Veranda at Pleasant Valley
Gresham, Oregon

Preliminary Stormwater Report

Date: May 2023

Client: Charlotte Point LLC

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AKS Job Number: 9804

Renewal Date: 12/31/24

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Preliminary Stormwater Report

VERANDA AT PLEASANT VALLEY
GRESHAM, OREGON

1.0 Purpose of Report

The purpose of this report is to analyze the effect that the development of this subdivision will have on the downstream stormwater conveyance system, document the criteria the proposed stormwater system was designed to meet, identify the sources of information on which the analysis was based, detail the design methodology, and document the results of the analysis.

2.0 Project Location/Description

The development is located on Tax Lot 1200 of Multnomah County Assessor's Map 1S 3E 20D. The subject site is located south of Kelley Creek and east of SE 190th Drive in Gresham, Oregon. The site is ±40.25 acres. The majority of stormwater runoff from the site drains to an existing culvert on the east side of SE 190th Drive, outfalls to the existing ditch on the west side of SE 190th Drive, and then flows north to Kelley Creek. New green stormwater facilities (street-side stormwater planters) will be installed throughout the site to the maximum extent practicable along with a new wet pond to provide a treatment and detention system for the site. The new wet pond is located on Tax Lot 400 of Multnomah County Assessor's Map 1S 3E 20C.

3.0 Regulatory Design Criteria

3.1. On-site Stormwater Quantity Management Criteria

According to Section 1.2.5 of the City of Gresham's (City's) *Stormwater Management Manual* (October 2019), to prevent hydromodification of the channel and mimic pre-development hydrology, stormwater facilities shall be sized to retain the 25-year event and control post-development peak flows to the pre-development levels in Table 1-1 of the City's *Stormwater Management Manual,* below.

Table 1-1: Flow Control Targets. Post-development peak runoff must match or be lower than the pre-development flow rate targets (taken from *City of Gresham Stormwater Management Manual)*

Post-Development Peak Flow Rate	Pre-Development Peak Flow Rate Target
2-year, 24-hour	50% of 2-year, 24-hour
5-year, 24-hour	5-year, 24-hour
10-year, 24-hour	10-year, 24-hour
25-year, 24-hour	25-year, 24-hour

3.2. On-Site Stormwater Quality Management Criteria

According to Section 1.2.3 of the City's *Stormwater Management Manual*, the pollutant reduction requirement for stormwater treatment is 80 percent of the average annual runoff. The stormwater quality design storm is 1.2 inches during a 24-hour period, which is equivalent to 80 percent of the average annual rainfall in Gresham. Stormwater facilities must be capable of reducing total suspended solids (TSS) by 70 percent, as well as treating any other pollutants of concern identified by the Oregon Department of Environmental Quality (DEQ) per the Clean Water Act (CWA) established Total Maximum Daily Loads (TMDLs), documented in DEQ's Integrated Report meeting the requirements of CWA Section 303(d) for impaired waters and TMDLs. Installation of the infiltration and green infrastructure facilities described in Section 3.0 are assumed to meet both the TSS and CWA Section 303(d) TMDL pollutant reduction goals.

3.3. Street and Public Infrastructure Stormwater Quality Management Criteria

According to Section 1.2.4.3 of the City's *Stormwater Management Manual*, all development projects that will create new public streets or infrastructure shall prioritize green infrastructure (i.e. street-side stormwater planters) at the most localized scale possible to the maximum extent practicable (MEP).

4.0 Design Methodology

The Santa Barbara Urban Hydrograph (SBUH) Method was used to design on-site stormwater quantity and conveyance systems. This method uses the Soil Conservation Service (SCS) Type 1A 24-hour design storm, as defined by the King County, Washington, *Surface Water Design Manual*. HydroCAD computer software aided in the analysis.

5.0 Design Parameters

5.1. Design Storm

5.1.1. On-Site Inlet and Conduit Sizing

Stormwater inlets/curb cuts for the site will be placed at locations that will adequately capture stormwater runoff from the roadways. The stormwater conduit pipes will be sized with Manning's equation, based on peak flows for the 10-year storm event.

5.1.2. Upstream and Off-Site Basin

Upstream stormwater runoff along the southern property line will be collected and routed to the existing ditch on the west side of SE 190th Drive (the same discharge location per existing conditions). Upstream stormwater runoff along the eastern property line will be collected and routed to the existing drainage, which will eventually flow to Kelley Creek.

5.2. Pre-Developed Site Topography and Land Use

5.2.1. Site Topography

The site area generally slopes from east to the west. Vegetative cover on the site consists of trees and grass.

5.2.2. Land Use

Currently, there are buildings on-site which will be removed with this development.

5.3. Soil Type

The soils on-site are classified as Cascade silt loam (hydrologic soil group C), Powell silt loam (hydrologic soil group D), and Wapato silt loam (hydrologic soil group C/D) by the Natural Resources Conservation Service (NRCS) Soil Survey for Multnomah County. Information on this soil type is provided in Appendix E.

5.4. Post-Developed Site Topography and Land Use

5.4.1. Site Topography

The post-developed site topography will be altered from the pre-developed conditions for the construction of public streets, single-family homes, green stormwater facilities, wet pond, and other associated infrastructure and features.

5.4.2. Land Use

The post-developed land use will consist of 175 lots, public streets, and stormwater facilities.

5.4.3. Post-Developed Input Parameters

Appendix C provides the HydroCAD reports and input parameters that were generated for the analyzed storm events with respect to the site improvements contributing to the drainage basins.

6.0 Calculation Methodology

6.1. Proposed Stormwater Conduit Sizing and Inlet Spacing

The stormwater conduit pipes will be sized using Manning's equation for the 10-year storm event. Stormwater inlets/curb cuts will be placed at locations to adequately capture stormwater runoff from the roadways.

6.2. Proposed Stormwater Quantity Control Facility Design

The new wet pond with additional detention storage capacity beyond the permanent pool is utilized to meet detention requirements. The wet pond is designed to accommodate flows generated by this development and meet City of Gresham water quantity requirements (described in Section 3.1).

6.3. Proposed Stormwater Quality Facility Design

Stormwater runoff from the roadways will be treated by street-side stormwater planters along all the streets where possible (the stormwater planters are sized at ±3 percent of the contributing impervious areas within the public right-of-way). The new wet pond constructed with a permanent pool of water will treat stormwater runoff from the rest of the development. All stormwater facilities were sized to provide water quality treatment in compliance with City of Gresham requirements (described in Section 3.2).

6.4. Emergency Overflow

The emergency overflow weir was sized to convey the 100-year storm event. Calculations are included in Appendix D. If the stormwater facility's outlet structures become plugged and cannot convey runoff from the site, the overflow stormwater from the stormwater facility will sheet flow across the overflow riprap pad and down to the creek.

6.5. Downstream Analysis

The stormwater discharge from the new wet pond will discharge into Kelley Creek. Because the stormwater facility is sized and designed to meet the requirements of the City of Gresham, peak flow discharges from the new wet pond will be detained and metered out at or below the pre-development runoff condition. Therefore, this project will not negatively impact downstream capacity.

7.0 Summary Table

The table below summarize the pre-developed and post-developed peak flows for the wet pond.

Table 7-1: Stormwater Facility (SWF)

CATCHMENT	PEAK FLOWS (cubic feet per second)			
	STORM EVENT			
	2-YR	5-YR	10-YR	25-YR
Pre-Developed Conditions				
EX (Existing Conditions)	3.06	4.63	6.36	8.22
Post-Developed Conditions				
P (Post-developed)	14.49	17.27	20.08	22.93
Allowable Release Rate*	1.53	4.63	6.36	8.22
Design Release Rate to Downstream	1.44	2.93	3.91	5.47

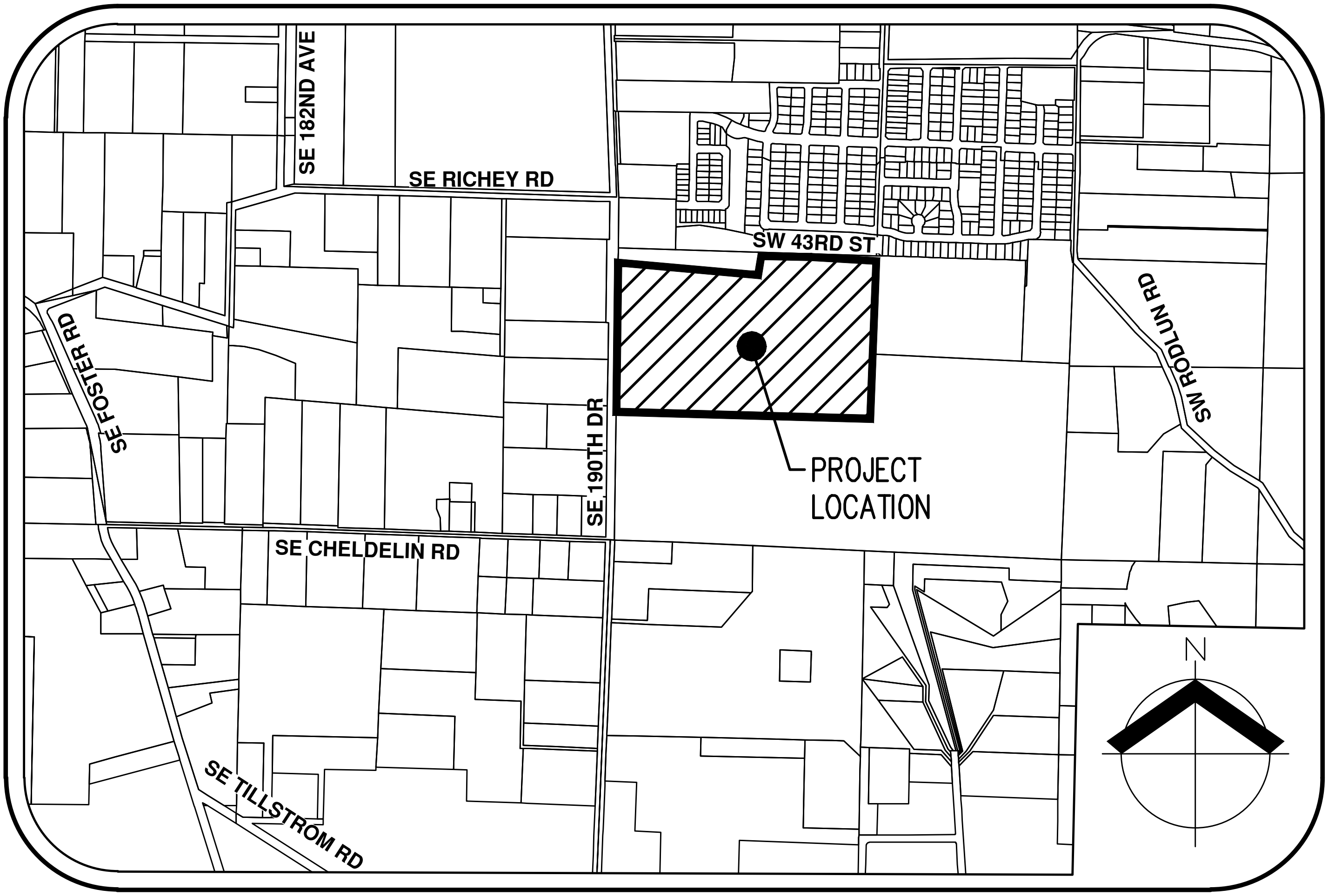
**The allowable release rate for the post-developed 2-year storm event per the City of Gresham standards is equal to 50% of the pre-developed peak runoff rate for the 2-year storm event from Catchment W (Existing Conditions).*

**The allowable release rate for the post-developed 5-year storm event per the City of Gresham standards is equal to the pre-developed peak runoff rate for the 5-year storm event from Catchment W (Existing Conditions).*

**The allowable release rate for the post-developed 10-year storm event per the City of Gresham standards is equal to the pre-developed peak runoff rate for the 10-year storm event from Catchment W (Existing Conditions).*

**The allowable release rate for the post-developed 25-year storm event per the City of Gresham standards is equal to the pre-developed peak runoff rate for the 25-year storm event from Catchment W (Existing Conditions).*

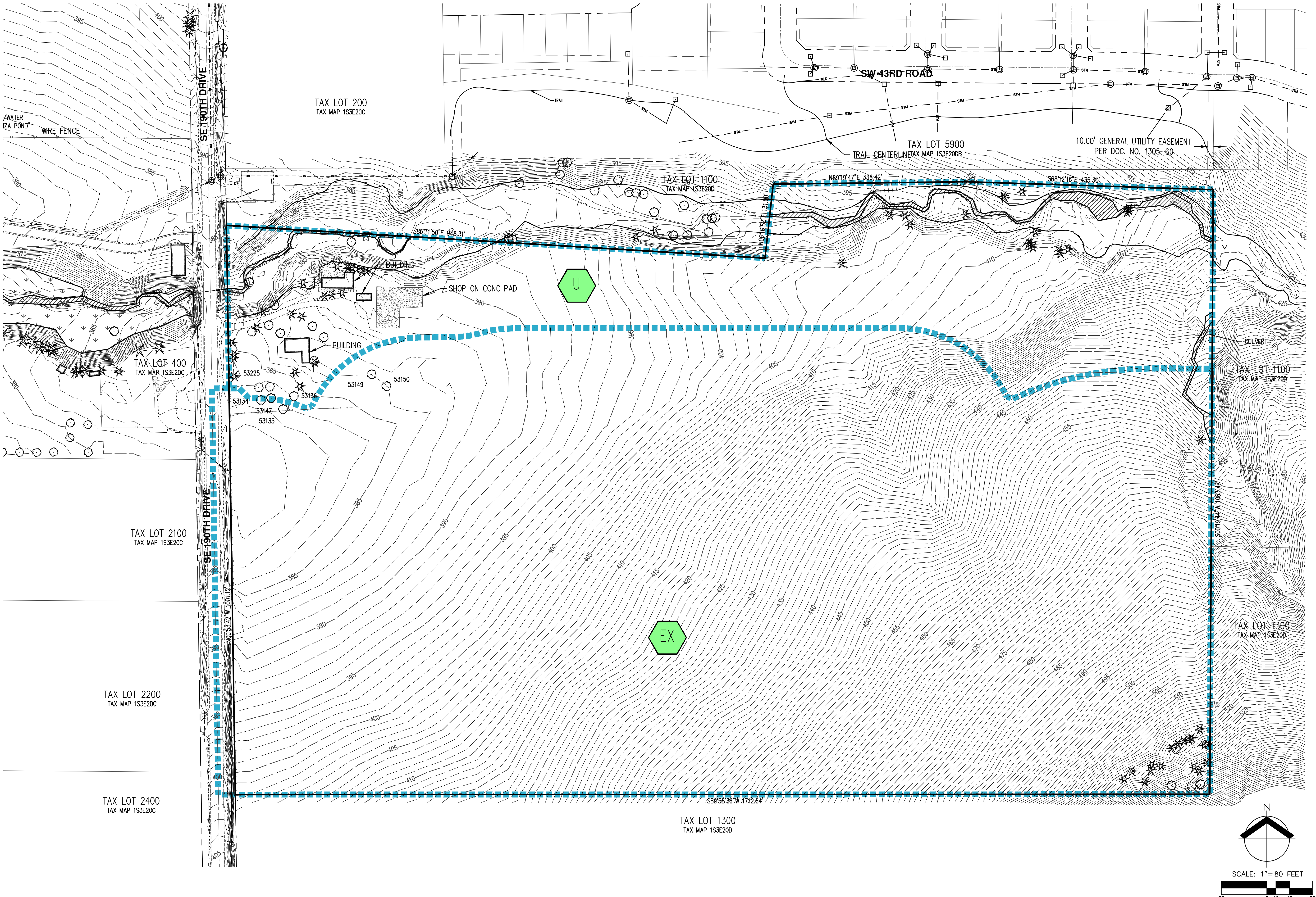
Appendix A: Vicinity Map



VICINITY MAP

NOT TO SCALE

Appendix B.1: Pre-Developed Catchment Map and Detail



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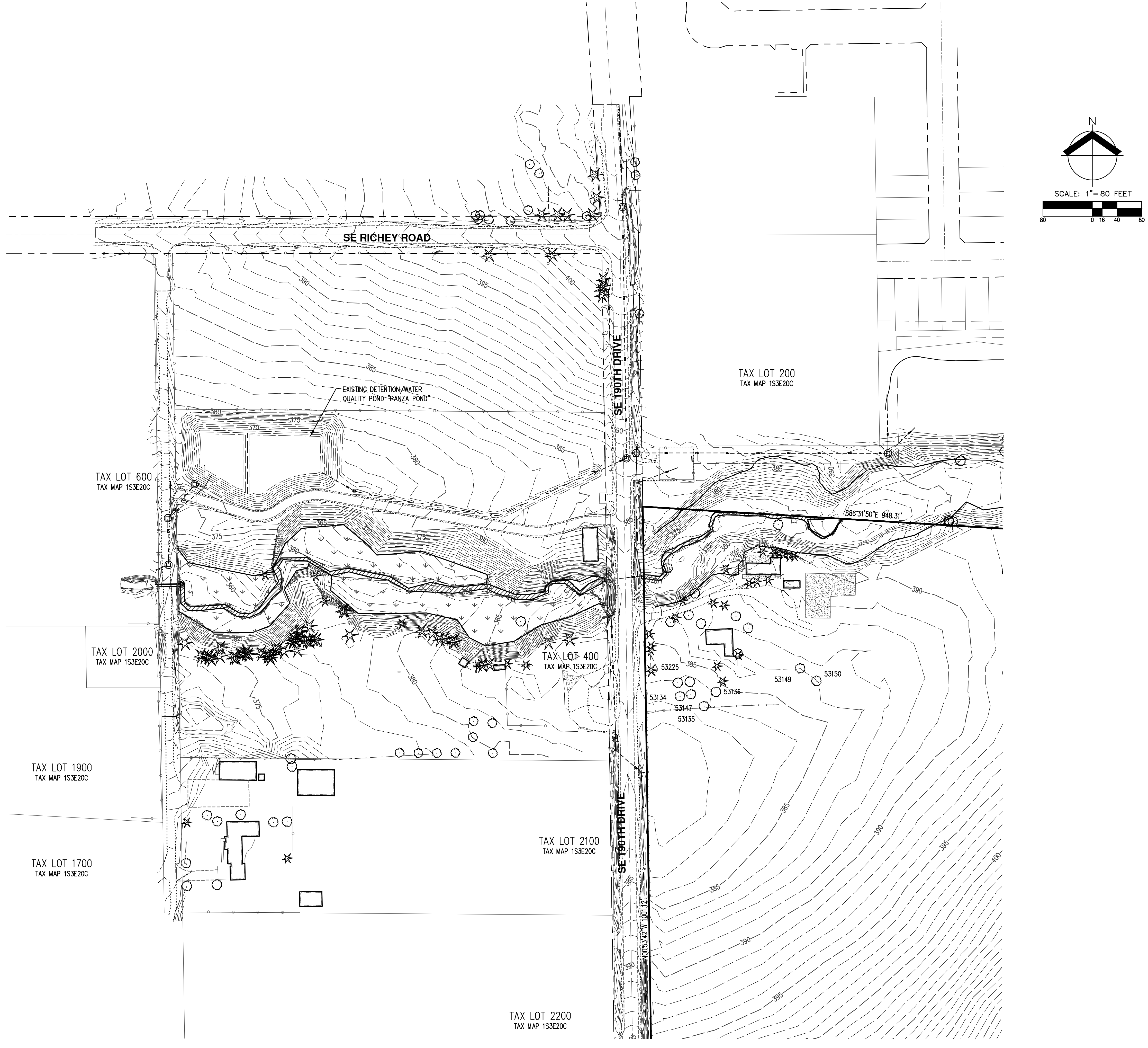
EXISTING CONDITIONS PLAN-EAST
VERANDA AT PLEASANT VALLEY
GRESHAM, OREGON

PRELIMINARY
NOT FOR
CONSTRUCTION

JOB NUMBER:	9804
DATE:	04/10/2023
DESIGNED BY:	
DRAWN BY:	SPS
CHECKED BY:	MK

1

AKS DRAWING FILE: 9804 MAP PRE.DWG | LAYOUT: EXCOND-EAST



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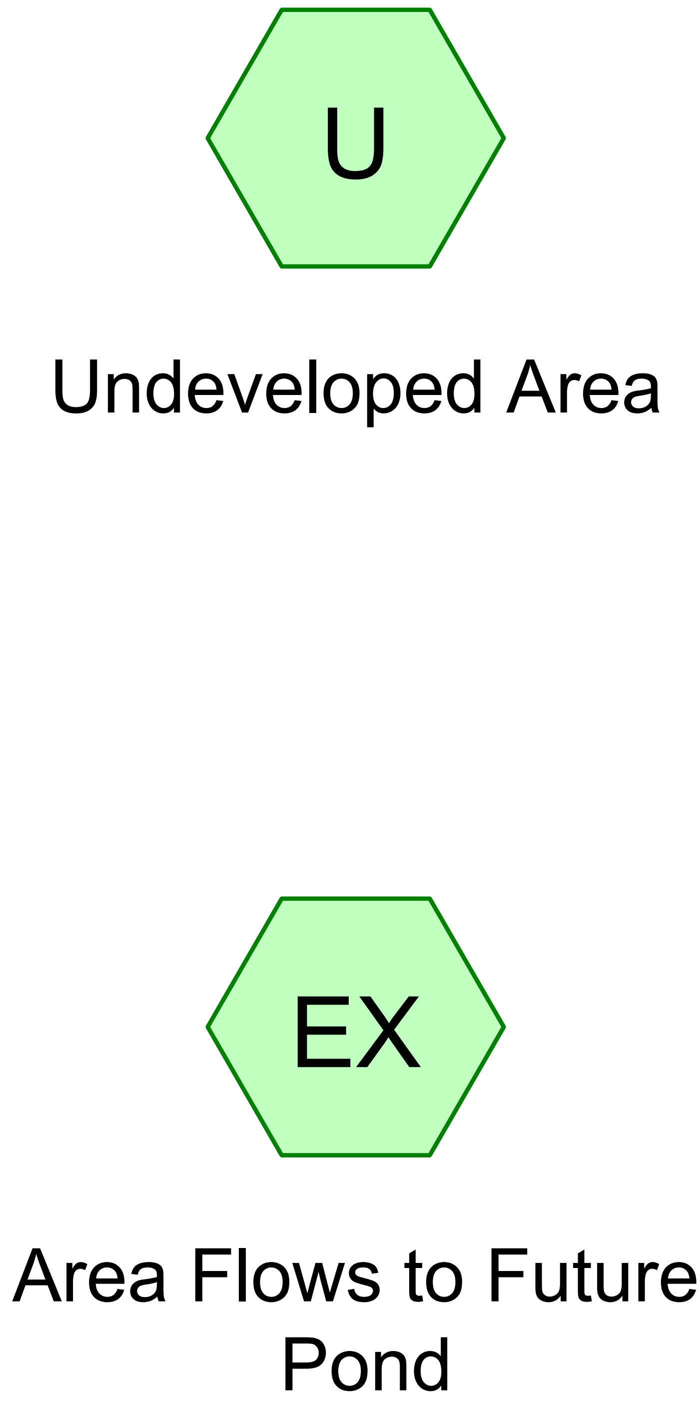
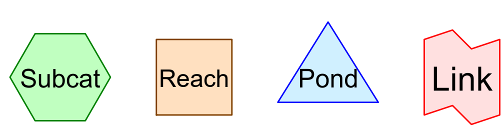
Appendix B.2: Pre-Developed Hydrograph and Flow Information 2-Year Storm Event





