BLUELINE

2825 W Mercer Way

City of Mercer Island, Washington

Date: March 1, 2019

Preliminary Storm Drainage Report

Prepared for
OB Mercer Island Properties, LLC
P.O. Box 726
Bellevue, WA 98009

Blueline Job No. 13-118

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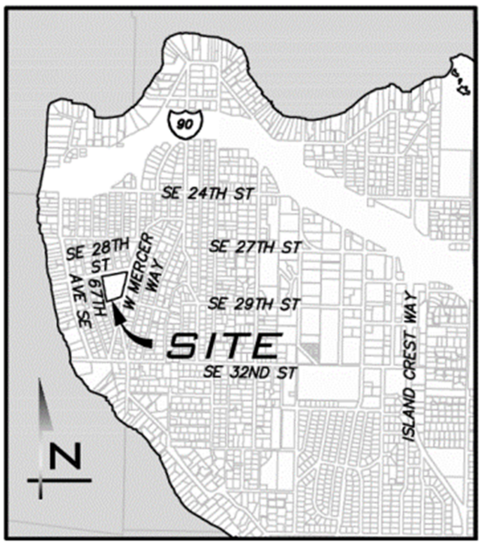
Section 1 Project Overview

The project is located at 2825 W Mercer Way in Mercer Island, WA 98040. More generally, the site is located in NE ¼ of Section 11, Township 24 N, Range 4 E, W.M. Please see the vicinity map below.



Vicinity Map- Not to Scale

The project site consists of a single 2.88-acre parcel (#217450-2425), and approximately 0.68-acres of frontage improvements along W Mercer Way, SE 28th St, SE 30th St, and 62nd Ave SE. The lot is currently developed with an existing building, parking areas and associated infrastructure. Vegetation is comprised primarily of lawn areas, with mature trees along the property boundaries of the site perimeter. The project proposes the construction of 14 detached single-family homes with associated access drives, utilities, and landscaping. Refer to the *Developed Conditions Exhibit* included in Section 4.

The property is bounded by right-of-way and adjacent single-family residences on all sides.

Per the geotechnical report, the site is generally underlain by very dense silty sand and silt, generally consistent with typical makeup of glacial till. These types of soils are not typically conducive to infiltration. See Section 6 for the *Geotechnical Engineering Study* prepared by Earth Solutions NW, LLC. dated November 29, 2018.

The site is divided into north and south sub-basins, which drain into Lake Washington within a quarter mile. In the existing condition, runoff along the northern boundary of property generally sheet flows in the westerly direction and is collected in the various catch basins along SE 28th St. The majority of the onsite runoff generally sheet flows in the southwestern direction where it enters drainage ditches along the south and west boundaries of the property and eventually merges with the existing public conveyance system along SE 30th St. Flow control is not required as the project discharges directly to a flow control-exempt receiving water (Lake Washington). The total of pollution-generating hard surface (PGHS) for the project exceeds 5,000 sf, and will therefore provide runoff treatment via biofiltration swale.

The proposed improvements for this project are greater than 5,000 sf of new impervious area, thus the project, per the Department of Ecology 2012 Stormwater Management Manual for Western Washington, as amended in December 2014 (DOE Manual), and is therefore required to meet Minimum Requirements 1 – 9 as detailed in Section 2.5 of DOE Manual.

Section 2 Minimum Requirements

The following summary describes the minimum stormwater management requirements for the proposed development project per the DOE Manual as adopted by the City of Mercer Island.

MINIMUM REQUIREMENT #1: PREPARATION OF STORMWATER SITE PLANS

All projects meeting the thresholds in section 2.4 shall prepare a stormwater Site Plan for City review. Refer to the Preliminary Plat Submittal included under separate cover for detailed information about the proposed stormwater design.

MINIMUM REQUIREMENT #2: CONSTRUCTION STORMWATER POLLUTION PREVENTION (SWPP)

See Section 5. A Construction SWPPP will be provided with the final engineering submittal.

MINIMUM REQUIREMENT #3: SOURCE CONTROL OF POLLUTION

All known, available and reasonable source control BMPs must be applied to all projects. Source control BMPs will be selected, designed, and maintained in accordance with the DOE Manual.

