623 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	0	0.0	0	0
97.01	4,850	100.0	24	24
98.00	5,695	100.0	5,220	5,244
99.00	6,611	100.0	6,153	11,397
100.00	7,595	100.0	7,103	18,500
101.00	8,650	100.0	8,123	26,623

Device	Routing	Invert	Outlet Devices
#1	Primary	97.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	97.65'	**6.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=3.69429 cfs @ 8.16 hrs HW=98.26' (Free Discharge)
├─**1=Orifice/Grate** (Orifice Controls 2.95316 cfs @ 5.41 fps)
└─**2=Orifice/Grate** (Orifice Controls 0.74113 cfs @ 3.77 fps)

Pond 1P: Lined Vegetated Basin



PAC Report

Project Name	Permit No.	Created
Monroe Apartments		7/10/19 3:34 PM
Project Address	**Designer**	**Last Modified**
Milwaukie Milwaukie, OR 97222	Jerome Klima	7/17/19 2:51 PM
	Company	**Report Generated**
	DOWL	7/17/19 2:51 PM

Project Summary

Garden Apartment Complex in Milwaukie, OR

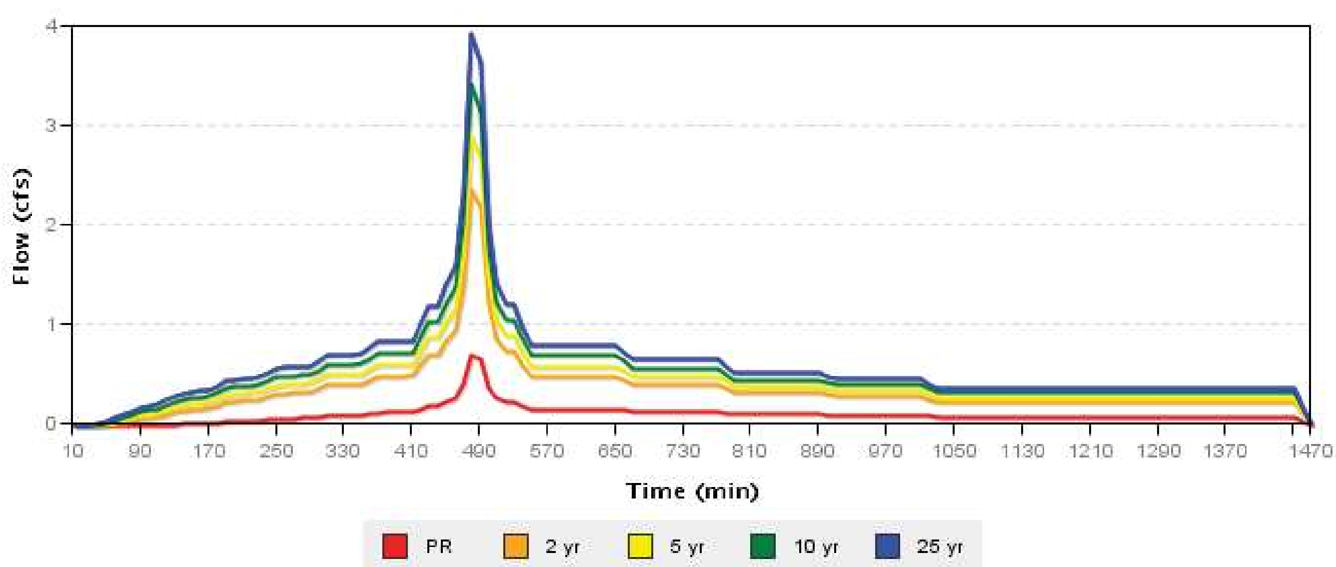
Catchment Name	Impervious Area (sq ft)	Native Soil Design Infiltration Rate	Hierarchy Category	Facility Type	Facility Config	Facility Size (sq ft)	Facility Sizing Ratio	PR Results	Flow Control Results
Monroe Apartments	167920	0.00	4	Basin	D	4000	5.8%	Pass	Pass
SE 37th Ave	16177	0.00	4	Planter (Flat)	D	900	5.6%	Pass	Pass
Monroe St	28346	0.00	4	Planter (Flat)	D	1600	5.6%	Pass	Pass