Routing Diagram for 9804 HydroCAD Pre
Prepared by AKS Engineering & Forestry, LLC, Printed 3/22/2023
HydroCAD® 10.00-22 s/n 01338 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
14,500	98	Existing Impervious (U)
7,000	98	Existing Pavement (EX)
1,753,100	74	Grass (EX, U)

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EX: Area Flows to Future Pond Runoff Area=1,370,000 sf 0.51% Impervious Runoff Depth>0.78"
Flow Length=925' Tc=18.9 min CN=74/98 Runoff=3.06 cfs 89,252 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 3.58% Impervious Runoff Depth>0.83"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/98 Runoff=0.84 cfs 27,961 cf

Summary for Subcatchment EX: Area Flows to Future Pond

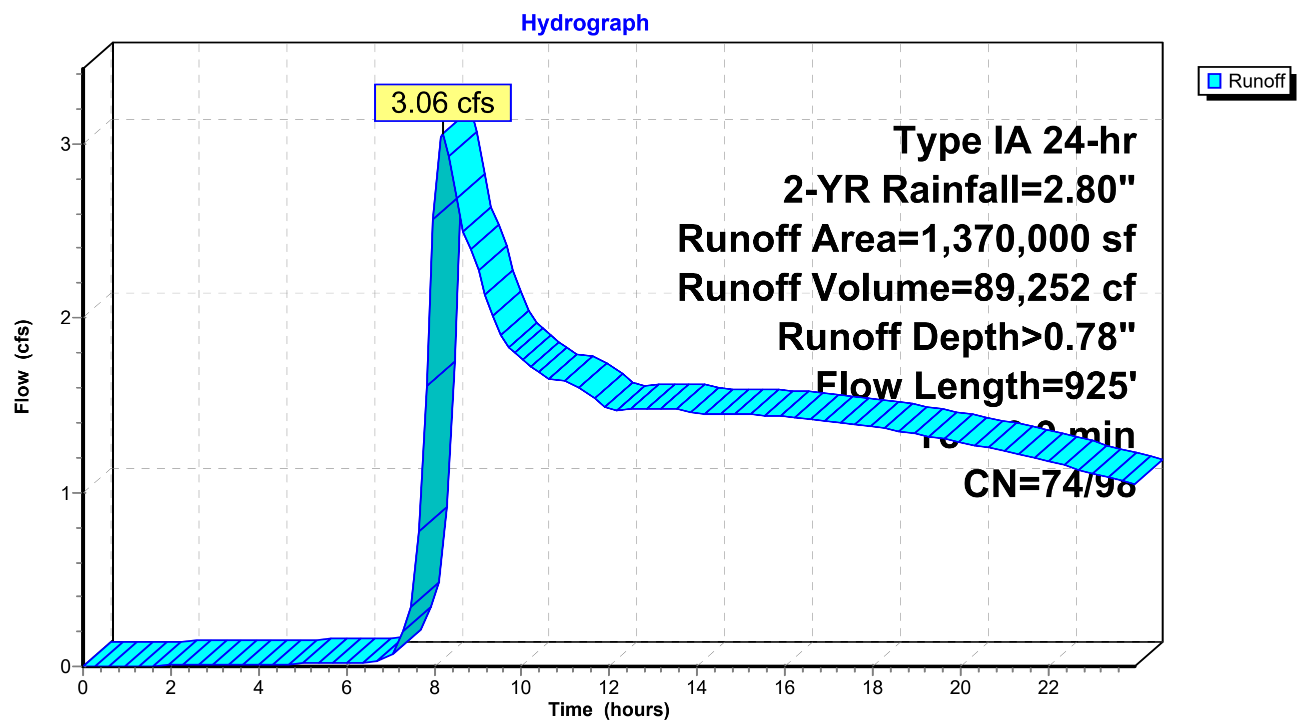
Runoff = 3.06 cfs @ 8.21 hrs, Volume= 89,252 cf, Depth> 0.78"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 2-YR Rainfall=2.80"

	Area (sf)	CN	Description
*	7,000	98	Existing Pavement
*	1,363,000	74	Grass
	1,370,000	74	Weighted Average
	1,363,000		99.49% Pervious Area
	7,000		0.51% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	300	0.2000	0.34		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"
4.3	625	0.1200	2.42		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.9	925	Total			

Subcatchment EX: Area Flows to Future Pond



Summary for Subcatchment U: Undeveloped Area

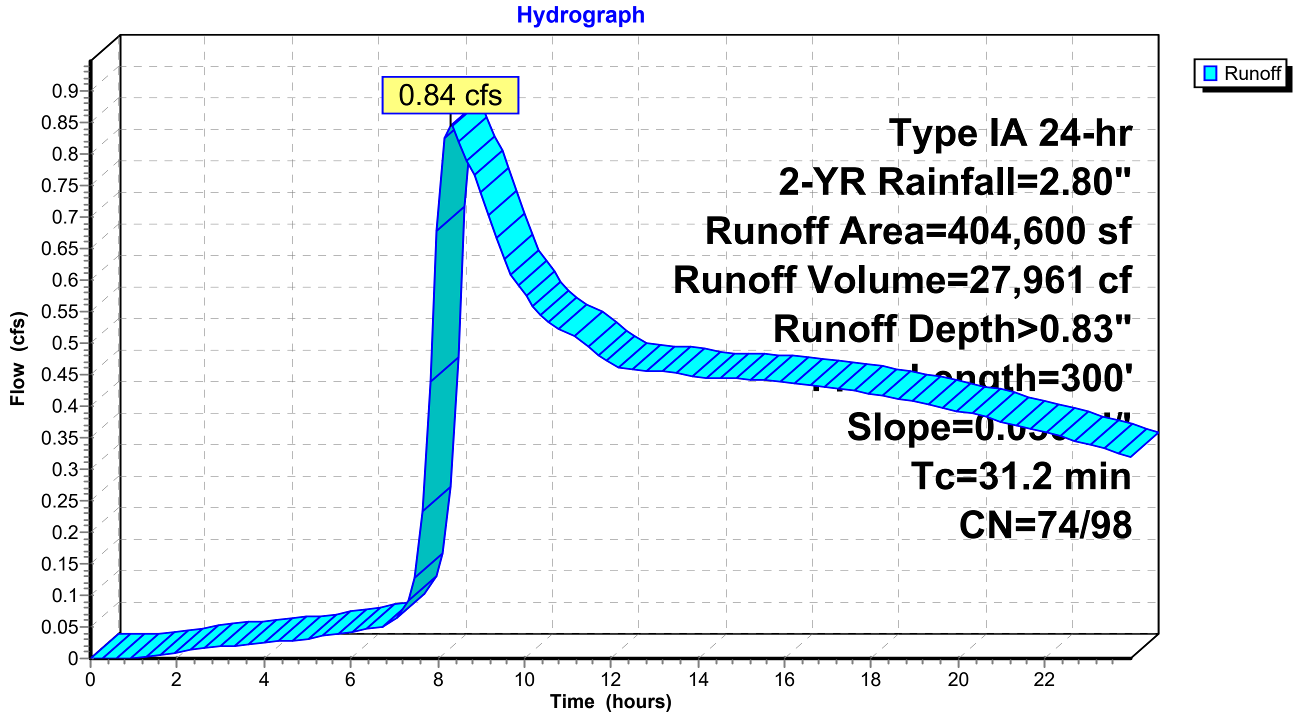
Runoff = 0.84 cfs @ 8.32 hrs, Volume= 27,961 cf, Depth> 0.83"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 2-YR Rainfall=2.80"

	Area (sf)	CN	Description
*	14,500	98	Existing Impervious
*	390,100	74	Grass
	404,600	75	Weighted Average
	390,100		96.42% Pervious Area
	14,500		3.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Appendix B.3: Pre-Developed Hydrograph and Flow Information 5-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EX: Area Flows to Future Pond Runoff Area=1,370,000 sf 0.51% Impervious Runoff Depth>1.03"
Flow Length=925' Tc=18.9 min CN=74/98 Runoff=4.63 cfs 117,981 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 3.58% Impervious Runoff Depth>1.08"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/98 Runoff=1.24 cfs 36,540 cf

Summary for Subcatchment EX: Area Flows to Future Pond

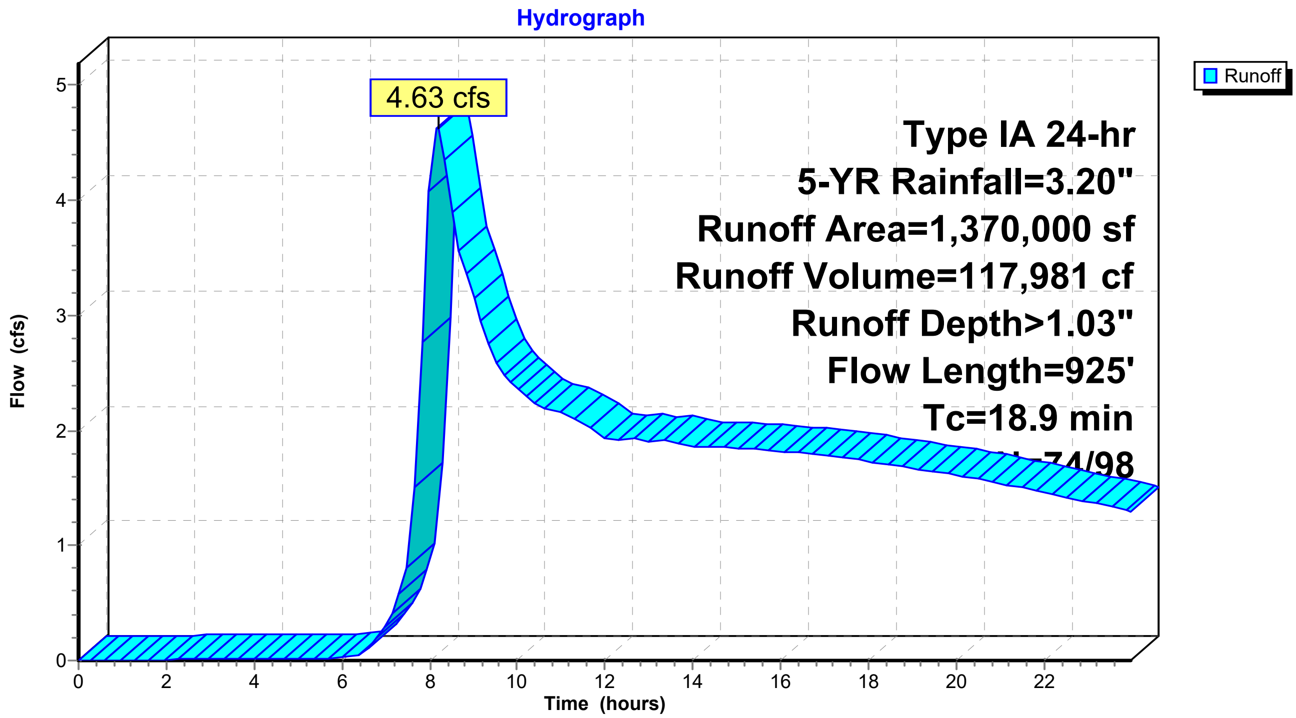
Runoff = 4.63 cfs @ 8.19 hrs, Volume= 117,981 cf, Depth> 1.03"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 5-YR Rainfall=3.20"

	Area (sf)	CN	Description
*	7,000	98	Existing Pavement
*	1,363,000	74	Grass
	1,370,000	74	Weighted Average
	1,363,000		99.49% Pervious Area
	7,000		0.51% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	300	0.2000	0.34		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"
4.3	625	0.1200	2.42		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.9	925	Total			

Subcatchment EX: Area Flows to Future Pond



Summary for Subcatchment U: Undeveloped Area

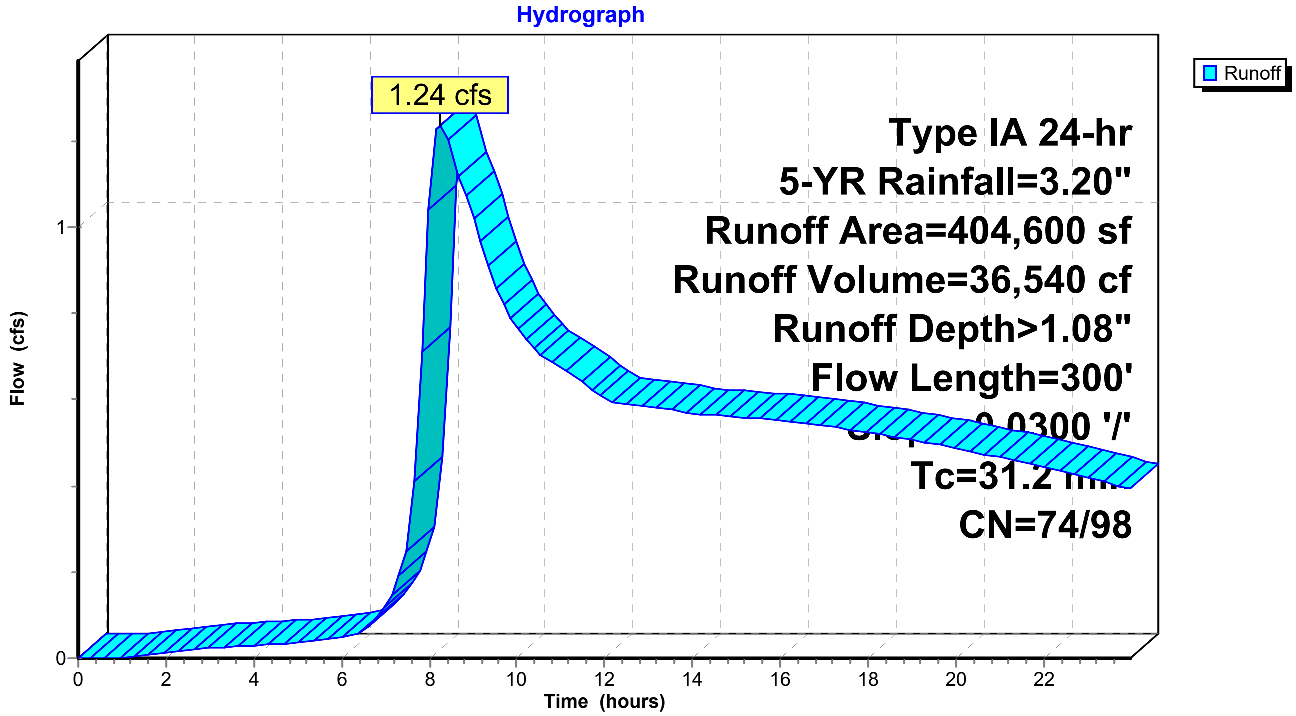
Runoff = 1.24 cfs @ 8.26 hrs, Volume= 36,540 cf, Depth> 1.08"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 5-YR Rainfall=3.20"

	Area (sf)	CN	Description
*	14,500	98	Existing Impervious
*	390,100	74	Grass
	404,600	75	Weighted Average
	390,100		96.42% Pervious Area
	14,500		3.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Appendix B.4: Pre-Developed Hydrograph and Flow Information 10-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EX: Area Flows to Future Pond Runoff Area=1,370,000 sf 0.51% Impervious Runoff Depth>1.30"
Flow Length=925' Tc=18.9 min CN=74/98 Runoff=6.36 cfs 148,779 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 3.58% Impervious Runoff Depth>1.36"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/98 Runoff=1.70 cfs 45,710 cf

Summary for Subcatchment EX: Area Flows to Future Pond

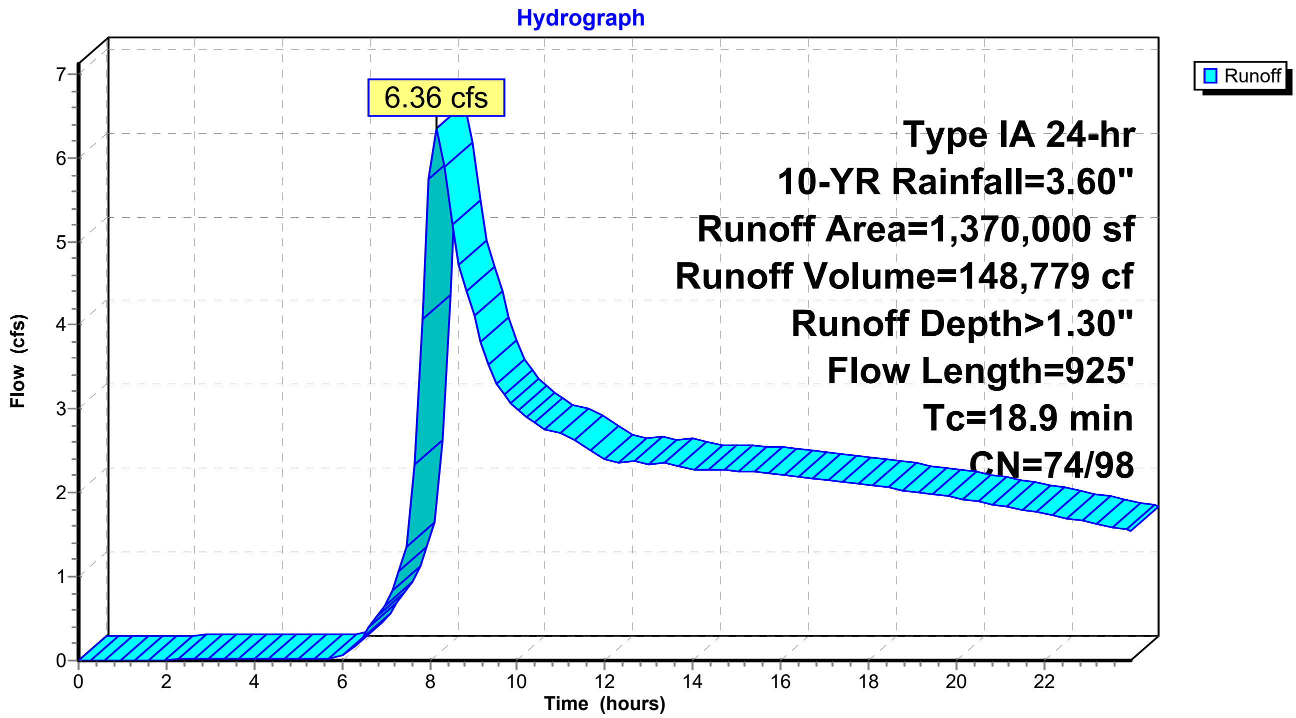
Runoff = 6.36 cfs @ 8.17 hrs, Volume= 148,779 cf, Depth> 1.30"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 10-YR Rainfall=3.60"

	Area (sf)	CN	Description
*	7,000	98	Existing Pavement
*	1,363,000	74	Grass
	1,370,000	74	Weighted Average
	1,363,000		99.49% Pervious Area
	7,000		0.51% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	300	0.2000	0.34		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"
4.3	625	0.1200	2.42		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.9	925	Total			