MINIMUM REQUIREMENT #4: PRESERVATION OF NATURAL DRAINAGE SYSTEMS AND OUTFALLS

See Sections 3 and 4. Runoff for the proposed development will be routed to leave the site at the existing natural discharge locations and will not cause adverse impacts downstream.

MINIMUM REQUIREMENT #5: ON-SITE STORMWATER MANAGEMENT

See Section 4. Per Section 2.5.5 of the DOE Manual, projects qualifying as flow control exempt in accordance with Section 2.5.7 do not have to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List #1 or List #2. The remaining BMPs are evaluated as part of this report. All landscaped and open areas will have compost amended soils per BMP T5.13.

MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

See Section 4. The total of PGHS for the project exceeds 5,000 sf, and will therefore provide runoff treatment via biofiltration swale and StormFilter.

MINIMUM REQUIREMENT #7: FLOW CONTROL

See Section 4. The project will discharge runoff to a conveyance system that is comprised entirely of manmade conveyance elements directly into Lake Washington (an exempt receiving water) and is therefore exempt from the flow control requirement.

MINIMUM REQUIREMENT #8: WETLANDS PROTECTION

The project will not discharge stormwater into a wetland either directly or indirectly through a conveyance system. Therefore, this Minimum Requirement is not applicable. Refer to the *Critical Area Reconnaissance Memorandum* prepared by The Watershed Company in Section 6.

MINIMUM REQUIREMENT #9 OPERATION AND MAINTENANCE

See Section 8. An operation and maintenance manual will be included with the final engineering submittal.

Section 3 Offsite Analysis

An offsite analysis was conducted on January 3rd, 2019, an overcast day with light rain and temperatures around 50º F.

TASK 1: DEFINE AND MAP THE STUDY AREA

The project is comprised of one parcel (#217450-2425). See Section 4 of this report for the *Existing Conditions Exhibit* and the *Developed Conditions Exhibit.* A Photo Exhibit and Downstream Path Exhibit are provided at the end of this section that show the study area boundaries and the observed stormwater runoff flow path from the site. The project site consists of two drainage basin paths which are further described in Task 3 and 4.

TASK 2: RESOURCE REVIEW

The best available resource information was reviewed for existing or potential problems. The following is a summary of the findings from the information used in preparing this report.

- Per *Geotechnical Engineering Study* prepared by Earthwork Solutions NW, LLC., the soils observed in the tests pits consisted of medium dense to very dense silty sand and silt, generally consistent with the typical makeup of glacial till.

- The site is a part of the Mercer Island Drainage Basin (King County iMap). There is one basin with two separate drainage paths that combine within ¼ mile.

- The site does not contain wetlands (King County iMap).

- The site does not contain streams and is not located within a floodplain (King County iMap).

- The is not located in a Landslide Hazard Area (King County iMap and City of Mercer Island GIS).

- The site is not located in a Seismic Hazard Area (King County iMap and City of Mercer Island GIS).

- The site is not located in an Erosion Hazard Area (King County iMap and City of Mercer Island GIS).

- Refer to excerpts from the *East Seattle Neighborhood Storm Drainage Basin Study*, provided by the City for commentary on drainage complaints.

TASK 3: FIELD INSPECTION:

A field inspection was conducted for the project at 2825 W Mercer Way on January 3rd, 2019, an overcast day with light rain and temperatures around 50° F. Task 4 of this section contains a detailed description of the downstream drainage paths as well as a *Downstream Path Exhibit*.

Onsite Basin

There is one basin with two separate drainage paths and outfalls to Lake Washington that combine within ¼ mile. Majority of the runoff from the larger subbasin area generally sheet flows southeast across the site and is tributary to drainage ditches along the south and west boundaries of the property. The runoff is then conveyed via public conveyance system along the north side of SE 30th St into the outfall in Lake Washington. A portion of SE 28th St runs along the panhandle portion of the site, providing access to the parking lot located on the west side of the parcel. Runoff from the panhandle portion of the site generally sheet flows to the public conveyances along the south side of SE 28th St and continues westward until the outfall in Lake Washington.

Per the geotechnical report, the site is underlain by very dense silty sand and silt, generally consistent with the typical makeup of glacial till. See Section 6 for Geotechnical Engineering Study prepared by Earth Solutions NW, LLC.