Catchment Monroe Apartments

Site Soils & Infiltration Testing Data	Infiltration Testing Procedure	**Open Pit Falling Head**
	Native Soil Infiltration Rate (I_{test})	**0.00** ⚠
Correction Factor	CF_{test}	**2**
Design Infiltration Rates	Native Soil (I_{dsgn})	**0.00 in/hr** ⚠
	Imported Growing Medium	**2.00 in/hr**
Catchment Information	Hierarchy Category	**4**
	Hierarchy Description	**Off-site flow to a combined sewer**
	Pollution Reduction Requirement	**Pass**
	10-year Storm Requirement	**N/A**
	Flow Control Requirement	**25-yr post-dev peak runoff rate ≤ 10-yr pre-dev peak rate**
	Impervious Area	**167920 sq ft** ⚠ **3.855 acre**
	Time of Concentration (Tc)	**5**
	Pre-Development Curve Number (CN_{pre})	**72**
	Post-Development Curve Number (CN_{post})	**98**

⚠ Indicates value is outside of recommended range

SBUH Results



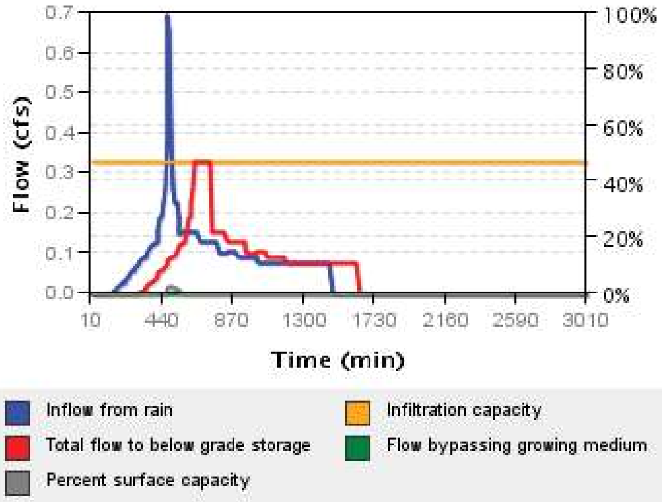
	Pre-Development Rate and Volume		Post-Development Rate and Volume	
	Peak Rate (cfs)	Volume (cf)	Peak Rate (cfs)	Volume (cf)
PR	0.002	9.683	0.693	8774.292
2 yr	0.209	6681.942	2.371	30384.432
5 yr	0.482	10484.51	2.896	37343.987
10 yr	0.798	14777.639	3.418	44313.956
25 yr	1.148	19456.376	3.938	51290.496

Facility Monroe Apartments

Facility Details	Facility Type	**Basin**
	Facility Configuration	**D: Lined Facility with RS and Ud**
	Facility Shape	**Rectangle**
	Above Grade Storage Data	
	Bottom Area	**4000 sq ft**
	Bottom Width	**20.00 ft**
	Side Slope	**3.0:1**
	Storage Depth 1	**36.0 in**
	Growing Medium Depth	**18 in**
	Freeboard Depth	**12.00 in**
	Surface Capacity at Depth 1	**18194.5 cu ft**
	Design Infiltration Rate for Native Soil	**0.000 in/hr**
	Infiltration Capacity	**0.329 cfs**
Facility Facts	Total Facility Area Including Freeboard	**9732.39 sq ft**
	Sizing Ratio	**5.8%**
Pollution Reduction Results	Pollution Reduction Score	**Pass**
	Overflow Volume	**8762.012 cf**
	Surface Capacity Used	**3%**
Flow Control Results	Flow Control Score	**Pass**
	Overflow Volume	**44142.343 cf**
	Surface Capacity Used	**99%**

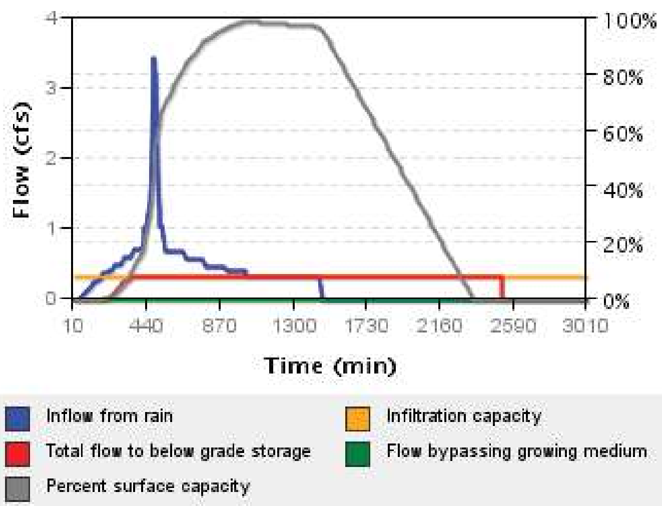
25 year post-development outflow (cfs)		**10 year pre-development inflow (cfs)**	
0.795	≤	0.798	**Pass**