Subcatchment EX: Area Flows to Future Pond



Summary for Subcatchment U: Undeveloped Area

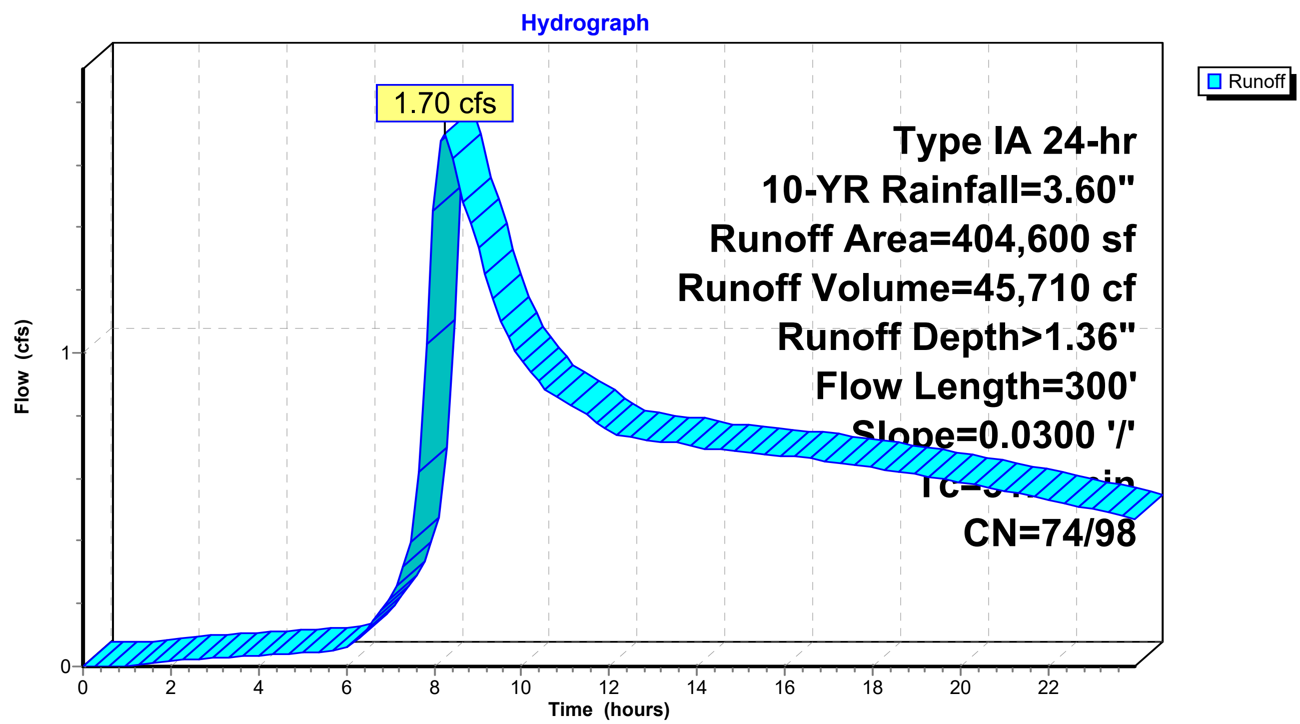
Runoff = 1.70 cfs @ 8.24 hrs, Volume= 45,710 cf, Depth> 1.36"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 10-YR Rainfall=3.60"

	Area (sf)	CN	Description
*	14,500	98	Existing Impervious
*	390,100	74	Grass
	404,600	75	Weighted Average
	390,100		96.42% Pervious Area
	14,500		3.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Appendix B.5: Pre-Developed Hydrograph and Flow Information 25-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EX: Area Flows to Future Pond Runoff Area=1,370,000 sf 0.51% Impervious Runoff Depth>1.59"
Flow Length=925' Tc=18.9 min CN=74/98 Runoff=8.22 cfs 181,283 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 3.58% Impervious Runoff Depth>1.64"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/98 Runoff=2.17 cfs 55,367 cf

Summary for Subcatchment EX: Area Flows to Future Pond

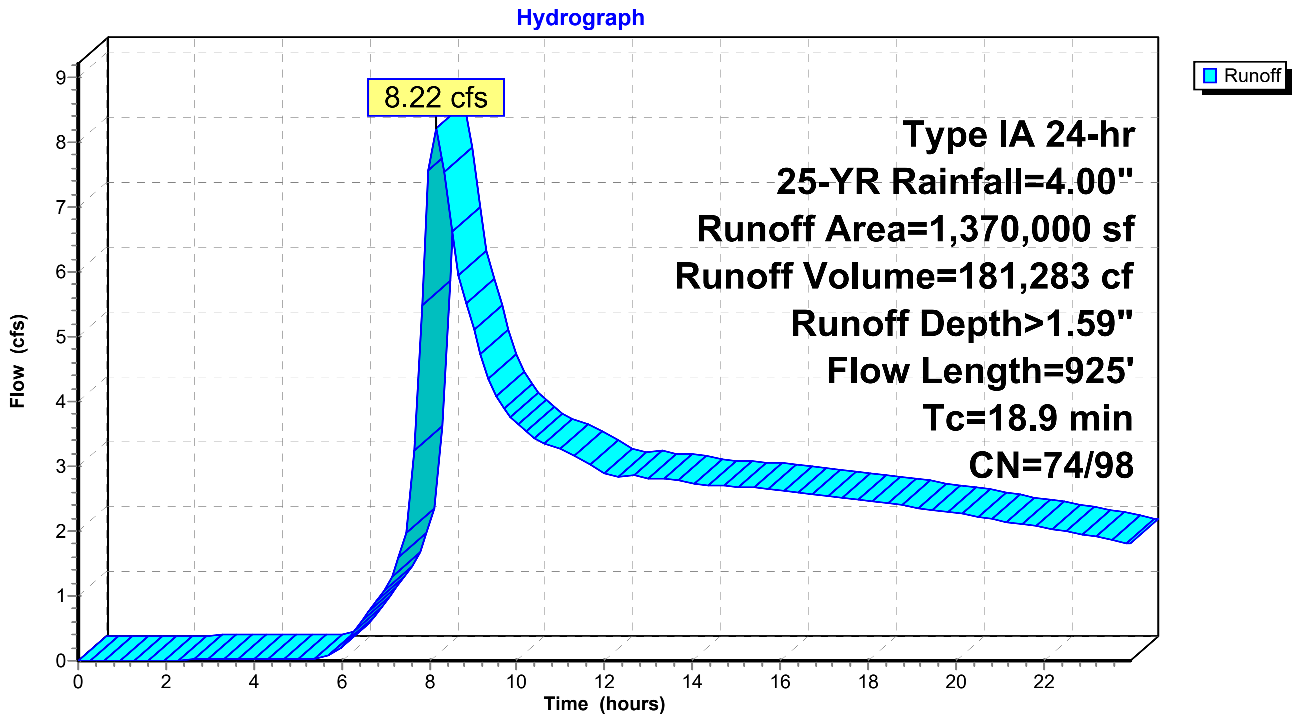
Runoff = 8.22 cfs @ 8.16 hrs, Volume= 181,283 cf, Depth> 1.59"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 25-YR Rainfall=4.00"

	Area (sf)	CN	Description
*	7,000	98	Existing Pavement
*	1,363,000	74	Grass
	1,370,000	74	Weighted Average
	1,363,000		99.49% Pervious Area
	7,000		0.51% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	300	0.2000	0.34		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"
4.3	625	0.1200	2.42		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
18.9	925	Total			

Subcatchment EX: Area Flows to Future Pond



Summary for Subcatchment U: Undeveloped Area

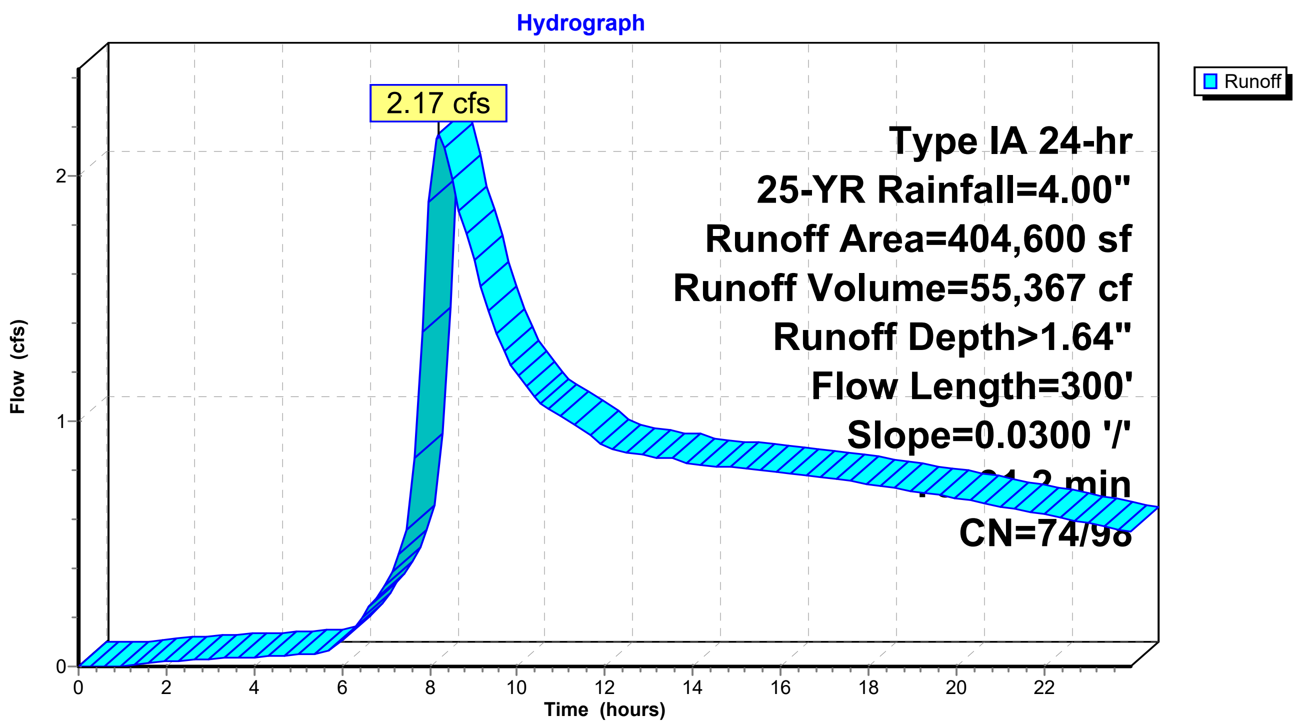
Runoff = 2.17 cfs @ 8.22 hrs, Volume= 55,367 cf, Depth> 1.64"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 25-YR Rainfall=4.00"

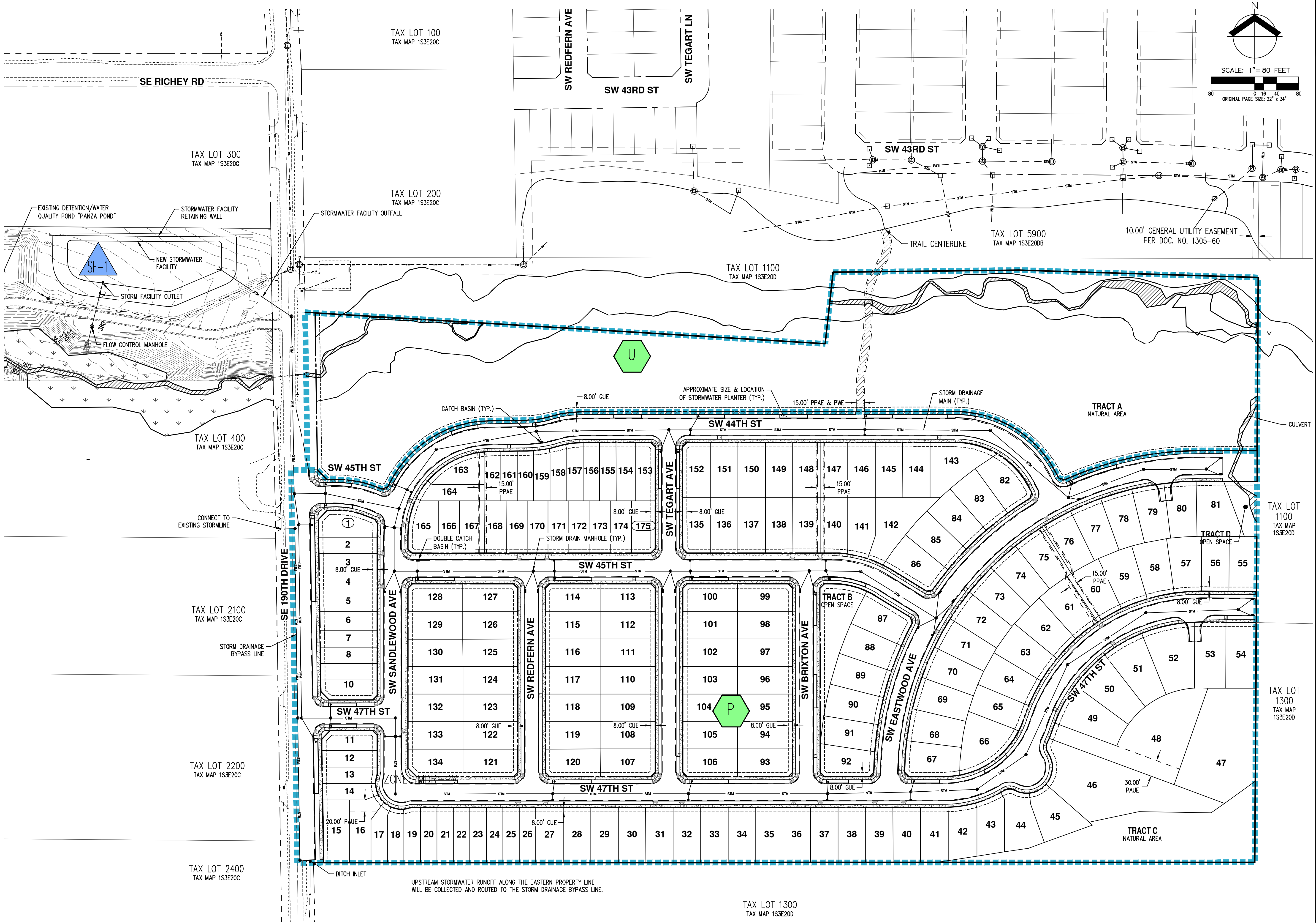
	Area (sf)	CN	Description
*	14,500	98	Existing Impervious
*	390,100	74	Grass
	404,600	75	Weighted Average
	390,100		96.42% Pervious Area
	14,500		3.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Appendix C.1: Post-Developed Catchment Map and Detail



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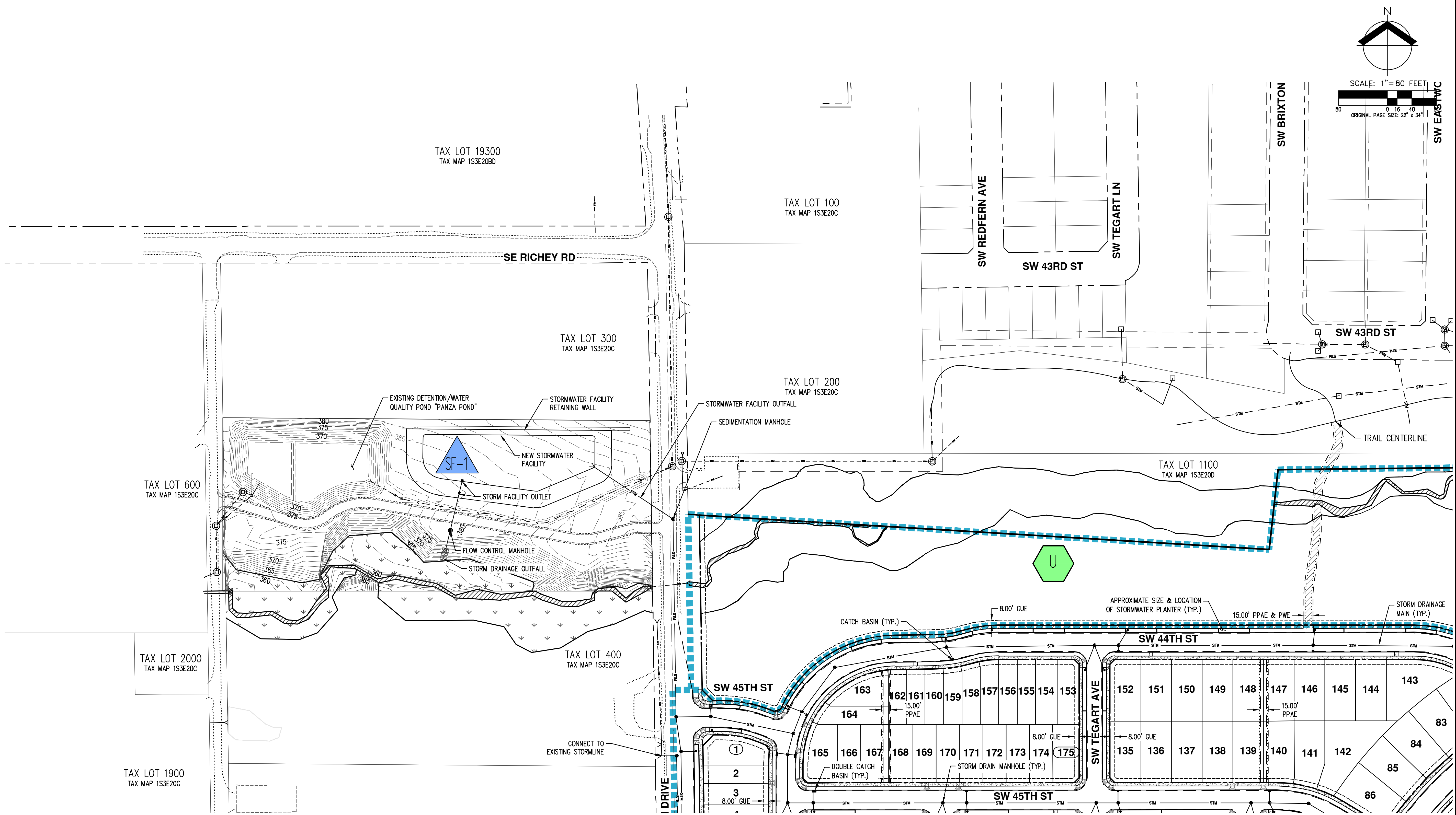
POST - DEVELOPED PLAN
VERANDA AT PLEASANT VALLEY
GRESHAM, OREGON

PRELIMINARY NOT FOR CONSTRUCTION

RENEWAL DATE: 6/30/25

JOB NUMBER:	9804
DATE:	05/15/2023
DESIGNED BY:	RLB
DRAWN BY:	RLB
CHECKED BY:	VN

1



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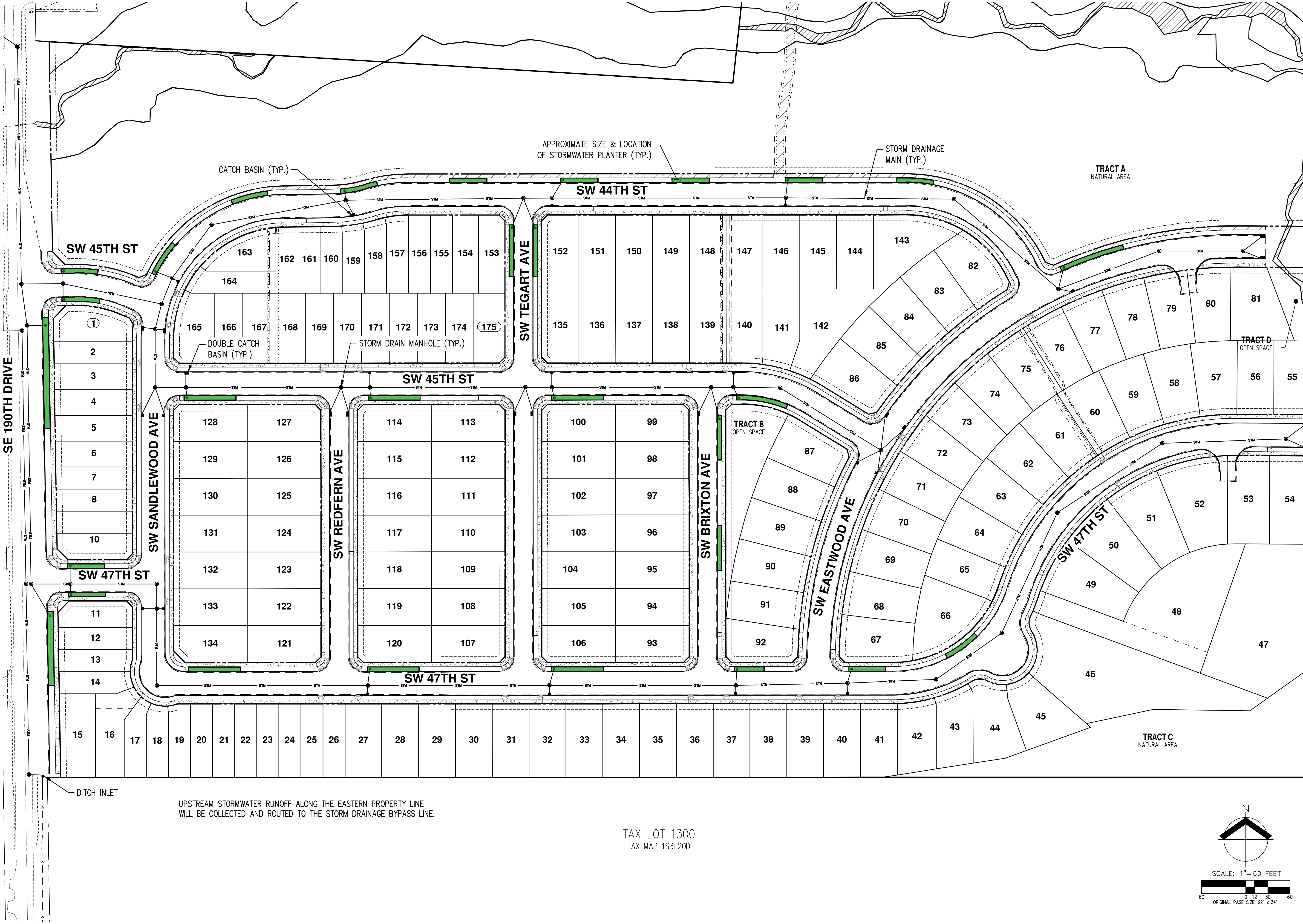
POST - DEVELOPED PLAN
VERANDA AT PLEASANT VALLEY
GRESHAM, OREGON