Upstream Area

In the existing condition, surface runoff from a portion of the adjacent streets (W Mercer Way, SE 28th St, and SE 30th St) surrounding the site sheet flows onto the site. These areas will be included in the analysis of the existing conveyance systems. Refer to the *Developed Conditions* provided in Section 4 of this report. In the developed condition, upstream runoff will be intercepted by ditches and catch basins along the project frontages.

TASK 4: DRAINAGE SYSTEM DESCRIPTION

The downstream drainage path was investigated up until the outfall at Lake Washington. Refer to the *Downstream Drainage Exhibit* for the path and photo locations referred to in this section.

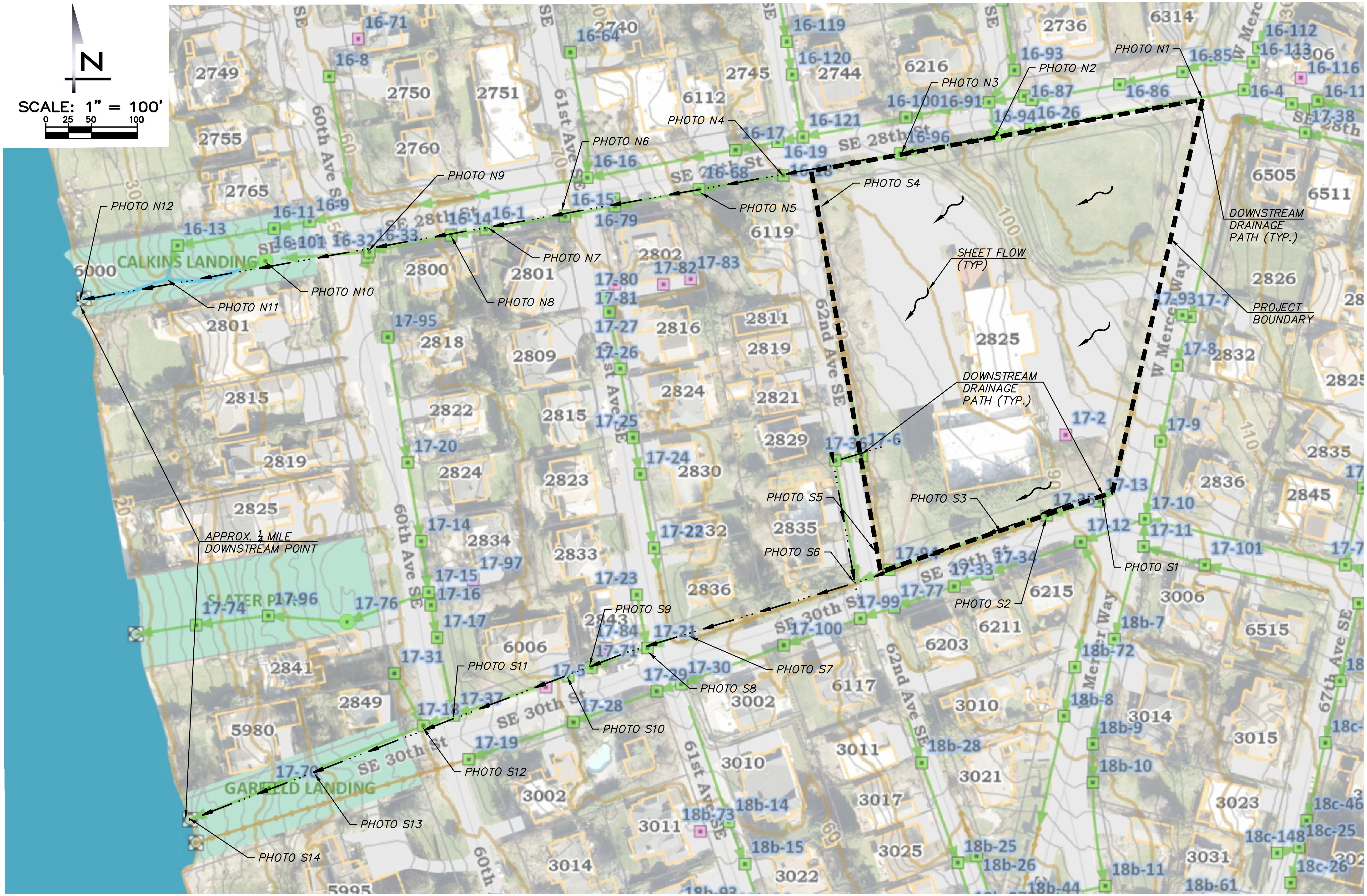
Existing Downstream Drainage Path 1 – North Subbasin