Pollution Reduction Event Surface Facility Modeling



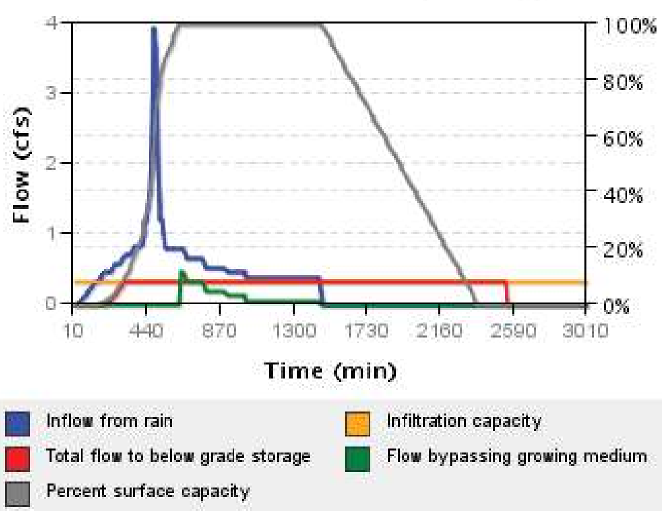
Pollution Reduction Event Below Grade Modeling

10 Year Event Surface Facility Modeling



10 Year Event Below Grade Modeling

25 Year Event Surface Facility Modeling



25 Year Event Below Grade Modeling

December 22, 2017

Marc Wyzykowski
Dan Katzenberger
Johnson Development Associates (JDA)
88 Kearny Street, Suite 1770
San Francisco, California 94108

Re: Geotechnical Engineering Due Diligence Study – DRAFT
Proposed Monroe Street Apartments Development
Clackamas County Parcels 00023174 (Parcel 1) and 00022825 (Parcel 2)
Milwaukie, Oregon
Project No. 170573-02

Dear Mark and Dan:

This geotechnical engineering due diligence letter summarizes the local soil and groundwater conditions and key geotechnical factors for consideration in the purchase and future development for property located on Clackamas County Parcels 00023174 and 00022825 in Milwaukie, Oregon. (Subject Property; Figure 1, Site Location Map). Aspect Consulting, LLC's (Aspect) geotechnical review included reviewing the geologic hazards and evaluating the earthwork, pavement, and foundation approaches. We have also provided general subsurface drainage recommendations and a qualitative assessment of infiltration feasibility for on-site stormwater management.

We have also included geotechnical exploration and testing recommendations for the Phase II Environmental/Geotechnical Assessment. If JDA proceeds with acquisition and redevelopment of the Subject Property, supplemental geotechnical engineering evaluations and design coordination will be required.

Project Description

The Subject Property is a roughly triangular-shaped property consisting of Parcel 1 and Parcel 2 on a total of approximately 7.3 acres that is located between SE Oak Street, SE Monroe Street, SE 37th Street, and the Union Pacific Railroad (UPRR) tracks. The Subject Property is vacant except for a chain-link fence around the perimeter of Parcel 2 and small storage shed on Parcel 2. Most of the site has been covered with grasses with scattered brush and deciduous trees and generally slopes down from the northeast to the southwest. The general site layout is shown on Figure 2, Site Map.

We understand that JDA has the former Parcel 1 Partition of the LD McFarland Site under contract, and that your 120-day due diligence period began the week of October 10, 2017. The 4.7-acre Parcel 1 has a well-documented environmental history and is an attractive location for redevelopment as a multiunit apartment complex. The LD McFarland Company conducted property cleanup with Oregon Department of Environmental Quality (DEQ) oversight under a formal Consent Decree beginning in 2001. DEQ issued a Certificate of Completion on July 1, 2002, and DEQ agreed to remove Parcel 1 from the inventory of hazardous substance sites.

The redevelopment plans (Project) by LRS Architects (sheet Site Plan – Option 2, dated 12/6/17) currently being considered include multiunit residential housing, common area amenities, garages, surface parking, and no below-grade structures. The apartment buildings will be located along SE Monroe Street and SE 37th Avenue with covered parking adjacent to the railroad property on the southwest side of the Subject Property. A pool, clubhouse, playground, and additional surface parking are planned in the southeast corner (Parcel 2) of the Subject Property.