REGISTERED PROFESSIONAL ENGINEER — PRELIMINARY NOT FOR CONSTRUCTION — MONTGOMERY B. HURLEY
RENEWAL DATE: 6/30/25

JOB NUMBER:	9804
DATE:	05/15/2023
DESIGNED BY:	RLB
DRAWN BY:	RLB
CHECKED BY:	VN

2

AKS DRAWING FILE: 9804 MAP POST.DWG | LAYOUT: 2



PRELIMINARY STORMWATER PLANTER LOCATION

VERANDA AT PLEASANT VALLEY

GRESHAM, OREGON

AKS ENGINEERING & FORESTRY, LLC
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ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

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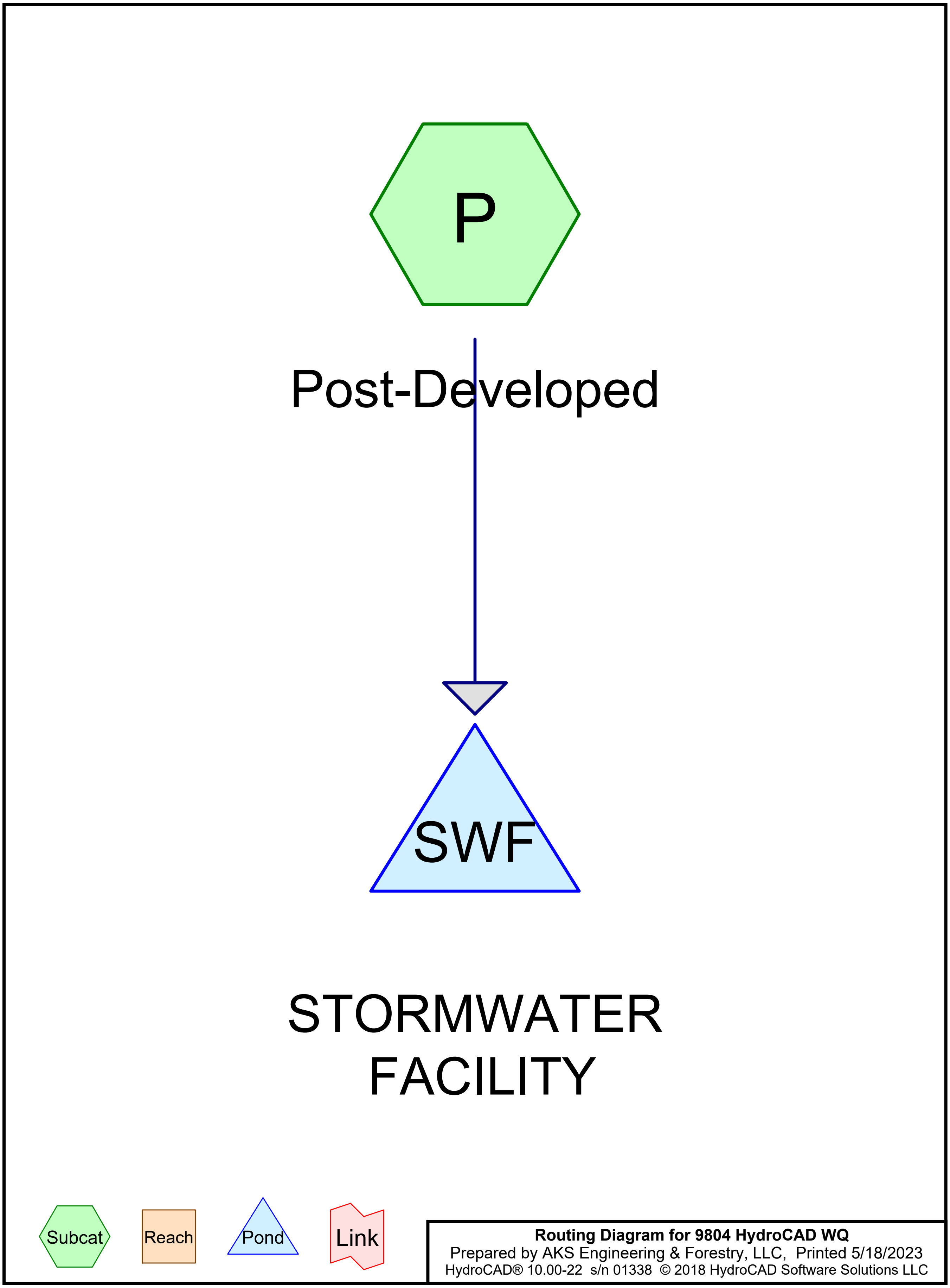
AKS DRAWING FILE: 9804 MAP POST.DWG | LAYOUT: 3

Appendix C.2: Post-Developed Hydrograph and Flow Information Water Quality Event


P
Post-Developed
SWF
STORMWATER FACILITY
Subcat
Reach
Pond
Link

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
437,500	98	2,500 sf of Impervious per Lot (172 Lots) (P)

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P: Post-Developed Runoff Area=437,500 sf 100.00% Impervious Runoff Depth>0.98"
Tc=5.0 min CN=0/98 Runoff=2.57 cfs 35,844 cf

Pond SWF: STORMWATERFACILITY Peak Elev=370.56' Storage=35,774 cf Inflow=2.57 cfs 35,844 cf
Outflow=0.00 cfs 0 cf

Summary for Subcatchment P: Post-Developed

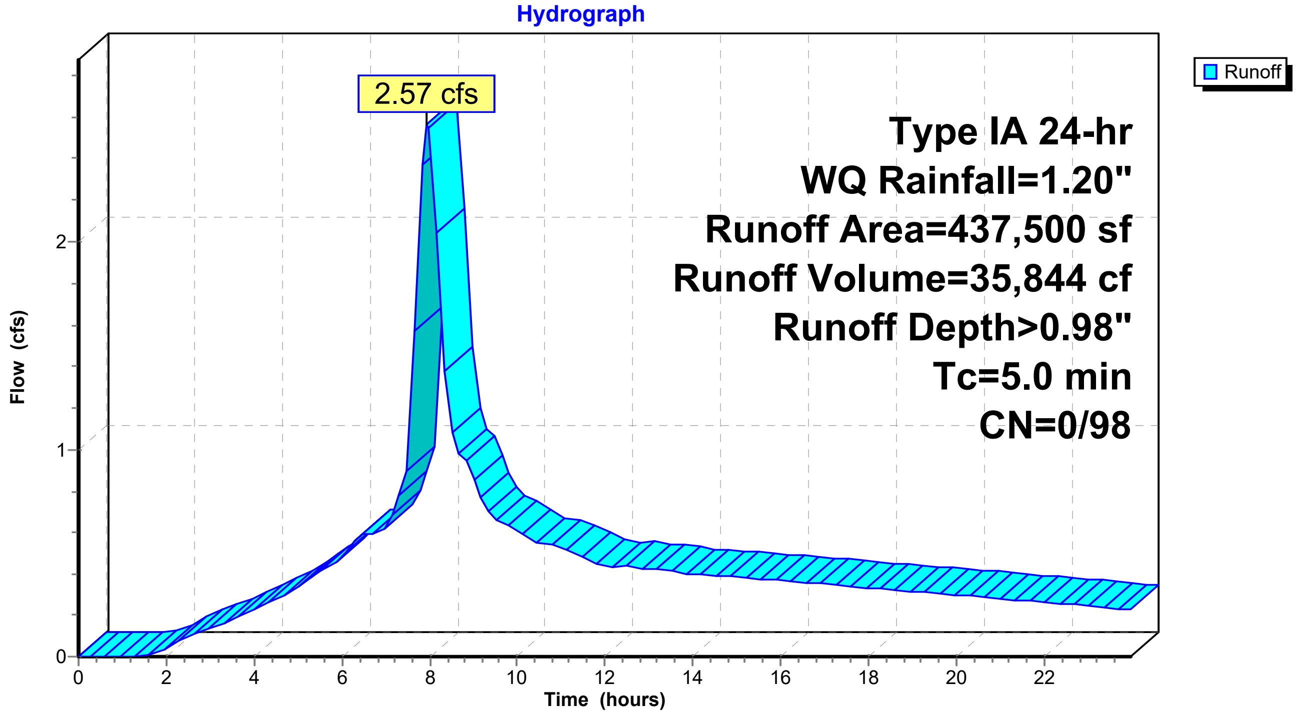
Runoff = 2.57 cfs @ 7.95 hrs, Volume= 35,844 cf, Depth> 0.98"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr WQ Rainfall=1.20"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (172 Lots)
	437,500		100.00% Impervious Area

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

Subcatchment P: Post-Developed



Summary for Pond SWF: STORMWATER FACILITY

Inflow Area = 437,500 sf,100.00% Impervious, Inflow Depth > 0.98" for WQ event
Inflow = 2.57 cfs @ 7.95 hrs, Volume= 35,844 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min

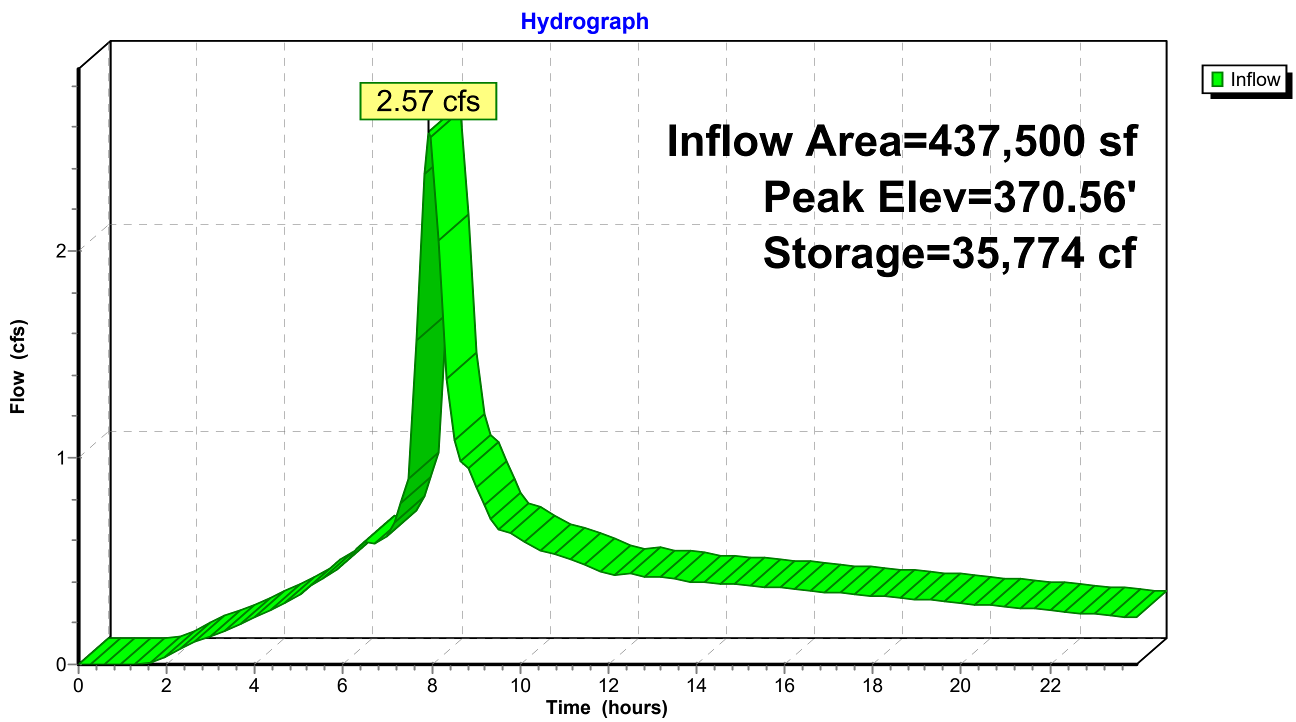
Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 370.56' @ 23.97 hrs Surf.Area= 24,614 sf Storage= 35,774 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

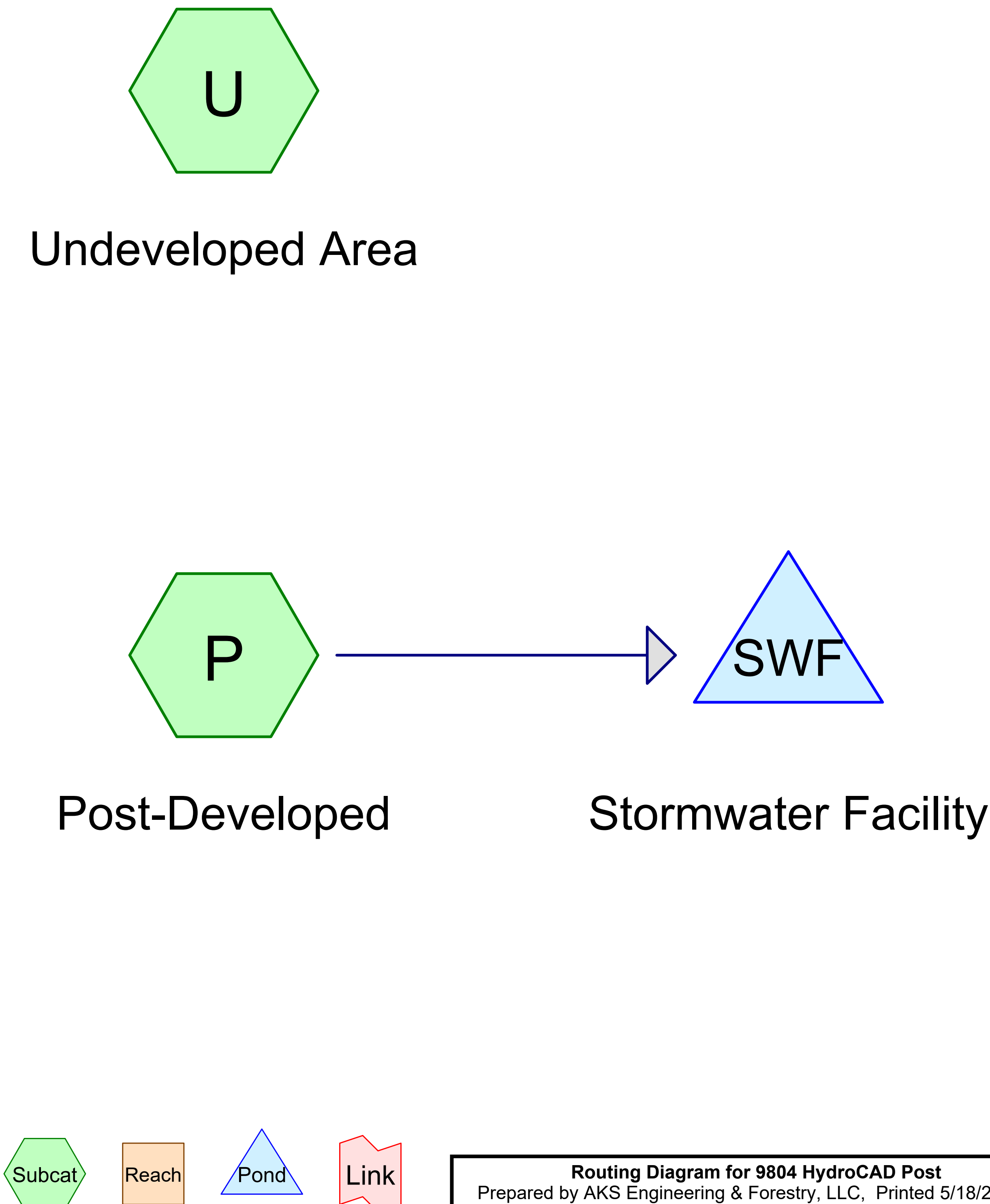
Volume	Invert	Avail.Storage	Storage Description
#1	369.00'	46,884 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
369.00	21,400	0	0	21,400
370.00	23,400	22,393	22,393	23,488
371.00	25,600	24,492	46,884	25,775

Pond SWF: STORMWATER FACILITY



Appendix C.3: Post-Developed Hydrograph and Flow Information 2-Year Storm Event



Routing Diagram for 9804 HydroCAD Post
Prepared by AKS Engineering & Forestry, LLC, Printed 5/18/2023
HydroCAD® 10.00-22 s/n 01338 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
437,500	98	2,500 sf of Impervious per Lot (175 lots) (P)
404,600	74	Grass (U)
593,500	86	Lawn/Landscape Area (P)
101,700	86	Public Streets & Sidewalks (30%) (P)
237,300	98	Public Streets & Sidewalks (70%) (P)

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P: Post-Developed Runoff Area=1,370,000 sf 49.26% Impervious Runoff Depth>2.01"
Tc=10.0 min CN=86/98 Runoff=14.54 cfs 229,839 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 0.00% Impervious Runoff Depth>0.77"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/0 Runoff=0.73 cfs 25,818 cf

Pond SWF: Stormwater Facility Peak Elev=375.84' Storage=143,770 cf Inflow=14.54 cfs 229,839 cf
Outflow=1.44 cfs 86,032 cf

Summary for Subcatchment P: Post-Developed

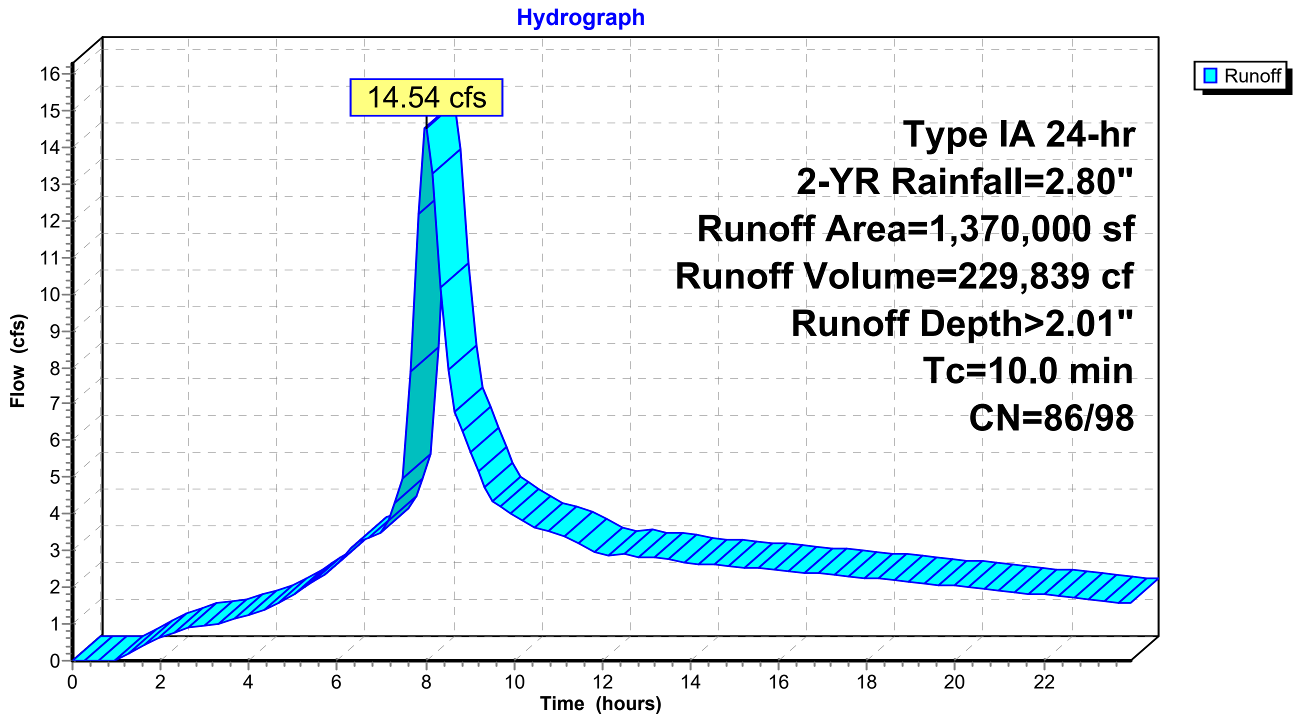
Runoff = 14.54 cfs @ 8.02 hrs, Volume= 229,839 cf, Depth> 2.01"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 2-YR Rainfall=2.80"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (175 lots)
*	237,300	98	Public Streets & Sidewalks (70%)
*	101,700	86	Public Streets & Sidewalks (30%)
*	593,500	86	Lawn/Landscape Area
	1,370,000	92	Weighted Average
	695,200		50.74% Pervious Area
	674,800		49.26% Impervious Area

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

Subcatchment P: Post-Developed



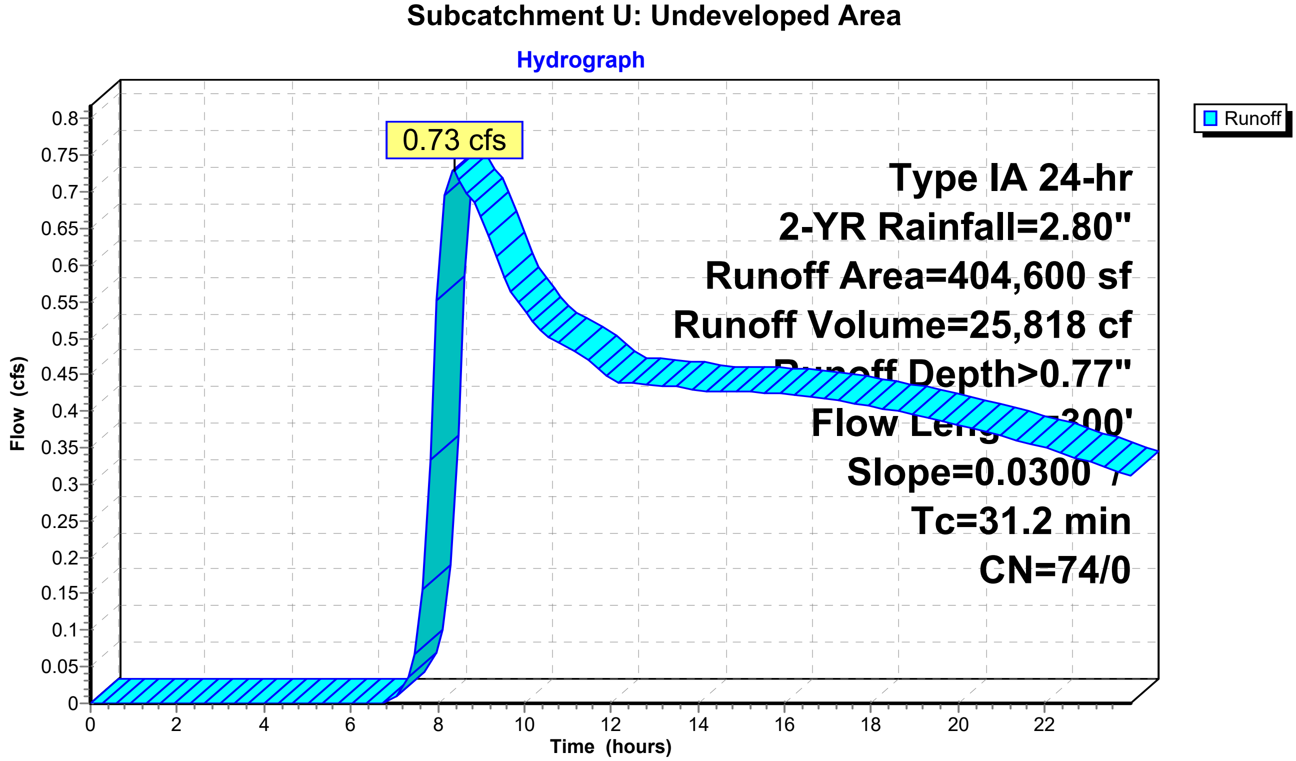
Summary for Subcatchment U: Undeveloped Area

Runoff = 0.73 cfs @ 8.37 hrs, Volume= 25,818 cf, Depth> 0.77"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 2-YR Rainfall=2.80"

	Area (sf)	CN	Description
*	404,600	74	Grass
	404,600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"



Summary for Pond SWF: Stormwater Facility

Inflow Area = 1,370,000 sf, 49.26% Impervious, Inflow Depth > 2.01" for 2-YR event
Inflow = 14.54 cfs @ 8.02 hrs, Volume= 229,839 cf
Outflow = 1.44 cfs @ 23.97 hrs, Volume= 86,032 cf, Atten= 90%, Lag= 957.2 min
Primary = 1.44 cfs @ 23.97 hrs, Volume= 86,032 cf

Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 375.84' @ 23.97 hrs Surf.Area= 33,076 sf Storage= 143,770 cf

Plug-Flow detention time= 498.3 min calculated for 85,426 cf (37% of inflow)
Center-of-Mass det. time= 192.8 min (913.5 - 720.8)

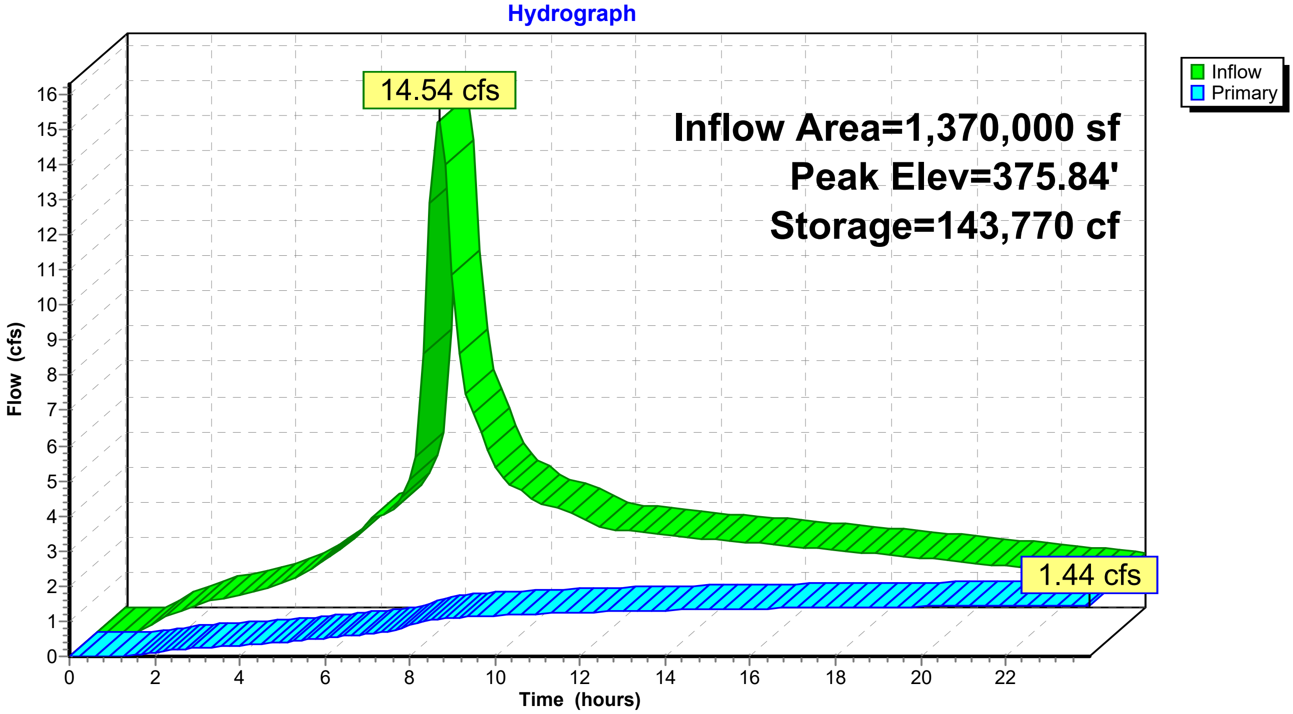
Volume	Invert	Avail.Storage	Storage Description
#1	371.00'	218,627 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
371.00	25,600	0	0	25,600
372.00	27,800	26,692	26,692	27,895
373.00	29,400	28,596	55,289	29,632
374.00	30,500	29,948	85,237	30,932
375.00	31,900	31,197	116,434	32,500
376.00	33,300	32,597	149,032	34,075
377.00	34,800	34,047	183,079	35,747
378.00	36,300	35,547	218,627	37,426

Device	Routing	Invert	Outlet Devices
#1	Primary	371.00'	**5.0" Horiz. Orifice** C= 0.600
#2	Primary	376.00'	**24.0" Horiz. Riser Inside of Control MH** C= 0.600

Primary OutFlow Max=1.44 cfs @ 23.97 hrs HW=375.84' (Free Discharge)
├─**1=Orifice** (Orifice Controls 1.44 cfs @ 10.59 fps)
└─**2=Riser Inside of Control MH** (Controls 0.00 cfs)

Pond SWF: Stormwater Facility



Appendix C.4: Post-Developed Hydrograph and Flow Information 5-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P: Post-Developed Runoff Area=1,370,000 sf 49.26% Impervious Runoff Depth>2.38"
Tc=10.0 min CN=86/98 Runoff=17.32 cfs 271,910 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 0.00% Impervious Runoff Depth>1.01"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/0 Runoff=1.11 cfs 34,222 cf

Pond SWF: Stormwater Facility Peak Elev=376.02' Storage=149,675 cf Inflow=17.32 cfs 271,910 cf
Outflow=2.93 cfs 122,802 cf

Summary for Subcatchment P: Post-Developed

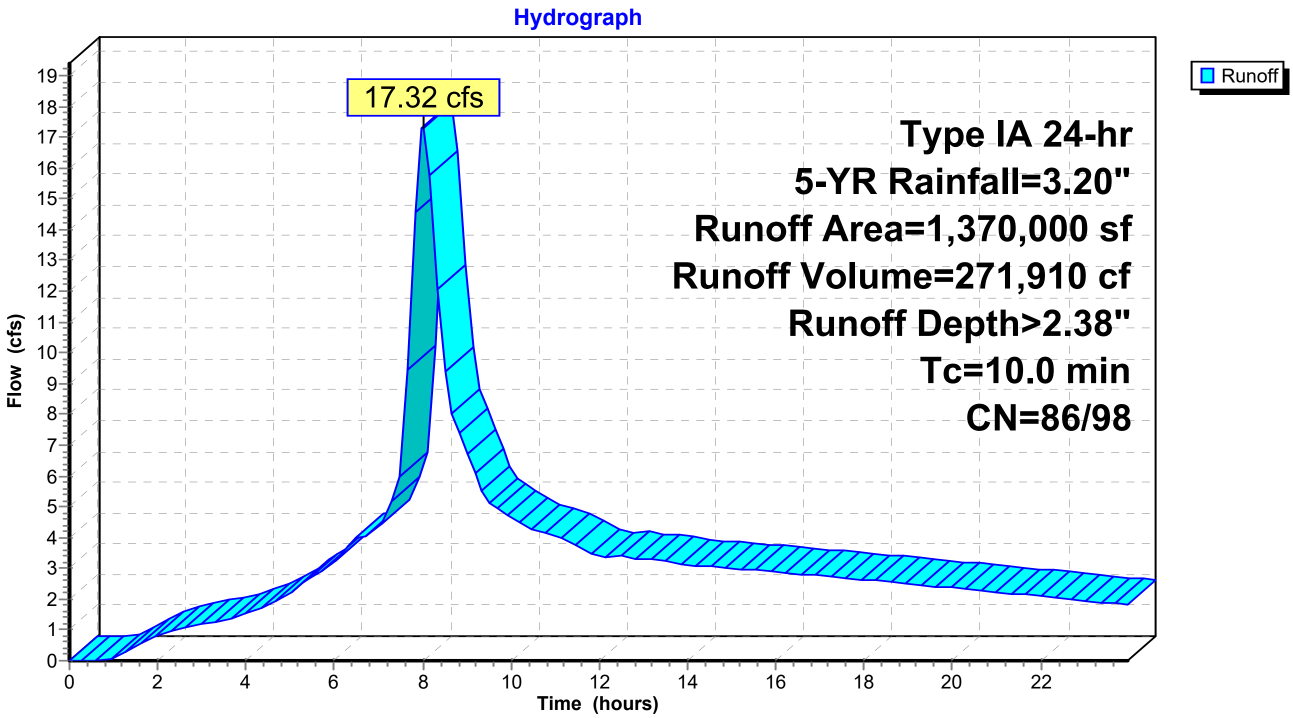
Runoff = 17.32 cfs @ 8.01 hrs, Volume= 271,910 cf, Depth> 2.38"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 5-YR Rainfall=3.20"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (175 lots)
*	237,300	98	Public Streets & Sidewalks (70%)
*	101,700	86	Public Streets & Sidewalks (30%)
*	593,500	86	Lawn/Landscape Area
	1,370,000	92	Weighted Average
	695,200		50.74% Pervious Area
	674,800		49.26% Impervious Area

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

Subcatchment P: Post-Developed



Summary for Subcatchment U: Undeveloped Area

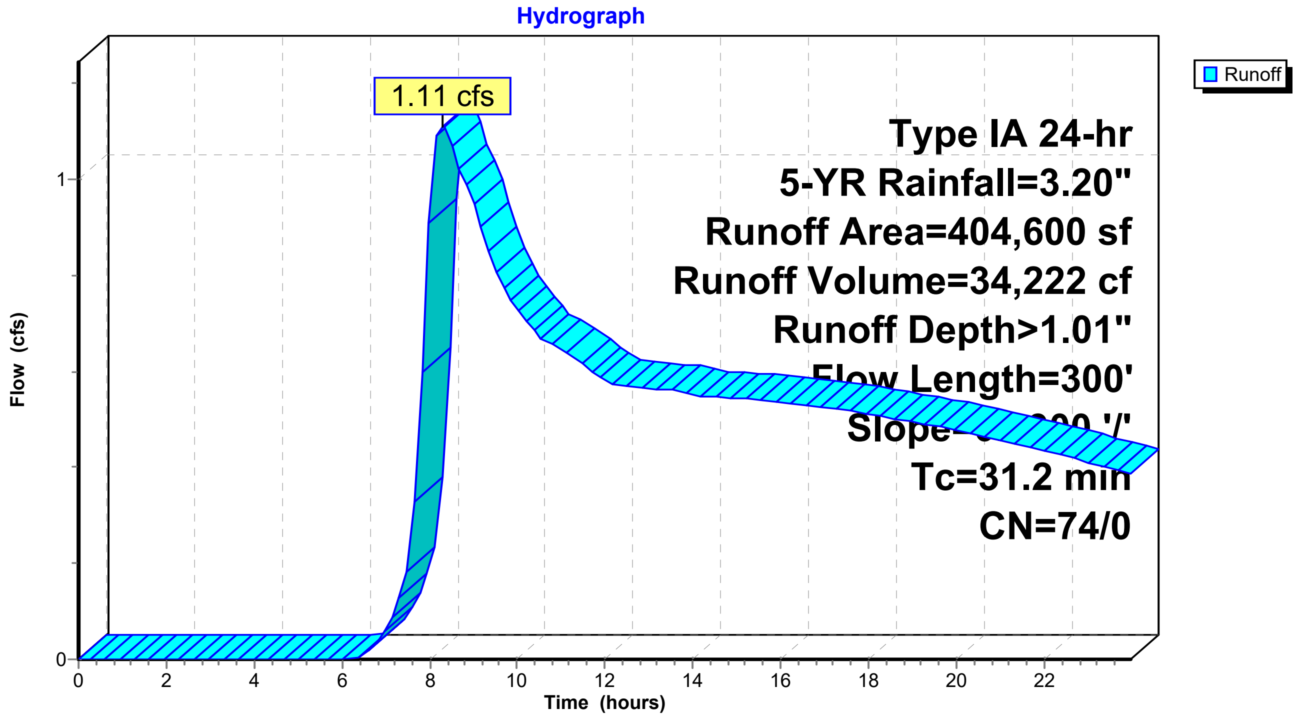
Runoff = 1.11 cfs @ 8.30 hrs, Volume= 34,222 cf, Depth> 1.01"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 5-YR Rainfall=3.20"

	Area (sf)	CN	Description
*	404,600	74	Grass
	404,600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Summary for Pond SWF: Stormwater Facility

Inflow Area = 1,370,000 sf, 49.26% Impervious, Inflow Depth > 2.38" for 5-YR event
Inflow = 17.32 cfs @ 8.01 hrs, Volume= 271,910 cf
Outflow = 2.93 cfs @ 15.63 hrs, Volume= 122,802 cf, Atten= 83%, Lag= 456.9 min
Primary = 2.93 cfs @ 15.63 hrs, Volume= 122,802 cf

Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 376.02' @ 15.63 hrs Surf.Area= 33,329 sf Storage= 149,675 cf

Plug-Flow detention time= 525.4 min calculated for 122,802 cf (45% of inflow)
Center-of-Mass det. time= 241.8 min (957.2 - 715.5)

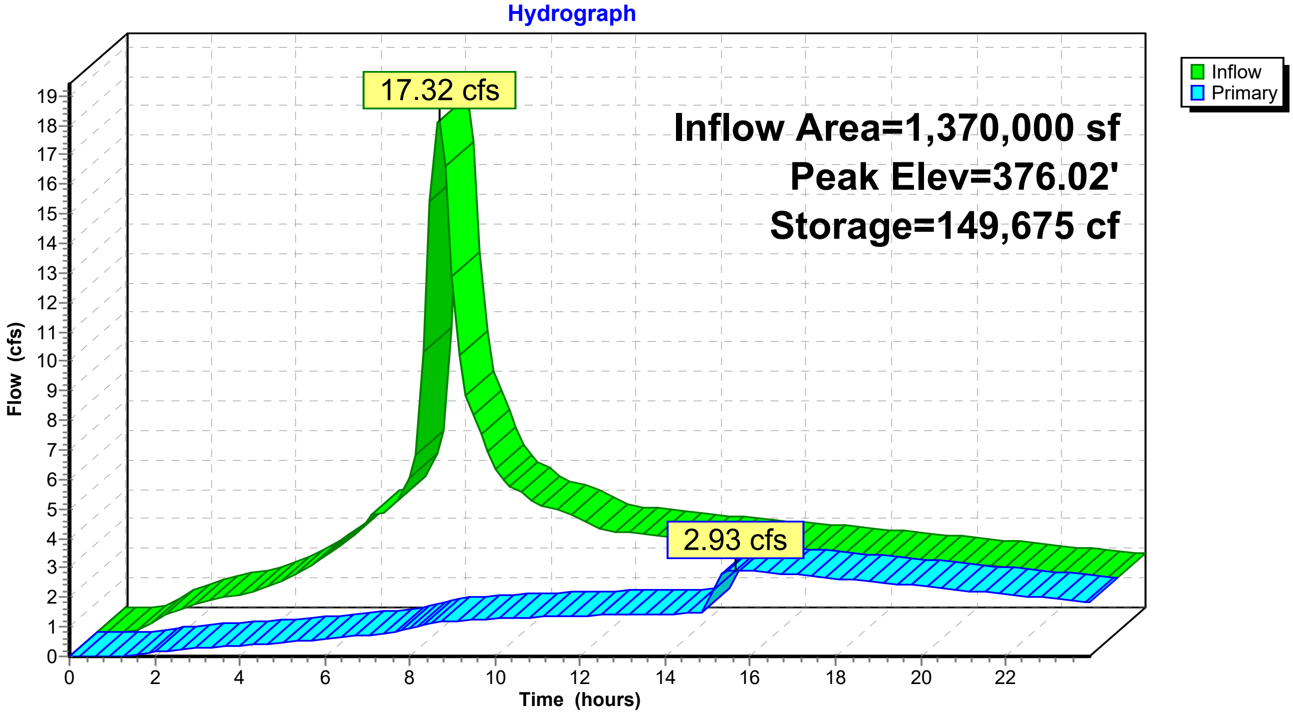
Volume	Invert	Avail.Storage	Storage Description
#1	371.00'	218,627 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
371.00	25,600	0	0	25,600
372.00	27,800	26,692	26,692	27,895
373.00	29,400	28,596	55,289	29,632
374.00	30,500	29,948	85,237	30,932
375.00	31,900	31,197	116,434	32,500
376.00	33,300	32,597	149,032	34,075
377.00	34,800	34,047	183,079	35,747
378.00	36,300	35,547	218,627	37,426

Device	Routing	Invert	Outlet Devices
#1	Primary	371.00'	**5.0" Horiz. Orifice** C= 0.600
#2	Primary	376.00'	**24.0" Horiz. Riser Inside of Control MH** C= 0.600

Primary OutFlow Max=3.57 cfs @ 15.63 hrs HW=376.02' (Free Discharge)
├─**1=Orifice** (Orifice Controls 1.47 cfs @ 10.79 fps)
└─**2=Riser Inside of Control MH** (Orifice Controls 2.10 cfs @ 0.67 fps)

Pond SWF: Stormwater Facility



Appendix C.5: Post-Developed Hydrograph and Flow Information 10-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentP: Post-Developed Runoff Area=1,370,000 sf 49.26% Impervious Runoff Depth>2.76"
Tc=10.0 min CN=86/98 Runoff=20.13 cfs 314,545 cf

SubcatchmentU: UndevelopedArea Runoff Area=404,600 sf 0.00% Impervious Runoff Depth>1.28"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/0 Runoff=1.54 cfs 43,238 cf

Pond SWF: StormwaterFacility Peak Elev=376.03' Storage=150,108 cf Inflow=20.13 cfs 314,545 cf
Outflow=3.91 cfs 165,212 cf

Summary for Subcatchment P: Post-Developed

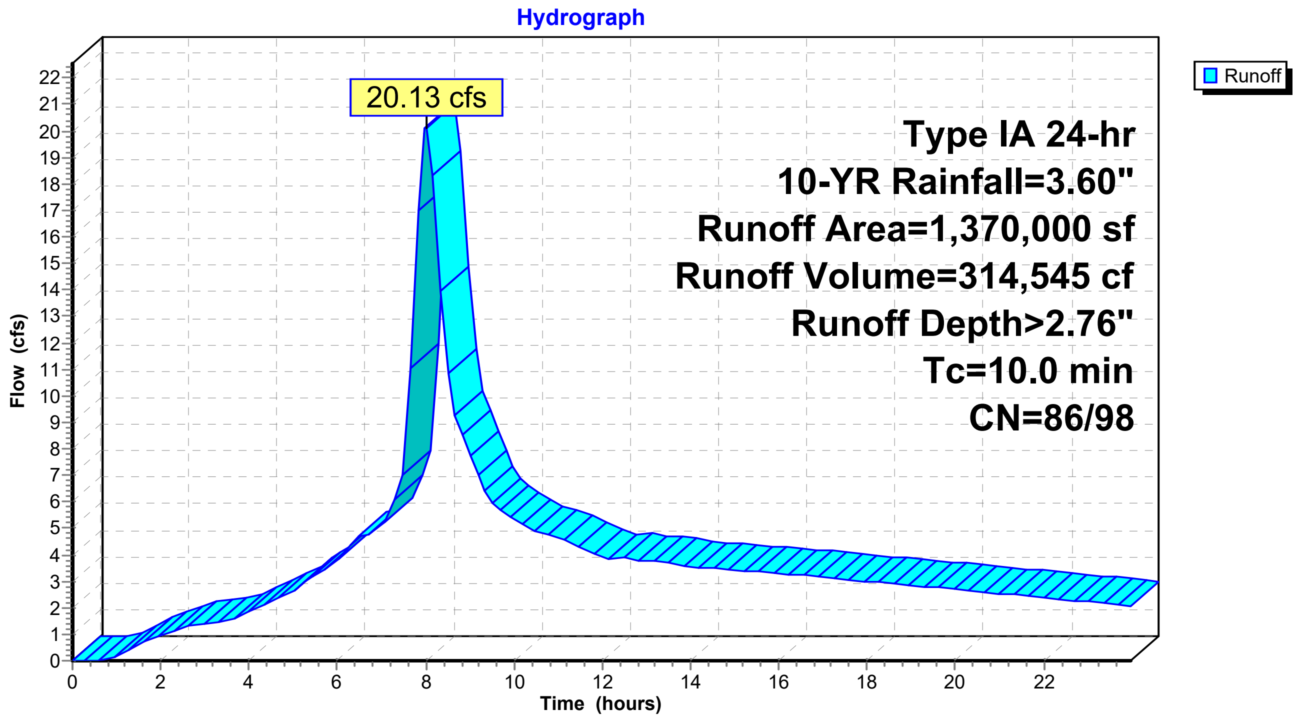
Runoff = 20.13 cfs @ 8.01 hrs, Volume= 314,545 cf, Depth> 2.76"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 10-YR Rainfall=3.60"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (175 lots)
*	237,300	98	Public Streets & Sidewalks (70%)
*	101,700	86	Public Streets & Sidewalks (30%)
*	593,500	86	Lawn/Landscape Area
	1,370,000	92	Weighted Average
	695,200		50.74% Pervious Area
	674,800		49.26% Impervious Area