Data Review

Resources

We reviewed several available documents, reports, and online information sources during our research of the Subject Property. The data review has been limited to information in the immediate vicinity of the Subject Property, and excludes any specific historical uses. Sources included:

- Published geology maps (Beeson and Tolan., 1989; Gannett and Caldwell,1998; Burns et al., 1997) available through the Oregon Department of Geology and Mineral Industries (DOGAMI)) and online geology sources
- DOGAMI Oregon HazVu: Statewide Geohazards Viewer (DOGAMI, 2017; accessed December 13, 2017)
- Clackamas County CMap online GIS portal (Clackamas County, 2017; accessed December 13, 2017)
- Previous reports in our files and provided by JDA, including the Phase I Soil Remedial Action Closeout Report (Bridgewater Group, 2002) and the LRS Architects Site Plan – Option 2 (LRS Architects, 2017)
- Oregon Water Resources Department (OWRD), well log query online portal (OWRD, 2017) for the Subject Property

Geologic Setting

The Subject Property is in Portland Basin, which is part of the Willamette Valley physiographic province—a narrow north to north-east trending valley approximately 20 to 30 miles wide and 130 miles long. Four basins comprise the province; from north to south, these include: the Portland Basin, Tualatin Basin, Central Willamette Valley, and the Southern Willamette Valley. The northwesterly trending Tualatin Mountains and the Chehalem Mountains separate the Tualatin Basin from the Portland Basin and the Central Willamette Valley, respectively.

The geology is mapped as Pleistocene channel facies (Qfch) deposits on the western portion of the Subject Property and as Pleistocene fine-grained facies (Qff) deposits on the eastern portion (Beeson and Tolan, 1989). The younger Qfch unit consists of interlayered silts, sands, and gravels deposited on major floodways that are cut in the older Qff unit. The irregular post-flood surfaces of Qfch deposits have been locally filled with bog and pond sediments. The Qff unit consists of course sand and silt deposited by catastrophic floods. The Subject Property near-surface conditions would also have been modified during more recent redevelopments by excavation, filling, and construction that buildings and other structures will be founded on.

The bedrock and sediment thickness map (Burns et al., 1997) estimates the unconsolidated sediment thickness underlying the Subject Property by these two units is between 300 and 600 feet.

Geologic and Seismic Hazards

Geologic and seismic hazards are defined as those conditions associated with the geologic and seismic environment that could influence existing and/or proposed improvements. In general, the geologic and seismic hazards most commonly associated with the physical and chemical characteristics of near surface soil, rock, and groundwater include the following.

Those shown in **bold** are the geologic and seismic hazards that could affect the study areas' development and should be considered during the planning process.

Geologic Hazards

- Slope stability
- Subsurface voids
- Volcanic hazards
- **Adverse soils**
- **Hydrology and drainage**
- Land subsidence
- **Hydrogeology and groundwater**
- Hazardous minerals and gases
- Erosion and sedimentation

Seismic Hazards

- **Liquefaction**
- **Ground shaking**
- Seiches
- Lateral spreading
- Tsunamis
- **Fault ground rupture**
- Earthquake-induced landslides

Specific hazards identified above in **bold** are presented in Table 1 below. The "Level of Concern" is a qualitative assessment based on our engineering geology and geotechnical engineering judgment. Where noted with footnotes, the terminology is taken from a specific source (e.g., HazVu Program).

Table 1. Summary of Geologic and Seismic Hazards Potentially Affecting the Subject Property

Geologic and Seismic Hazard	Examples	Level of Concern
Adverse Soils	Artificial Fill	Low to Moderate, Subject Property was graded and filled as part of remedial actions
	Expansive Soil, Compressible Soil, Organic-Rich Soil, Sensitive Clay	None to Low
Hydrology and Drainage	Flooding[a]	Not in FEMA 100-year flood plain
	Seiches or Standing Water	None to Low
Hydrogeology and Groundwater	Shallow or artesian groundwater	Moderate
	Seepage	None to Low
	Permeability or percolation	Moderate

Seismic Hazards	Cascadia Earthquake Shaking[a]	Very Strong
	Local Source Earthquake Shaking[a]	Very Strong
	Local Fault Rupture[a]	Portland Hills fault traces across Subject Property
	Liquefaction[a]	Low to High, green, orange, and red colors shown on map

Notes: [a] – HazVu website: http://www.oregongeology.org/hazvu/

The primary geologic hazard that may require further evaluation during engineering design is related to the artificial fill placed during remediation. However, based on the construction observation letter (Hart Crowser, 2002), we do not currently consider this condition to cause geotechnical issues in developing the Subject Property.