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

Subcatchment P: Post-Developed



Summary for Subcatchment U: Undeveloped Area

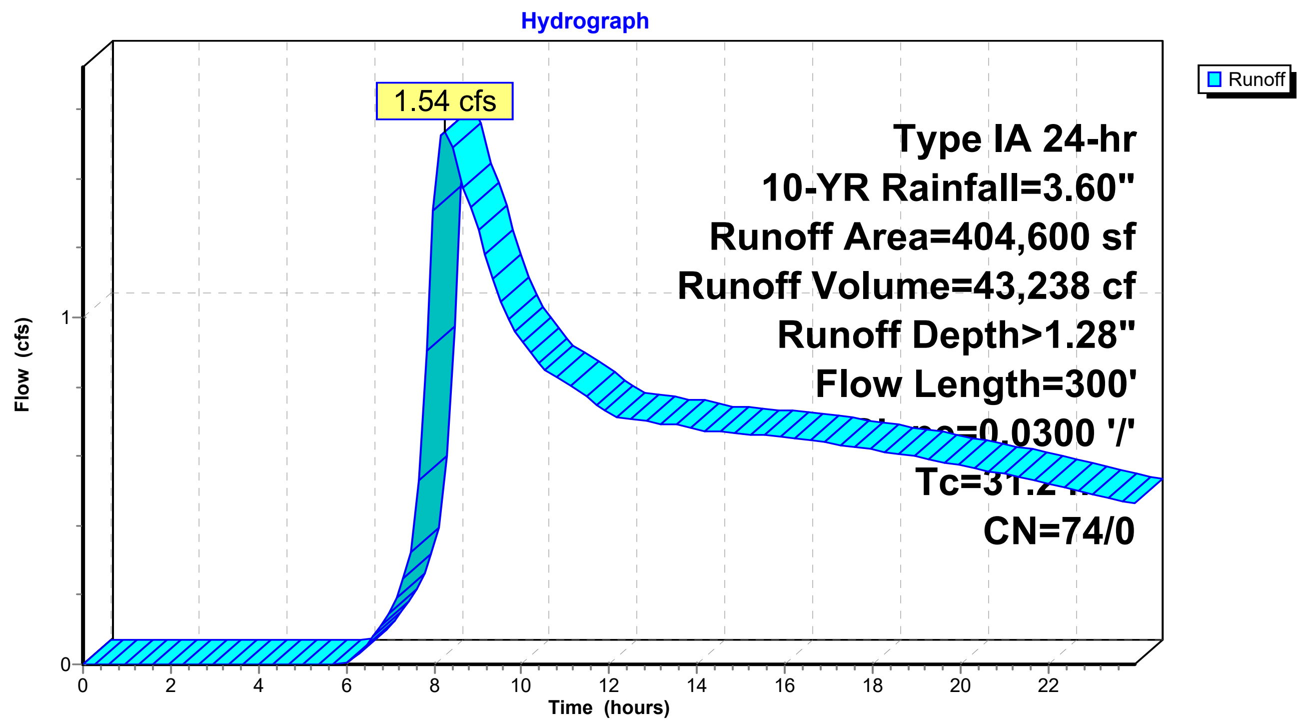
Runoff = 1.54 cfs @ 8.25 hrs, Volume= 43,238 cf, Depth> 1.28"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 10-YR Rainfall=3.60"

	Area (sf)	CN	Description
*	404,600	74	Grass
	404,600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Summary for Pond SWF: Stormwater Facility

Inflow Area = 1,370,000 sf, 49.26% Impervious, Inflow Depth > 2.76" for 10-YR event
Inflow = 20.13 cfs @ 8.01 hrs, Volume= 314,545 cf
Outflow = 3.91 cfs @ 11.90 hrs, Volume= 165,212 cf, Atten= 81%, Lag= 233.2 min
Primary = 3.91 cfs @ 11.90 hrs, Volume= 165,212 cf

Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 376.03' @ 11.90 hrs Surf.Area= 33,348 sf Storage= 150,108 cf

Plug-Flow detention time= 479.6 min calculated for 164,048 cf (52% of inflow)
Center-of-Mass det. time= 223.9 min (934.8 - 710.9)

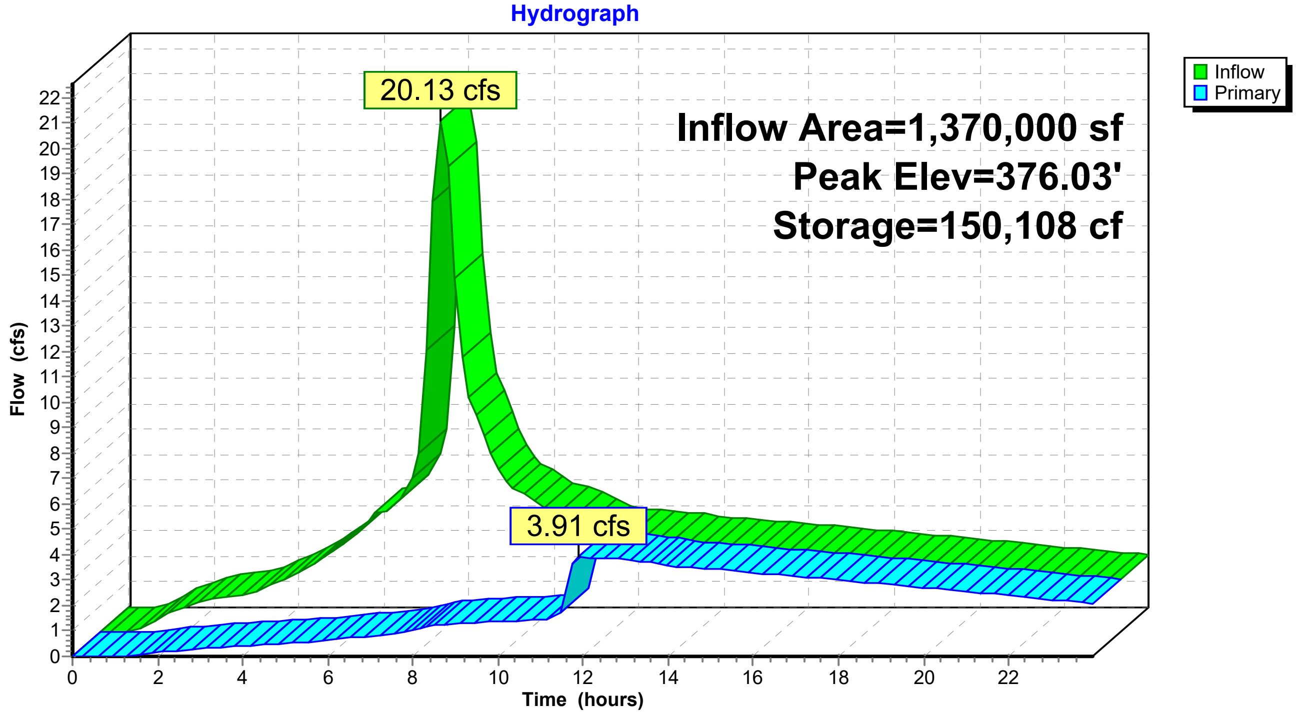
Volume	Invert	Avail.Storage	Storage Description
#1	371.00'	218,627 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
371.00	25,600	0	0	25,600
372.00	27,800	26,692	26,692	27,895
373.00	29,400	28,596	55,289	29,632
374.00	30,500	29,948	85,237	30,932
375.00	31,900	31,197	116,434	32,500
376.00	33,300	32,597	149,032	34,075
377.00	34,800	34,047	183,079	35,747
378.00	36,300	35,547	218,627	37,426

Device	Routing	Invert	Outlet Devices
#1	Primary	371.00'	**5.0" Horiz. Orifice** C= 0.600
#2	Primary	376.00'	**24.0" Horiz. Riser Inside of Control MH** C= 0.600

Primary OutFlow Max=4.19 cfs @ 11.90 hrs HW=376.03' (Free Discharge)
↑—**1=Orifice** (Orifice Controls 1.47 cfs @ 10.80 fps)
└—**2=Riser Inside of Control MH** (Orifice Controls 2.72 cfs @ 0.87 fps)

Pond SWF: Stormwater Facility



Appendix C.6: Post-Developed Hydrograph and Flow Information 25-Year Storm Event

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P: Post-Developed Runoff Area=1,370,000 sf 49.26% Impervious Runoff Depth>3.13"
Tc=10.0 min CN=86/98 Runoff=22.98 cfs 357,613 cf

Subcatchment U: Undeveloped Area Runoff Area=404,600 sf 0.00% Impervious Runoff Depth>1.56"
Flow Length=300' Slope=0.0300 '/' Tc=31.2 min CN=74/0 Runoff=2.03 cfs 52,761 cf

Pond SWF: Stormwater Facility Peak Elev=376.07' Storage=151,498 cf Inflow=22.98 cfs 357,613 cf
Outflow=5.47 cfs 208,005 cf

Summary for Subcatchment P: Post-Developed

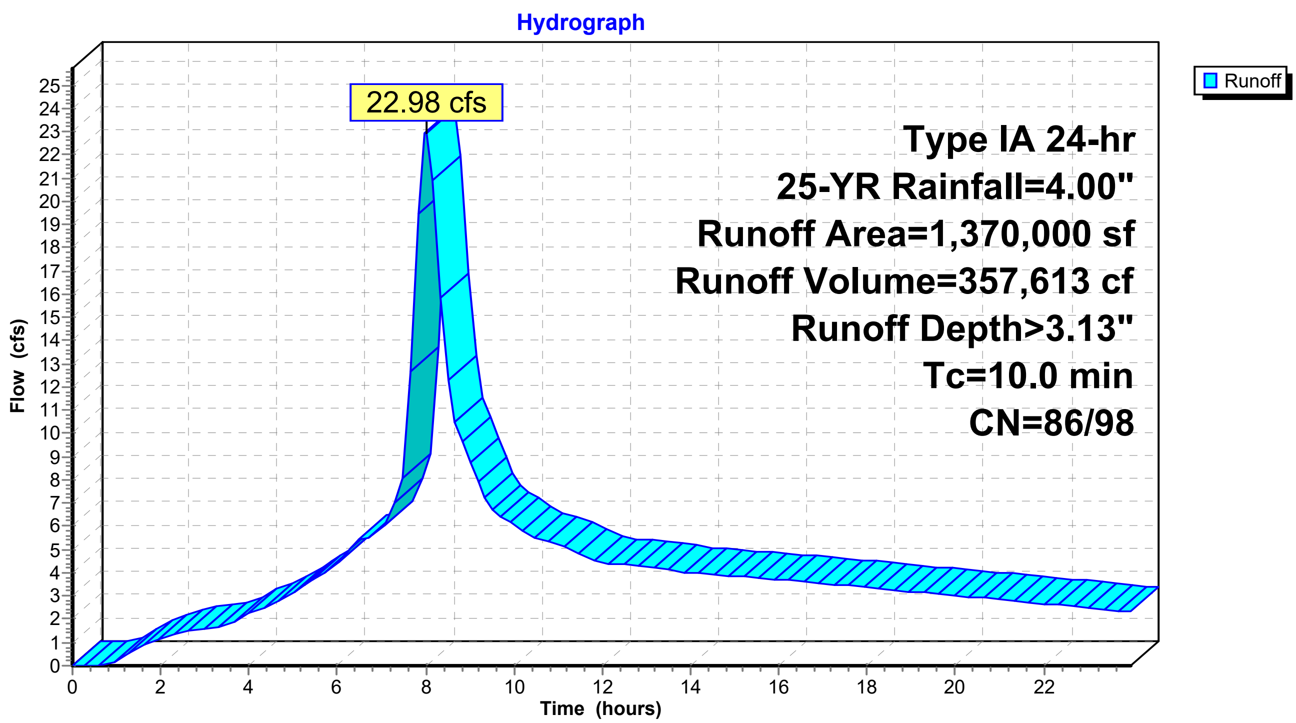
Runoff = 22.98 cfs @ 8.01 hrs, Volume= 357,613 cf, Depth> 3.13"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 25-YR Rainfall=4.00"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (175 lots)
*	237,300	98	Public Streets & Sidewalks (70%)
*	101,700	86	Public Streets & Sidewalks (30%)
*	593,500	86	Lawn/Landscape Area
	1,370,000	92	Weighted Average
	695,200		50.74% Pervious Area
	674,800		49.26% Impervious Area

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

Subcatchment P: Post-Developed



Summary for Subcatchment U: Undeveloped Area

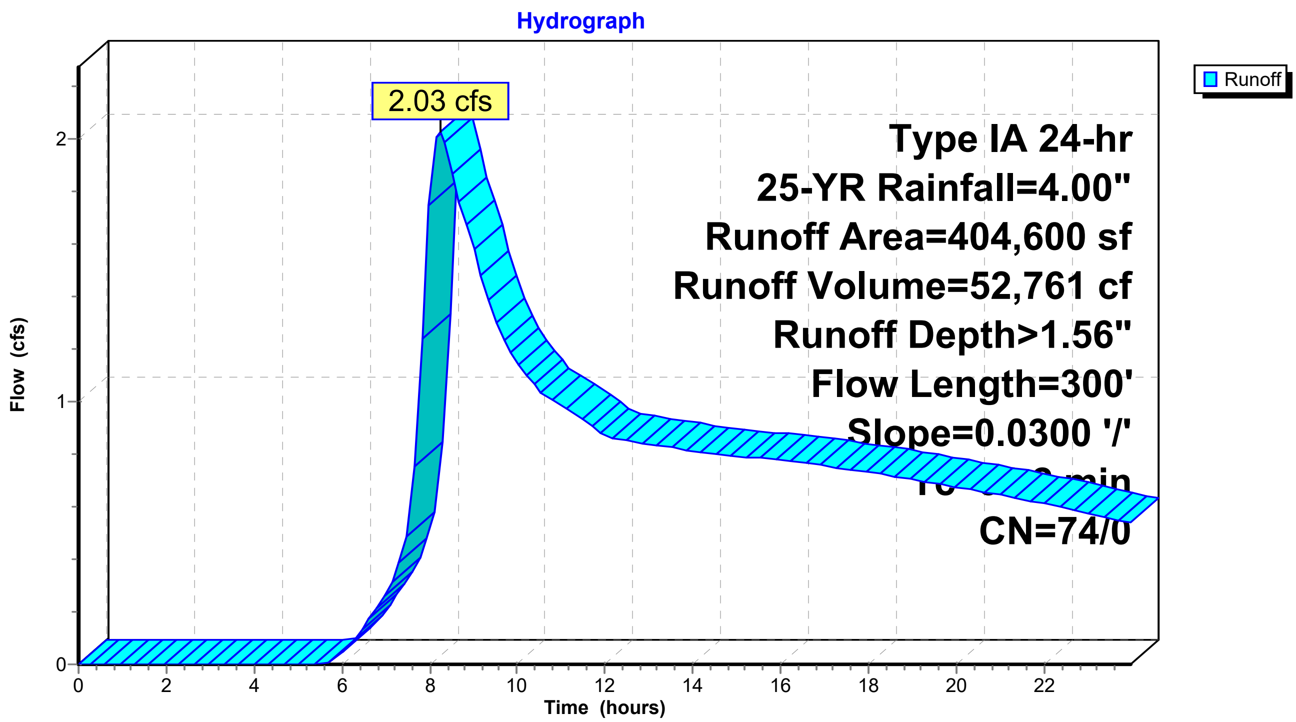
Runoff = 2.03 cfs @ 8.23 hrs, Volume= 52,761 cf, Depth> 1.56"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 25-YR Rainfall=4.00"

	Area (sf)	CN	Description
*	404,600	74	Grass
	404,600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
31.2	300	0.0300	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.80"

Subcatchment U: Undeveloped Area



Summary for Pond SWF: Stormwater Facility

Inflow Area = 1,370,000 sf, 49.26% Impervious, Inflow Depth > 3.13" for 25-YR event
Inflow = 22.98 cfs @ 8.01 hrs, Volume= 357,613 cf
Outflow = 5.47 cfs @ 10.56 hrs, Volume= 208,005 cf, Atten= 76%, Lag= 152.9 min
Primary = 5.47 cfs @ 10.56 hrs, Volume= 208,005 cf

Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 376.07' @ 10.56 hrs Surf.Area= 33,410 sf Storage= 151,498 cf

Plug-Flow detention time= 433.8 min calculated for 208,005 cf (58% of inflow)
Center-of-Mass det. time= 197.6 min (904.5 - 706.9)

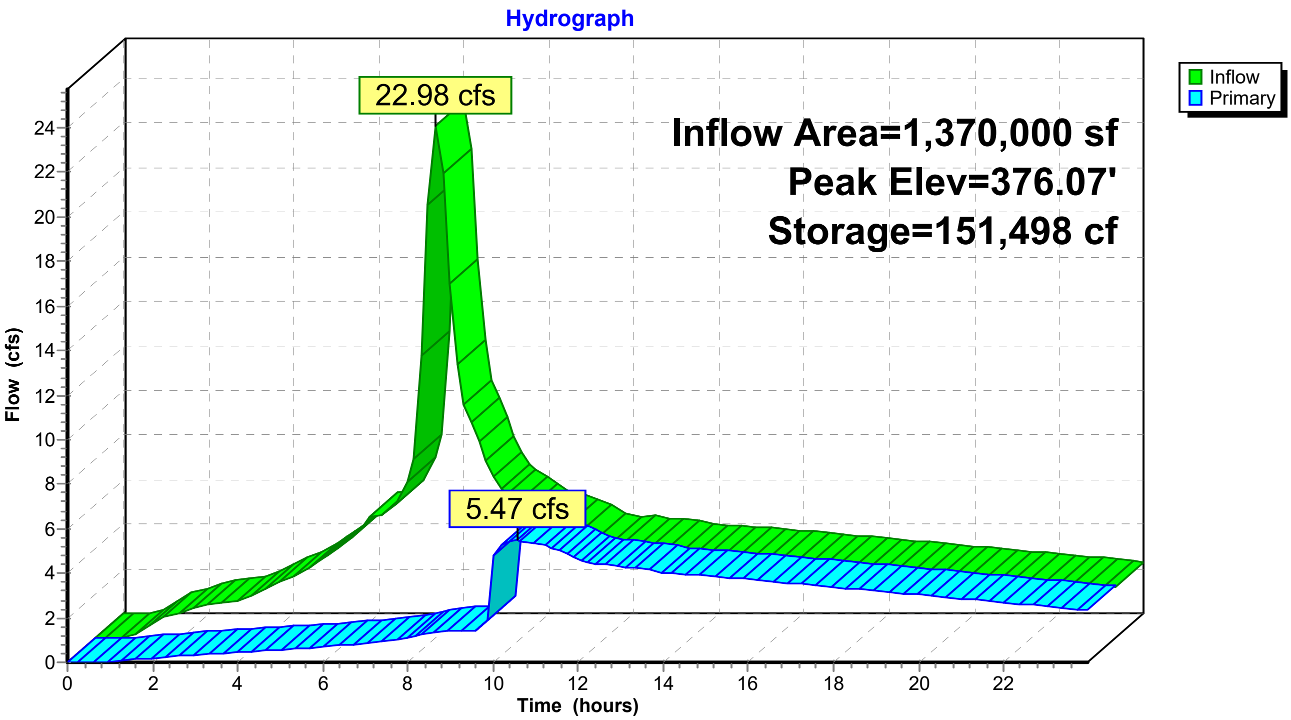
Volume	Invert	Avail.Storage	Storage Description
#1	371.00'	218,627 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
371.00	25,600	0	0	25,600
372.00	27,800	26,692	26,692	27,895
373.00	29,400	28,596	55,289	29,632
374.00	30,500	29,948	85,237	30,932
375.00	31,900	31,197	116,434	32,500
376.00	33,300	32,597	149,032	34,075
377.00	34,800	34,047	183,079	35,747
378.00	36,300	35,547	218,627	37,426

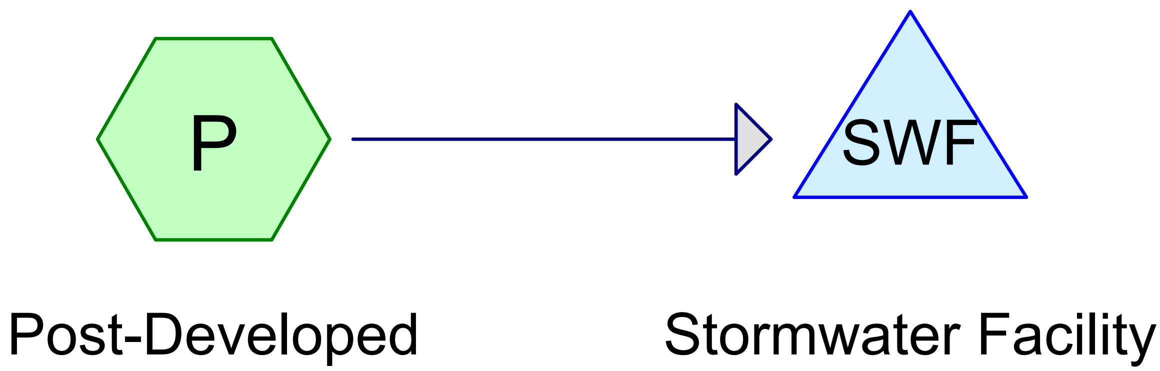
Device	Routing	Invert	Outlet Devices
#1	Primary	371.00'	**5.0" Horiz. Orifice** C= 0.600
#2	Primary	376.00'	**24.0" Horiz. Riser Inside of Control MH** C= 0.600