The primary seismic hazards that could impact the Subject Property are ground shaking from a Cascadia or local fault earthquake (“very strong”), potential for fault ground rupture from the Portland Hills fault zone, liquefaction.

The Cascadia Subduction Zone (CSZ), a major zone of plate convergence located offshore, is located approximately 10 miles west of the Subject Property and is the primary seismogenic ground shaking source. The CSZ extends from offshore northern California to southern British Columbia and may have generated at least seven great earthquakes (those of magnitude M8 or greater) in the last 3,500 years, suggesting a recurrence interval of approximately 300 to 600 years. Detailed tsunami records from Japan indicated the last significant CSZ earthquake occurred on January 26, 1700. Atwater and others (2005) estimated the earthquake had a magnitude of between M8.7 and 9.2.

The Portland Hills fault traces through the Subject Property and is regionally mapped along the northeastern margin of the Tualatin Mountains (Portland Hills) and the southwestern margin of the Portland basin. The crest of the Portland Hills is defined by the northwest-striking Portland Hills anticline. Displacement on the Portland Hills fault is poorly known and controversial. No fault scarps on surficial Quaternary deposits have been described along the fault, but some geomorphic and geophysical evidence suggest Quaternary displacement (Personius, 2002).

Subsurface Conditions

Subject Property Soils

Our understanding of subsurface conditions is based on the Phase I Soil Remedial Action Closeout Report (Bridgewater Group, 2002), geology maps (Beeson and Tolan, 1989), and local well logs. The Phase I Soil Remedial Action Closeout Report noted that in 2001:

In general, at the hot spots the upper 2 to 10 feet in Parcel 2 and upper 2 to 5 feet in Parcel 1 were removed. Approximately 10,580 cubic yards of soil excavated from Parcel 1, UPRR parcel, and the Milwaukie Marketplace parcel was placed on Parcel 2. According to the specifications, the soil was placed in lifts, graded with dozers, and compacted with a vibratory roller compactor. A greater volume of soil was placed on Parcel 2 than was anticipated in the remedial design. The additional soil was accommodated by raising the overall Parcel 2 grade and consolidating the organic *surface material into a single berm in the southeast corner of Parcel 2. The soil was compacted to relative densities greater than 92 percent of the Modified Proctor Maximum Density (ASTM-1557).*

A geotextile fabric and gravel cover was placed over Parcel 2 after placement, grading, and compaction of the relocated soil from Parcel 1, UPRR, and Milwaukie Marketplace parcels. Import fill consisting of silty, sandy gravel was placed on top of the fabric. The gravel was placed to a nominal thickness of about 4- inches across all of Parcel 2 and graded with a small dozer to match the grade of the underlying compacted soil. Other than any compaction caused by the dozer tracks, the gravel was not compacted.

The well logs that were noted as being related to L.D. McFarland and reviewed included:

Table 2. Local Well Logs at or near the Subject Property

CLAC 18214	CLAC 19906	CLAC 54558	CLAC 57431
CLAC 18526	CLAC 19965	CLAC 54567	CLAC 57432
CLAC 18527	CLAC 19966	CLAC 57421	CLAC 57433
CLAC 18528	CLAC 19969	CLAC 57422	CLAC 58341
CLAC 18529	CLAC 20019	CLAC 57423	CLAC 58342
CLAC 18530	CLAC 20020	CLAC 57424	CLAC 62564
CLAC 18531	CLAC 20021	CLAC 57425	CLAC 62565
CLAC 18532	CLAC 20022	CLAC 57426	CLAC 62566
CLAC 18533	CLAC 53806	CLAC 57427	CLAC 62567
CLAC 18534	CLAC 53807	CLAC 57428	CLAC 62568
CLAC 18535	CLAC 53808	CLAC 57429	
CLAC 19905	CLAC 54557	CLAC 57430	

These well/soil borings were drilled to between 19 and 172 feet below ground surface (bgs) and are primarily associated with the previous environmental work. The soils encountered in the borings generally consisted of an upper silt and sand deposit typically less than 10 feet thick from the ground surface underlain by coarse-grained mixtures of sand, gravel, and cobble deposits to at least the 172 feet bgs explored.

Groundwater

Groundwater was noted at between 6 and 16 feet in several of the shallower borings drilled between 1992 and 1994, and in 2006. The groundwater table can change significantly over time; therefore, the more-recently drilled borings or groundwater monitoring should be considered more reliable.

Groundwater can generally be assumed to be below shallow excavation depths for spread footing foundations and utility trenches, though localized, perched groundwater zones should be anticipated within an excavation. Deeper excavations for below-ground structures, such as parking garages or basements, may require dewatering considerations. Fluctuations in static and perched groundwater conditions may occur due to changes in precipitation or seasonal influences.

Site Reconnaissance

We performed our geotechnical site reconnaissance of the Subject Property on December 20, 2017. Heavy rain preceded our site reconnaissance and intermittent showers continued throughout the duration of the reconnaissance.

Topographically, the ground surface at the Subject Property generally slopes gently down from the northeast to the southwest and from north to south. Parcel 2 is mostly flat and approximately 4 to 5 feet higher in elevation than the majority of Parcel 1. In the southeast corner of Parcel 2, we observed a short, topographic mound that was approximately 6 -feet tall and 125 feet in diameter. The topographic low point is located along the southern boundary west of Parcel 2. Maximum slope angles were on the order of 12 percent or less than 7 degrees below horizontal.

We observed standing water along the southern boundary of the Subject Property, typically less than 6 inches and likely the result of recent heavy precipitation. We did not observe evidence of concentrated surface flow across the Subject Property or any groundwater seepage. Surface drainage conditions as well as groundwater conditions at the Subject Property will vary with fluctuations in precipitation; site usage, such as irrigation; and off-site land use. Perched water could occur in the upper soil deposits.

The majority of the Subject Property is covered with grass or surfaced with gravel (Parcel 2) and we did not observe any evidence of recent or active soil erosion.

Geotechnical Design Considerations

The proposed development of the Subject Property is feasible from a geotechnical engineering perspective with the following design and construction considerations.

Foundation Support

The Pleistocene channel facies (Qfch) deposits mapped across the western portion of the Subject Property exhibit moderate shear strength and typically low to moderate compressibility characteristics and are capable of providing sufficient support for new building foundations. Similarly, based on the construction observation letter (Hart Crowser, 2002), the fill underlying the eastern portion of the Subject Property (Parcel 2) appears to have been placed in lifts, compacted to structural fill standards with appropriate quality control measures, and is capable of providing sufficient support for new building foundations. We anticipate the new buildings may be supported using appropriately proportioned spread footings or structural mat foundations.

Based on the past grading activities at the Subject Property, some overexcavation of previously disturbed or softened soils and replacement with structural fill should be expected. Geotechnical borings should be advanced at the locations of the proposed buildings to develop final foundation design parameters, and to evaluate the potential for liquefaction at the Subject Property and any associated impacts to the building foundations.

Stormwater Management and Permanent Subsurface Drainage

The Pleistocene channel facies (Qfch) deposits underlying the Subject Property are variable ranging from a relatively fine-grained mixture of silt and sand in the upper 10 feet of the soil profile to relatively coarse-grained mixtures of sand, gravel, and cobbles below 10 feet. Groundwater is between 6 and 16 feet below the ground surface at the Subject Property. The upper silt and sand may provide limited infiltration opportunities while the relatively shallow groundwater levels will limit infiltration into the more favorable coarse-grained deposits below 10 feet.

We recommend stormwater management be accomplished using Low Impact Development (LID) methods combined with conventional methods, including catch basins and storm drain pipes that discharge into an appropriate system. LID methods, such as small raingardens, bioswales, and permeable pavements are feasible, provided the systems incorporate underdrains and/or overflow redundancy to account for the low permeability and low-infiltration capacity of the Subject Property soils. Any stormwater infiltration design must consider the potential impacts of increased groundwater on adjacent properties and the potential for mobilizing any remaining contaminants off-site. Stormwater management should be accomplished in accordance with the City of Portland Stormwater Management Manual (as adopted by the City of Milwaukie).

Subsurface drainage elements should include perimeter foundation drains, a capillary break and drainage layer under the lowest mat foundations or concrete slabs, and permanent wall drainage for any small retaining walls. Appropriate soil vapor intrusion mitigation should also be included, where needed.