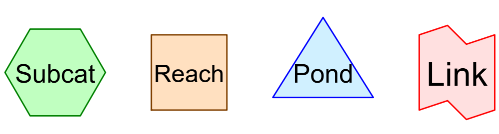
Primary OutFlow Max=5.59 cfs @ 10.56 hrs HW=376.07' (Free Discharge)
├─**1=Orifice** (Orifice Controls 1.48 cfs @ 10.85 fps)
└─**2=Riser Inside of Control MH** (Orifice Controls 4.11 cfs @ 1.31 fps)

Pond SWF: Stormwater Facility



Appendix D: Emergency Overflow Calculations





Routing Diagram for 9804 HydroCAD Overflow
Prepared by AKS Engineering & Forestry, LLC, Printed 5/18/2023

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
437,500	98	2,500 sf of Impervious per Lot (175 lots) (P)
593,500	86	Lawn/Landscape Area (P)
101,700	86	Public Streets & Sidewalks (30%) (P)
237,300	98	Public Streets & Sidewalks (70%) (P)

Time span=0.00-24.00 hrs, dt=0.17 hrs, 142 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P: Post-Developed Runoff Area=1,370,000 sf 49.26% Impervious Runoff Depth>3.99"
Tc=10.0 min CN=86/98 Runoff=29.43 cfs 455,668 cf

Pond SWF: Stormwater Facility Peak Elev=377.26' Storage=192,300 cf Inflow=29.43 cfs 455,668 cf
Outflow=9.79 cfs 268,566 cf

Summary for Subcatchment P: Post-Developed

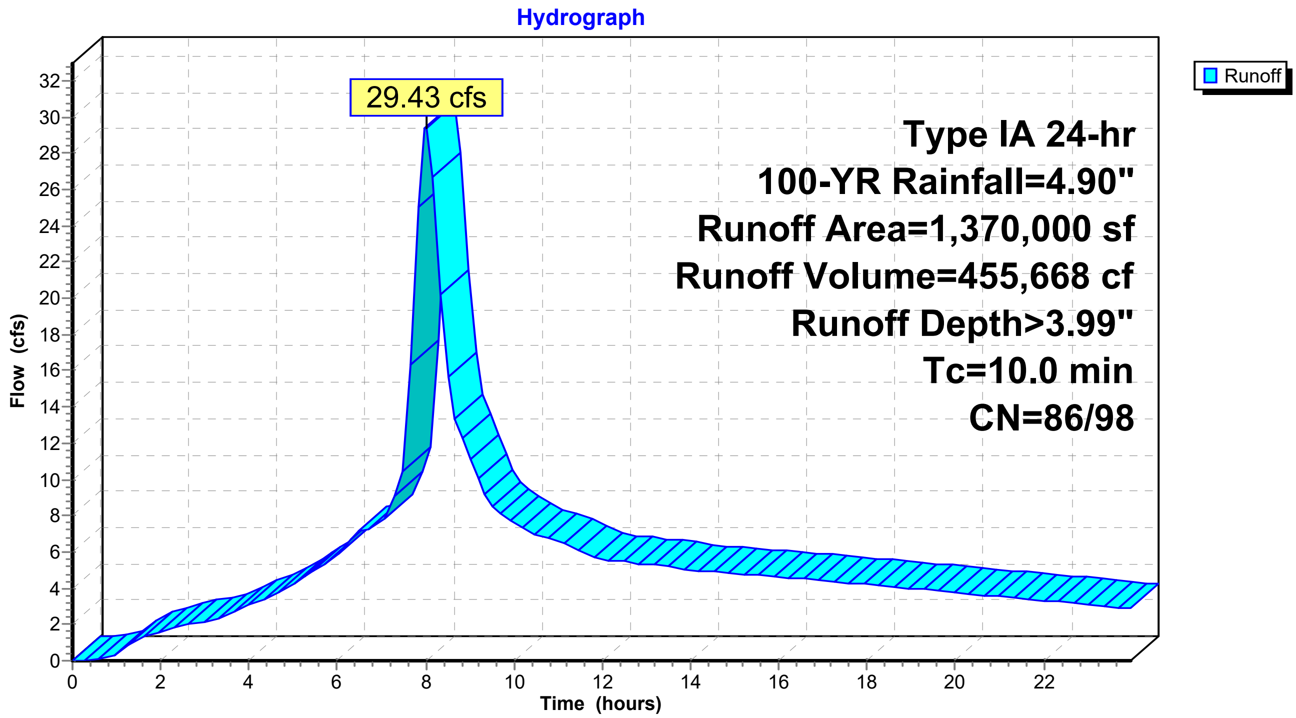
Runoff = 29.43 cfs @ 8.01 hrs, Volume= 455,668 cf, Depth> 3.99"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-23.97 hrs, dt= 0.17 hrs
Type IA 24-hr 100-YR Rainfall=4.90"

	Area (sf)	CN	Description
*	437,500	98	2,500 sf of Impervious per Lot (175 lots)
*	237,300	98	Public Streets & Sidewalks (70%)
*	101,700	86	Public Streets & Sidewalks (30%)
*	593,500	86	Lawn/Landscape Area
	1,370,000	92	Weighted Average
	695,200		50.74% Pervious Area
	674,800		49.26% Impervious Area

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

Subcatchment P: Post-Developed



Summary for Pond SWF: Stormwater Facility

Inflow Area = 1,370,000 sf, 49.26% Impervious, Inflow Depth > 3.99" for 100-YR event
Inflow = 29.43 cfs @ 8.01 hrs, Volume= 455,668 cf
Outflow = 9.79 cfs @ 9.26 hrs, Volume= 268,566 cf, Atten= 67%, Lag= 75.2 min
Primary = 9.79 cfs @ 9.26 hrs, Volume= 268,566 cf

Routing by Stor-Ind method, Time Span= 0.00-23.97 hrs, dt= 0.17 hrs / 2
Peak Elev= 377.26' @ 9.26 hrs Surf.Area= 35,192 sf Storage= 192,300 cf

Plug-Flow detention time= 442.2 min calculated for 268,566 cf (59% of inflow)
Center-of-Mass det. time= 210.7 min (910.2 - 699.5)

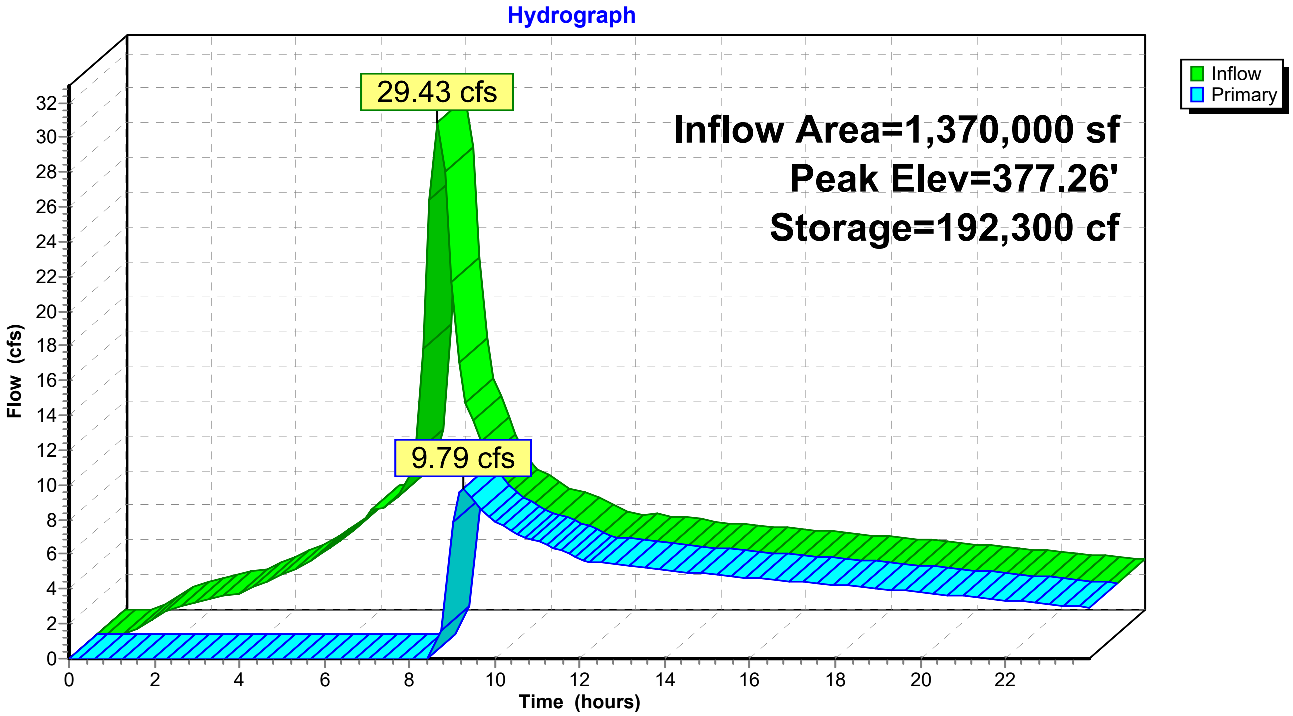
Volume	Invert	Avail.Storage	Storage Description
#1	371.00'	218,627 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
371.00	25,600	0	0	25,600
372.00	27,800	26,692	26,692	27,895
373.00	29,400	28,596	55,289	29,632
374.00	30,500	29,948	85,237	30,932
375.00	31,900	31,197	116,434	32,500
376.00	33,300	32,597	149,032	34,075
377.00	34,800	34,047	183,079	35,747
378.00	36,300	35,547	218,627	37,426

Device	Routing	Invert	Outlet Devices
#1	Primary	377.00'	**30.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=9.48 cfs @ 9.26 hrs HW=377.26' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 9.48 cfs @ 1.22 fps)

Pond SWF: Stormwater Facility



Appendix E: Soil Information from the NRSC Soil Survey for Multnomah County, Oregon

United States Department of Agriculture

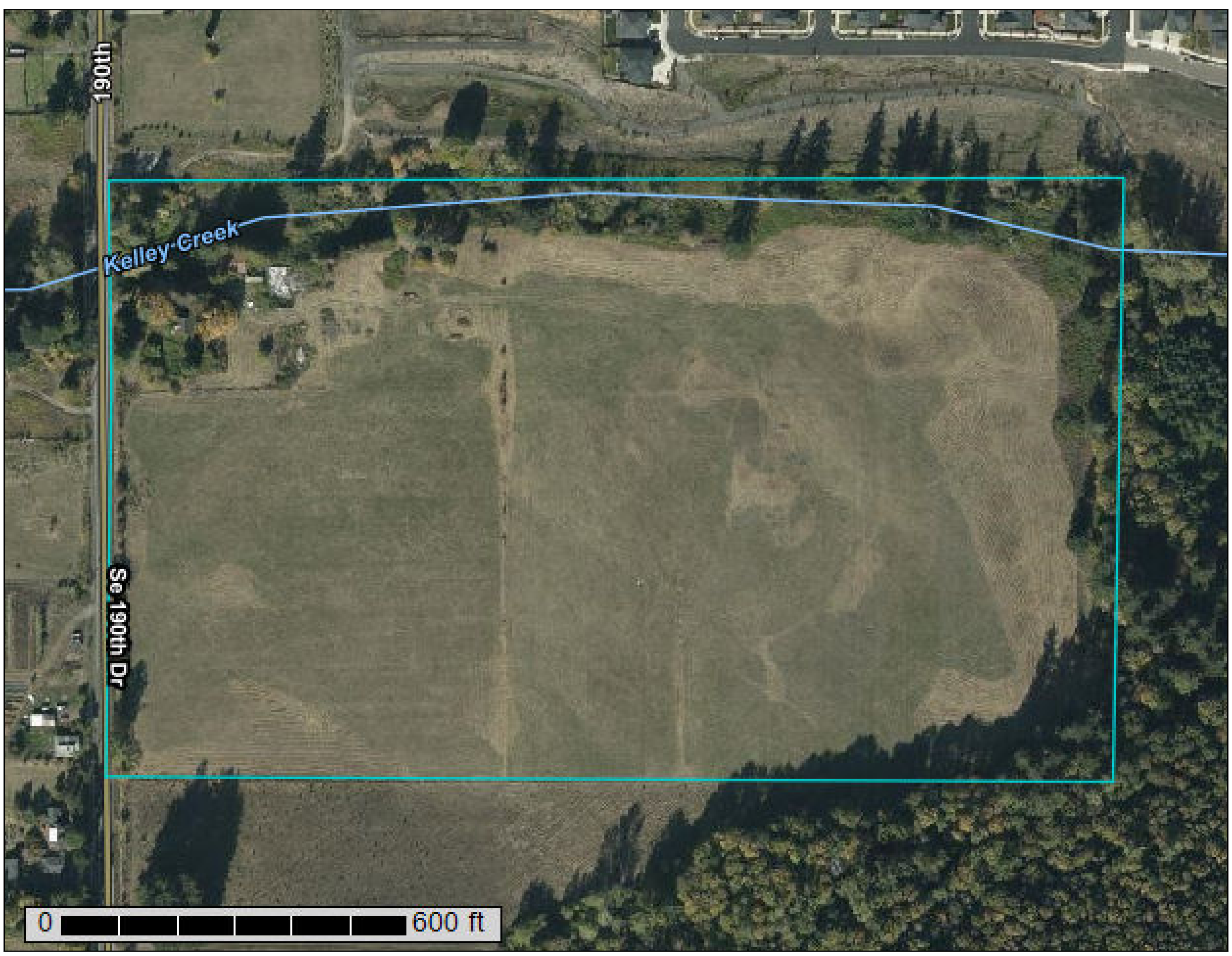
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Multnomah County Area, Oregon



March 1, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

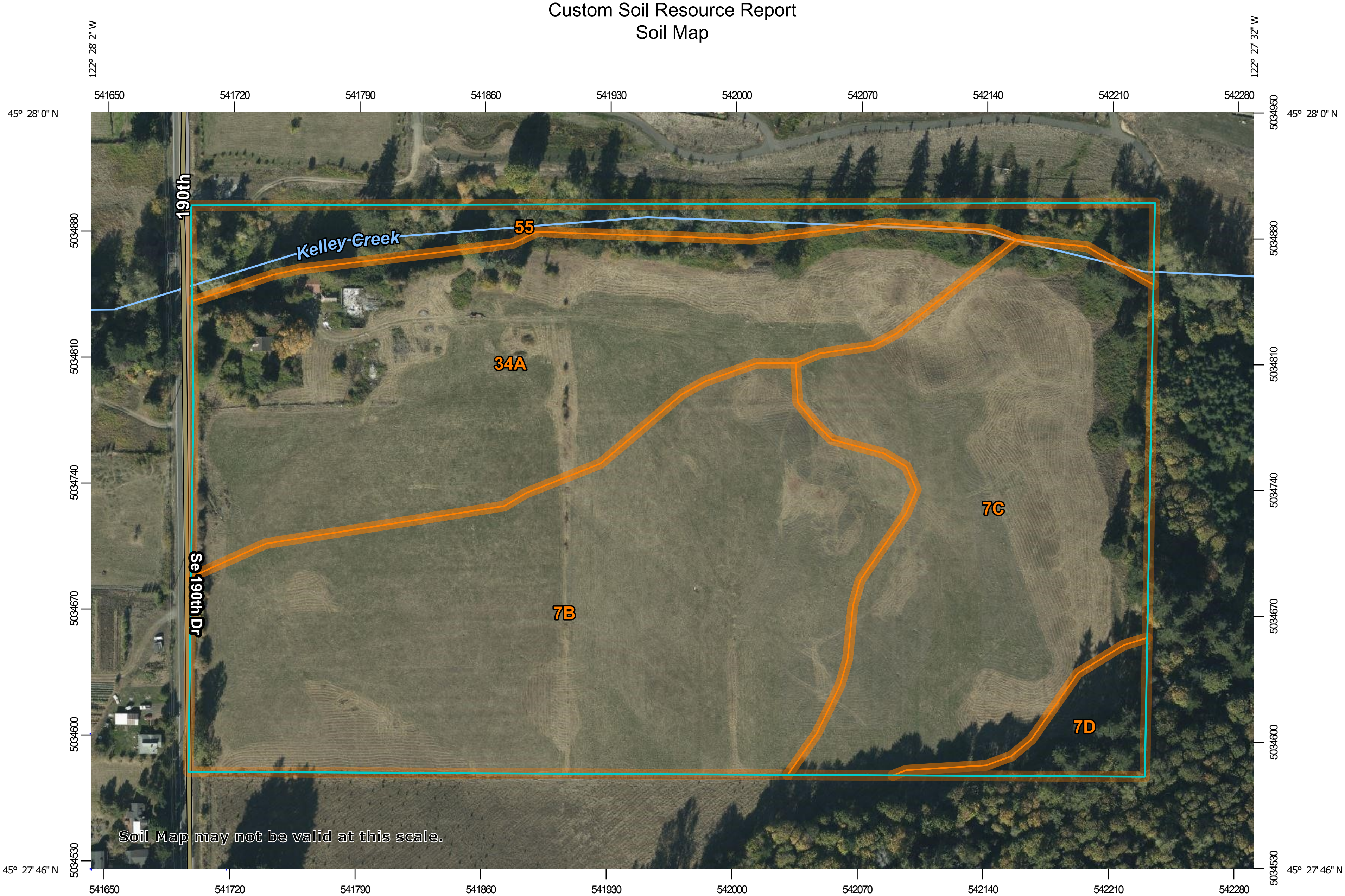
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:2,960 if printed on A landscape (11" x 8.5") sheet.

N

0 40 80 160 240 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 Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

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: Multnomah County Area, Oregon
Survey Area Data: Version 21, Sep 14, 2022

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

Date(s) aerial images were photographed: Oct 15, 2018—Oct 18, 2018

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7B	Cascade silt loam, 3 to 8 percent slopes	15.3	36.4%
7C	Cascade silt loam, 8 to 15 percent slopes	10.5	24.9%
7D	Cascade silt loam, 15 to 30 percent slopes	1.0	2.4%
34A	Powell silt loam, 0 to 3 percent slopes	12.1	28.8%
55	Wapato silt loam	3.1	7.5%
Totals for Area of Interest		**42.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Multnomah County Area, Oregon

7B—Cascade silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 22cq
Elevation: 250 to 1,400 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Cascade and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cascade

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 27 inches: silt loam
H3 - 27 to 60 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 30 inches to fragipan
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: F002XB005OR - Loess Hill Group
Forage suitability group: Somewhat Poorly Drained (G002XY005OR)
Other vegetative classification: Somewhat Poorly Drained (G002XY005OR)
Hydric soil rating: No

7C—Cascade silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 22cr
Elevation: 250 to 1,400 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Cascade and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cascade

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 27 inches: silt loam
H3 - 27 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 30 inches to fragipan
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: F002XB005OR - Loess Hill Group
Forage suitability group: Somewhat Poorly Drained (G002XY005OR)
Other vegetative classification: Somewhat Poorly Drained (G002XY005OR)
Hydric soil rating: No

7D—Cascade silt loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: 22cs
Elevation: 250 to 1,400 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Cascade and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cascade

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 27 inches: silt loam
H3 - 27 to 60 inches: silt loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 30 inches to fragipan
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F002XB005OR - Loess Hill Group
Forage suitability group: Somewhat Poorly Drained (G002XY005OR)
Other vegetative classification: Somewhat Poorly Drained (G002XY005OR)
Hydric soil rating: No

34A—Powell silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 229w
Elevation: 200 to 600 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Powell and similar soils: 90 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powell

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess over old silty alluvium

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 16 inches: silt loam
H3 - 16 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 15 to 24 inches to fragipan
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.5 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Ecological site: F002XB004OR - Fragipan Hill Group
Forage suitability group: Somewhat Poorly Drained (G002XY005OR)
Other vegetative classification: Somewhat Poorly Drained (G002XY005OR)
Hydric soil rating: No

Minor Components

Wollent

Percent of map unit: 3 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Other vegetative classification: Poorly Drained (G002XY006OR)
Hydric soil rating: Yes

55—Wapato silt loam

Map Unit Setting

National map unit symbol: 22c9
Elevation: 100 to 1,400 feet
Mean annual precipitation: 40 to 70 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Wapato and similar soils: 90 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wapato

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Recent alluvium

Typical profile

H1 - 0 to 18 inches: silt loam
H2 - 18 to 45 inches: silt loam
H3 - 45 to 60 inches: very gravelly sandy clay 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 (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: Frequent

Available water supply, 0 to 60 inches: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F002XC002OR - Backswamp Group
Forage suitability group: Poorly Drained (G002XY006OR)
Other vegetative classification: Poorly Drained (G002XY006OR)
Hydric soil rating: Yes

Minor Components

Delena

Percent of map unit: 2 percent
Landform: Terraces
Landform position (three-dimensional): Riser
Down-slope shape: Concave
Across-slope shape: Linear
Other vegetative classification: Poorly Drained (G002XY006OR)
Hydric soil rating: Yes

Wollent

Percent of map unit: 1 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Other vegetative classification: Poorly Drained (G002XY006OR)
Hydric soil rating: Yes

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

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.

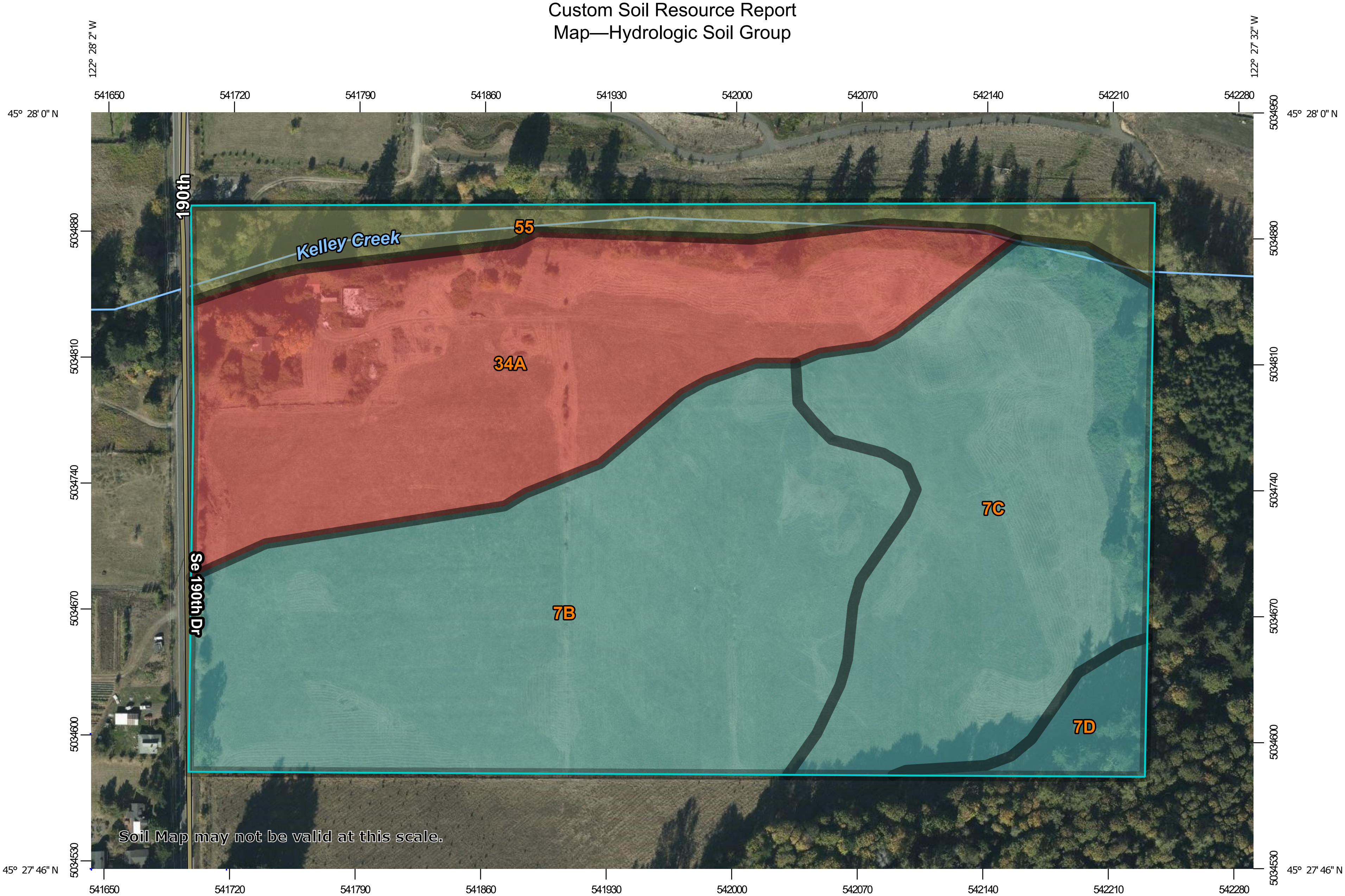
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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.

Map—Hydrologic Soil Group



Map Scale: 1:2,960 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

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: Multnomah County Area, Oregon
Survey Area Data: Version 21, Sep 14, 2022

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

Date(s) aerial images were photographed: Oct 15, 2018—Oct 18, 2018

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.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
7B	Cascade silt loam, 3 to 8 percent slopes	C	15.3	36.4%
7C	Cascade silt loam, 8 to 15 percent slopes	C	10.5	24.9%
7D	Cascade silt loam, 15 to 30 percent slopes	C	1.0	2.4%
34A	Powell silt loam, 0 to 3 percent slopes	D	12.1	28.8%
55	Wapato silt loam	C/D	3.1	7.5%
Totals for Area of Interest			**42.0**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Appendix F: Relevant Information from City of Gresham

CITY OF GRESHAM

Stormwater Management Manual

An Implementation Guide for Development Projects

October 2019

A. **Dispersed.** Infiltrate/retain the 10-year storm event in a private facility located on the same residential taxlot as the impervious surface being treated. Conveyance must be provided, but no further downstream detention/flow control required.

B. **Hybrid.** Infiltrate or manage the water quality event (**section 1.2.3**) at most localized scale possible, then meet the flow control requirements (**section 1.2.5**) at a downstream centralized facility. Can assume impervious surfaces treated for water quality are 50% pervious for sake of downstream facility detention/flow control calculations.

C. **Centralized.** Use centralized facility to treat both water quality (**section 1.2.3**) and flow control (**section 1.2.5**) for all impervious surface within development.

Green streets shall be used to the maximum extent practicable for any public streets or improvements within development per **section 1.2.4.3**.

Unless approved by the City, centralized facilities shall be located in a separate tract within the parent parcel. For developments that are primarily single family residential, this tract shall have an easement or dedication to the City for public stormwater management and maintenance per **section 6.1**. Approval for locating a facility off-site will consider criteria such as ownership, access, impacts to adjacent resources (e.g. other properties, existing or planned utilities, environmental resource areas, etc.)

1.2.4.3 Streets and Public Infrastructure

All development projects that will create new public streets or infrastructure shall prioritize green infrastructure (i.e. street-side stormwater planters) at the most localized scale possible to the maximum extent practicable (MEP). MEP is assumed to be achieved when stormwater planters are sized at 5% (or swales/rain gardens sized at 6%) of the contributing impervious area. When the developer can demonstrate that site specific constraints (e.g. gradient, utility conflicts) make it infeasible to achieve MEP, the assumed 50% pervious assumption shall be proportionally decreased (e.g. stormwater planters sized at 3% can assume 30% of treated street surface is pervious, instead of 50%).

1.2.5 Flow Control

For facilities that cannot retain the 10-year storm event on-site, flow control is required to prevent stream channel erosion (also called hydromodification). Sites where the 10-year event can be stored in an on-site facility, but would not fully draw down/infiltrate within 48-hours, need to ensure that an overflow conveyance (**section 4.0**) is provided to safely convey larger storm events. Sites where there is not an off-site conveyance system (e.g. designated drywell area) must size facilities to manage the 25-year storm event. Sites retaining the 25-year storm event on-site may be eligible for a reduction in the on-site portion of the monthly stormwater fee.

For subdivisions that manage the water quality event on-lot (**section 1.2.3**), any downstream detention facility must be sized to detain the 25-year storm event and meet the City's flow control requirements to ensure that post-development storm flows leaving the site:

- mimic the storm flows of the site prior to development, to the maximum extent possible;
- do not exceed the capacity of the receiving system or water body;
- do not increase the potential for stream bank and stream channel erosion; and
- do not create or increase any upstream or downstream flooding problems.

The flow volume causing hydromodification varies from stream to stream. Unless more specific data is available, the City assumes that channel-eroding flow begins to occur when one-half of the 2-year, 24-hour pre-development design storm peak flow is exceeded**.** To prevent hydromodification of the channel and mimic predevelopment hydrology, stormwater facilities shall be sized to retain the 25-year event and control post-development peak flows to the pre-development levels in **Table 1-1**.

Table 1-1: Flow control targets. Post-development peak runoff must match or be lower than the pre-development flow rate targets

Post-Development Peak Flow Rate	Pre-Development Peak Flow Rate Target
2-year, 24-hour	50% of 2-year, 24-hour
5-year, 24-hour	5-year, 24-hour
10-year, 24-hour	10-year, 24-hour
25-year, 24-hour	25-year, 24-hour

Pre-development is assumed to be conditions that existed at the site prior to any grading and land clearing activity related to the current development. The most frequently occurring pre-developed conditions are listed in **section 2.3.2.1** (e.g. forest, brush, grass, or paved/impervious surface). A weighted value should be calculated to reflect the portion of the site covered by each pre-existing surface condition.

1.2.6 Conveyance

A conveyance system must be designed to route stormwater into and away from any stormwater facility that cannot fully infiltrate water on-site. **Section 4.0** has requirements for sizing pipes and open channel conveyance systems for on-site and sub-basin drainage.

1.3 Source Control

All businesses within the City whose activities result in recurring sources of pollution as defined in GRC 3.23.025, shall be subject to the Stormwater Pollution Prevention for Businesses Program inspections, technical assistance and pollution prevention factsheets of policies and best practices for preventing, controlling, and cleanup of pollutants.

Certain business classifications/end uses have additional requirements to meet during site development to ensure that pollutants do not leave the site and enter the stormwater system to protect local waterways. The uses, activities, and materials requiring additional measures to protect stormwater on-site include:

- Fuel Dispensing Facilities and Surrounding Traffic Areas (**Section 5.3**)
- Above-Ground Storage of Liquid Materials (**Section 5.4**)
- Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 5.5**)
- Exterior Storage of Bulk Materials (**Section 5.6**)
- Material Transfer Areas/Loading Docks (**Section 5.7**)
- Equipment and/or Vehicle Washing Facilities (**Section 5.8**)
- Equipment and/or Vehicle Repair Facilities (**Section 5.9**)
- Stormwater and Groundwater Management for Development on Land with Suspected or Known Contamination (**Section 5.10**)
- Multilevel Parking Structures (**Section 5.11**)

- Optimize site design and reduce or eliminate potential conflicts between planned development and required stormwater management systems;
- Reduce new impervious surfaces to minimize stormwater requirements;
- Integrate site attributes to mimic natural hydrology and preserve natural resources;
- Optimize multifunctional uses such as neighborhood greenways and wildlife habitat.

2.3 Stormwater Facility Sizing

There are two methods that can be used to size facilities to meet the water quality and flow control requirements in **section 1.2**, the Simple Method and the Engineered Method.

2.3.1 Simple Method

The Simple Method uses pre-defined sizing factors to size stormwater facilities based on the amount of impervious area being added or replaced; this includes the building roof area and any other structures or hardened surfaces (e.g. driveway, patio, walkways, etc.) that will be included in the final site design.

To size stormwater facilities, the project designer quantifies the amount of new or redeveloped impervious area that is proposed and multiplies that area by the sizing factor for the stormwater facility being proposed. The sizing factors are listed on the Simple Sizing Form, which is described in **section 2.4.2** and included at the end of this section (page 2-8).

The Simple Sizing Form was developed assuming retention of the 10-year/24-hour storm event using generalized infiltration rates based on hydrologic soil types (see **Table D-2** in **Appendix D** for values assumed for each soil type). Based on the mapped soils at the development site, a stormwater facility sized using the factors on the Simple Sizing Form is assumed to comply with the City's flow control and pollution reduction requirements. On-site and off-site conveyance (**section 4.0**) needs to be addressed for pipes, outfalls and channels based on **Table 4-1**.

Stormwater facilities designed using the Simple Method are not required to be stamped by an engineer unless the project will be going through the Development Engineering review process.

Development projects that are adding or altering public infrastructure can utilize the Simple Sizing Form for sizing on-site stormwater facilities, but a Stormwater Report completed by a licensed engineer must be submitted to Development Engineering to demonstrate that water quality, flow control and conveyance requirements are being met.

Development projects in Type A and B soils should be able to fully manage stormwater on-site using a facility following sizing factors on the Simple Sizing Form. When on-site infiltration is not feasible, an on-site facility meeting the sizing requirements for Type A soils may be installed (assumed to treat the water quality event), and then the Engineered Method must be used to design a downstream centralized facility to detain and provide flow control to meet the requirements in **section 1.2.5**.

Projects in Type C and D soils that use the Simple Sizing Form to size lot-level facilities for water quality (using the Type A soil sizing factor) must then use the Engineered Method to size a downstream facility to provide detention and flow control. Downstream facilities designed in this manner can assume a 50% reduction in impervious area draining from water quality treated areas for hydrological calculations.

2.3.2 Engineered Method

The Engineered Method uses hydraulic and hydrologic engineering calculations to determine the facility size required. Any project is allowed to use the Engineered Method, which requires design by a licensed engineer. Detailed engineering calculations must be provided in a Stormwater Report (described in **section 2.4.4**) as evidence of the proposed design's performance with respect to the stormwater requirements provided in this manual.

Facilities sized by routing a hydrograph through the facility (rate-based facilities with a storage volume component) may use a continuous simulation program (using a minimum of 20 years of Gresham rainfall data) or a single-storm hydrograph-based analysis method, such as the Santa Barbara Urban Hydrograph (SBUH), to demonstrate treatment of 80 percent of the average annual runoff volume. The SBUH is preferred, but the Natural Resource Conservation Service (NRCS) TR-55 method, or Stormwater Management Model (SWMM) may also be used to generate the hydrograph. The Soil Conservation Service Type 1-A, 24-hour rainfall distribution, shall be used in all single storm hydrograph methods.

For projects following the Engineered Method, the engineer or qualified design professional must demonstrate that the proposed stormwater management meets or exceeds all stormwater requirements in this manual.

Appendix D has additional details about the Engineered Approach, but the overview of details and assumptions that should be made using this method are outlined below:

2.3.2.1 Pre-developed Surface Conditions

The pre-developed condition Runoff Coefficients (C) and Runoff Curve Numbers (CN) shall be based on conditions that existed at a site prior to any grading and land clearing activities related to the current development. The most common CN and C values for pre-developed conditions are listed in **Tables 2-1** and **2-2**.

Table 2-1. Common Curve Number (CN) values for Pre-developed conditions

Hydrologic Soil Type:	A	B	C	D
CN values for Forest/Woods	30	55	70	77
CN values for Woods/Grass combination	32	58	72	79
CN values for Pasture or Grass	39	61	74	80
CN values for Impervious Surfaces	98	98	98	98

Table 2-2. Common Runoff Coefficient (C) values for Pre-developed conditions

Site slope:	Flat 0% to 2%	Rolling 2% to 10%	Hill Over 10%
C values for Woodland and Forest	0.1	0.15	0.2
C values for Meadow, Pasture or Farm	0.25	0.3	0.35
C values for Mixed (Forest/Grass)	0.15	0.2	0.25
C values for Impervious Surfaces	0.9	0.9	0.9

For modeling other pre-development surfaces, see the Runoff Curve Number, CN, table (**Table D-3**) and the Runoff Coefficient, C, table (**Table D-6**) in **Appendix D**.

2.3.2.2 Post-developed Surface Conditions

The Runoff Curve Numbers (CN) used for post-developed surface conditions shall be based on conditions that will exist after development. The most common CN values for post-developed conditions are listed in **Table 2-3**. For developments doing stormwater quality treatment at the localized scale and treating 50% of the impervious surface as pervious, the CN value for "lawn/landscaped areas with amended soils" shall be used.

Table 2-3. Common Curve Number (CN) values for Post-developed conditions

Hydrologic Soil Type:	A	B	C	D
CN values for lawn/landscaped areas with un-amended soils	68	79	86	89
CN values for lawn/landscaped areas with amended soils	39	61	74	80
CN values for Impervious Surfaces	98	98	98	98
CN values for Pervious Pavement	76	85	89	91
CN values for Green Roof	61	61	61	61
CN values for Infiltration and Filtration Stormwater Planter	30	48	65	73

2.3.2.3 Time of Concentration

Time of concentration (Tc) calculations shall consist of three segments: sheet flow, shallow concentrated flow, and channel/pipe flow. Total time of concentration should be a minimum of 10 minutes for pre-developed conditions and a maximum of 10 minutes for post-developed conditions. However, if the portion of the contributing area within 300' upstream of the developed site will remain in an undeveloped condition and is 50% or more of the total contributing area, the post-developed Tc shall be determined by the engineer of record and may exceed 10 minutes.

2.3.2.4 Rainfall Depths

Table 2-4 lists the 24-hour rainfall depths that shall be used for sizing stormwater facilities and determining conveyance.

Table 2-4. Gresham 24-hour rainfall depths

Recurrence Interval (Years):	WQ	2	5	10	25	50	100
24-Hour Rainfall Depth (inches)	1.2	2.8	3.2	3.6	4.0	4.4	4.9

2.4 Submittal Plans, Forms and Reports

In order to demonstrate compliance with the stormwater requirements in this manual, the forms, plans and information listed in **Table 2-5** are required to be included with permit application materials submitted to the City.

Table D-3. Runoff Curve Number (CN) values for NRCS Hydrologic Soil Groups

Cover Description	A	B	C	D
Pervious Surfaces				
Compacted lawn. Un-amended soil	68	79	86	89
Pasture or grass/lawn with **amended soil**	39	61	74	80
Grass/Woods combination	32	58	72	79
Forest/Woods	30	55	70	77
Impervious Surfaces				
Paved roads, parking lots, roofs, driveways	98	98	98	98
Gravel roads and parking areas	76	85	89	91
Compacted Dirt	72	82	87	89
Green Practices				
Pervious Pavement	76	85	89	91
Trees	36	60	73	79
Green Roof	61	61	61	61
Infiltration and Filtration Stormwater Planter	30	48	65	73

Sources: Pervious and impervious values are from National Engineering Handbook (2004). Values for green practices come from Portland's Stormwater Management Manual

D.3.4 Time of Concentration (T_c)

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed.

T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration. T_c depends on several factors, including ground slope, ground roughness, and distance of flow.

Total time of concentration should be a minimum of 10 minutes for pre-developed conditions and a maximum of 10 minutes for post-developed conditions. However, if the portion of the contributing area within 300' upstream of the developed site will remain in an undeveloped condition and is 50% or more of the total contributing area, the post-developed Tc shall be determined by the engineer of record and may exceed 10 minutes.

Calculations for total T_c should be divided into three segments: sheet flow, shallow concentrated flow, and channel/pipe flow. The total time of concentration (T_c) is calculated as:

$$T_c = T_{osf} + T_{scf} + T_{ocf}$$

Simple Sizing Form

This form is to be used to size stormwater facilities following the Simple Method. The following table contains acceptable stormwater sizing factors for facilities described in the Stormwater Management Manual that will be managing stormwater within 100 feet of the impervious surface being treated.

Name: ____________________________ Site Address: ___________________________________

Impervious Area from Development (sf): __________________ Soil Type: A B C D
(circle one)

Instructions:

1. Determine the amount of impervious area (in square feet) to be managed by each stormwater facility
2. Multiply the Impervious Area Managed by the sizing factor for your soil type to determine the Facility Size needed. **If facility is being designed for water quality only, use the sizing factor for Soil Type A**
3. Total Impervious Area Managed must match Impervious Area from Development

Stormwater Facility Type	**Impervious Area Managed (sf)**	**Facility Sizing Factor (by soil type)**				**Facility Size (sf)**
		A	**B**	**C**	**D**	
Rain Garden, Basin, Swale		0.06	0.08	0.20	0.40	
Planter		0.05	0.07	0.15	0.28	
Filter Strip (paved areas only)		0.20	0.20	0.20	0.20	
Ecoroof		1:1 ratio				
Porous Pavement		1:1 ratio				
Soakage Trench, Infiltration Vault, or Drywell[1]		Sizing Chart in SWMM				
Total Impervious Area Managed (sf)						

[1] Stormwater generated from anything other than residential roof area must be pre-treated with more than a silt basin, and also needs to be registered with DEQ. The surface vegetated facilities in **section 3.2** are typically deemed adequate pre-treatment.

[2]If a filtration rain garden or planter is allowed (per **section 1.2.4**), then use the sizing factor for Type A Soil

All pervious and impervious areas within a given basin or sub-basin shall be analyzed separately. By analyzing pervious and impervious areas separately, the cumulative errors associated with averaging these areas are avoided, resulting in a more accurate runoff hydrograph.

D.3.2 Rainfall Distribution and Depth

The rainfall distribution to use within the City is the design storm for a 24-hour duration based on the standard NRCS Type 1A rainfall distribution. This distribution is contained in **Table D-5**.

Table D-1 contains the 24-hour rainfall totals that shall be used in determining the runoff hydrograph for various sized storm events.

Table D-1. 24-hour rainfall depths for Gresham, OR

Recurrence Interval (Years)	WQ	2	5	10	25	50	100
24-hour Rainfall (inches)	1.2	2.8	3.2	3.6	4.0	4.4	4.9

D.3.3 Runoff Curve Number (CN)

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to consolidate diverse characteristics such as soil type, land usage, and vegetation into a single variable for computing runoff.

Runoff CNs to be used in the hydrograph methods are included in **Table D-3**. The CN values are based on the hydrologic soil groups described in **Tables D-2a** and **D-2b**. For developments doing stormwater quality treatment at the localized scale and treating 50% of the impervious surface as pervious, the CN value for "lawn/landscaped areas with amended soils" shall be used for that modeled impervious surface.

The CN values in **Table D-3** are for wet antecedent moisture conditions. Wet conditions assume previous rainstorms have reduced the capacity of soil to absorb water. Given the frequency of rainstorms in the Gresham area, wet conditions are most likely, and give conservative hydrographic values.

Table D-2a. Gresham soil types from the Natural Resource Conservation Service's (NRCS) Soil Survey of Multnomah County (1983, Table 24). The NRCS soil maps can be found on-line at web soil survey.

Soil Survey Map ID#	Soil Group	Hydrologic Soil Group
1	Aloha silt loam	C
2	Aloha-Urban land complex	B
7	Cascade silt loam	C
10	Cornelius silt loam	C
25	Latourell loam	B
26	Latourell-Urban land complex	B