Pavement Considerations

The soils underlying the Subject Property can provide adequate support for relatively standard pavement sections. The pavements should be designed for the anticipated traffic loading. For efficiency, we recommend developing at minimum of two pavement sections for the Project; one section for nonroadway and nonheavy traffic areas, and one section for the primary access drives that will receive higher traffic volumes and loading. For planning purposes, we recommend the following asphaltic concrete (AC) pavement sections:

- Nonroadway/Nonheavy Traffic Areas: 3 inches AC over 6 inches of crushed rock base (CRB)

- Access Drives/Heavy Traffic Areas: 4 inches AC over 8 inches of CRB

Earthwork Considerations

It is our opinion that the earthwork for the Project can be completed with standard construction equipment. Although not observed, regional experience indicates that oversized materials such as large cobbles and boulders could be present in the Pleistocene channel facies (Qfch) deposits and the fill present at the Subject Property could contain oversized debris.

The soils at the Subject Property are typically moisture sensitive and may be difficult to handle, prepare, or compact with construction equipment during periods of wet weather. Earthwork is typically most economical when performed under dry weather conditions.

In general, the soils across the Subject Property classify as OSHA Soil Classification Type B. Temporary excavation cut slopes should be sloped no steeper than 1H:1V (Horizontal:Vertical). The estimated maximum cut slope inclination is applicable to excavations without groundwater seepage, or runoff, and assume dewatered conditions. Flatter slopes will likely be necessary in areas where groundwater seepage exists, or where construction equipment surcharges are placed in close proximity to the crest of the excavation. We recommend planning permanent slopes no steeper than 2H:1V for the Project.

Structural fill may consist of on-site soils provided they are free of organics and other deleterious matter and can be moisture conditioned for compaction. The on-site soils are moisture sensitive and their use for structural fill will likely be limited to the drier summer months. During the wet weather season, imported materials for structural fill should have a maximum of 7 percent fines (particles passing the No. 200 sieve). Structural fill should be compacted to a minimum of 95 percent of the maximum dry density (MDD) as determined by American Society for Testing and Materials (ASTM) D1557. The moisture content should be controlled to within 3 percent of the optimum moisture content.

Construction Dewatering

Significant excavations are not anticipated for the Project; however, utility trenching may encounter the relatively shallow groundwater at the Subject Property. We anticipate groundwater seepage into the utility trenches can likely be managed with conventional sumps and pumps; however, deeper utility trenches may require a more robust dewatering system to facilitate dry conditions.

The potential settlement of the surrounding soils during any active dewatering should be carefully considered along with the potential for remnant contaminants in the groundwater and excavated soil that could require special treatment and management.

Recommendations for Further Study

Final design of the Project structure foundations, pavement sections, any stormwater management through infiltration, and key earthwork considerations will require additional geotechnical data. Depending on the evolution of the Project design, we recommend a series of geotechnical explorations across the Subject Property, including soil borings in the areas of the proposed buildings and pavements, and test pits in the areas of significant earthwork/grading and any stormwater infiltration.

The details of the geotechnical investigation plan can be developed in sequence with the Project design through collaboration with you and the other Project design team members.

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Closing

The feasibility-level design and construction considerations detailed above have been encountered and successfully addressed at other similar project sites in the Milwaukie area, and we expect they can be successfully implemented at this Subject Property.

If you proceed with this development, Aspect will be pleased to provide detailed geotechnical engineering studies, and design and permitting support for the Project.

Limitations

Work for this project was performed for Johnson Development Associates (Client), and this letter was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This letter does not represent a legal opinion. No other warranty, expressed or implied, is made.

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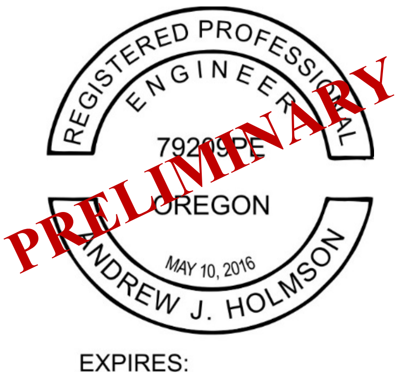

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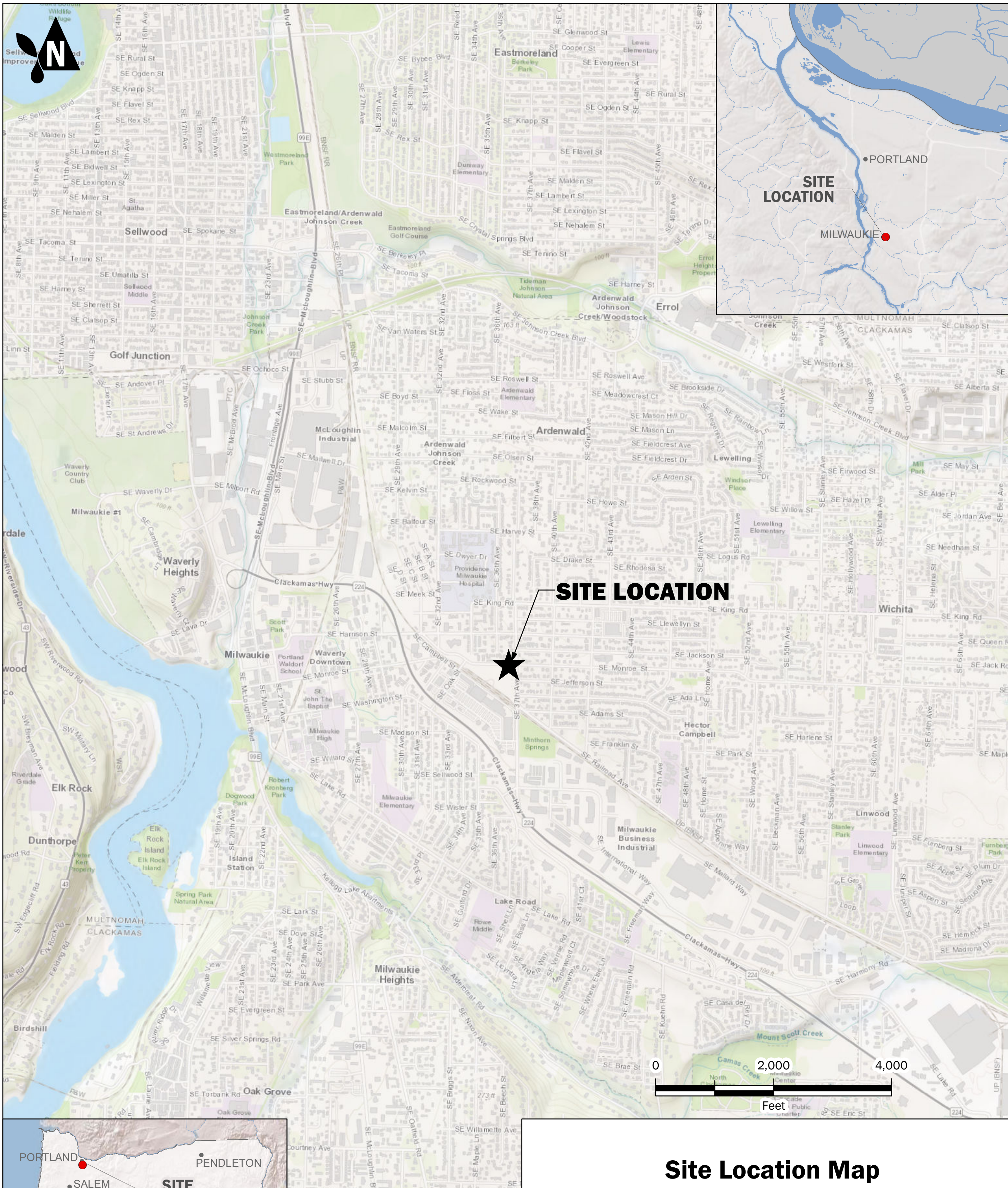
Attachments

Figure 1 Site Location Map
Figure 2 Site Map

FIGURES



Site Location Map

Geotechnical Engineering Due Diligence Study
Monroe Apartments
Milwaukie, Oregon

Aspect CONSULTING	DEC-2017	BY: MLK / RAP	FIGURE NO. 1
	PROJECT NO. 170573	REVISED BY: - - -	

GIS Path: T:\projects_8\MonroeApartments_170573\Delivered\Phase I ESA\Site Location Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/15/2017 || User: rpepin || Print Date: 12/15/2017

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Site Map

Geotechnical Engineering Due Diligence Study
Monroe Apartments
Milwaukie, Oregon

Aspect CONSULTING	DEC-2017	BY: MLK / RAP	FIGURE NO. 2
	PROJECT NO. 170573	REVISED BY: - - -	

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GIS Path: T:\projects_8\MonroeApartments_170573\Delivered\Phase I ESA\Site Plan.mxd || Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 || Date Saved: 12/15/2017 || User: rpepin || Print Date: 12/15/2017