Onsite runoff along the edge of the northern parcel boundary sheet flows southwest towards a series of tight-lined catch basins along the south side of SE 28th St (Photos N1-N3). The runoff is then conveyed via the 12" tight-lined system along the south side of SE 28th St toward an outfall in Lake Washington (Photos N4 – N13).

Existing Downstream Drainage Path 2 – South Subbasin

The majority of onsite runoff sheet flows southwest towards a series of open channels and catch basins along the east, west, and southern parcel boundaries (Photo S1-S5). The runoff is conveyed through more open channels, driveway culverts, and catch basins along the north side of SE 30th St until it reaches the outfall in Lake Washington (Photos S5-S13).

DOWNSTREAM DRAINAGE EXHIBIT



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DOWNSTREAM DRAINAGE EXHIBIT
2825 W MERCER WAY
PRELIMINARY STORM DRAINAGE REPORT

SCALE	AS NOTED
PROJECT MANAGER	BRETT PUDISTS, PE.
DESIGNED BY	LYNDSEY MUNKEL, PE.
DRAWN BY	GLORIA CONTRERAS, EIT.
PLOT DATE	March 1, 2019

JOB NUMBER: 13-118

FIGURE: DS

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DOWNSTREAM DRAINAGE PHOTOGRAPHS

Note: See the Downstream Drainage Exhibit for numbered locations of pictures.

NORTH BASIN DOWNSTREAM PATH PHOTOS

Photo N1 – Facing west along SE 28th St. Onsite runoff sheet flows northwest toward the conveyance system on the south side of the street.

Photo N2 – Facing west along SE 28th St approximately 170 feet west of Photo N1. Runoff continues to sheet flow northwest towards the conveyance system on the south side of the street.

Photo N3 – Facing west along SE 28th St approximately 145 feet west of Photo N2. This catch basin is located adjacent to the driveway into the back parking lot on the western portion of the property. Runoff continues to sheet flow northwest towards the conveyance system on the south side of the street.

Photo N4 – Facing west along SE 28th St approximately 130 feet west of Photo N3. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N5 – Facing west along SE 28th St approximately 95 feet west of Photo N4. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N6 – Facing west along SE 28th St approximately 150 feet west of Photo N5. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N7 – Facing west along SE 28th St approximately 90 feet west of Photo N6. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N8 – Facing west along SE 28th St approximately 40 feet west of Photo N7. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N9 – Facing west along SE 28th St approximately 95 feet west of Photo N8 at southeast corner of the intersection of SE 28th St and 60th Ave SE. Runoff is conveyed via this catch basin on the south side of the street toward Lake Washington.

Photo N10 – Facing west in Calkins Landing approximately 95 feet west of Photo N9. Runoff is collected in the pre-settling vault pictured before being discharged into Lake Washington.

Photo N11 – Facing west in Calkins Landing. Runoff discharges via a pipe with a trash rack to a ditch upstream of the outfall to Lake Washington.

Photo N12 – Facing west in Calkins Landing showing the outfall in Lake Washington.

SOUTH BASIN DOWNSTREAM PATH PHOTOS

Photo S1 – Facing west along the north side of SE 30th St. Onsite runoff sheet flows in the southwestern direction to the catch basin above and is conveyed west toward Lake Washington.

Photo S2 – Facing west along the north side of SE 30th St approximately 55 feet west of Photo S1. Onsite runoff sheet flows in the southwestern direction to the catch basin above and is conveyed west toward Lake Washington.

Photo S3 – Facing west along the north side of SE 30th St approximately 35 feet west of Photo S2. Onsite runoff sheet flows in the southwestern direction to the ditch above and is conveyed west toward Lake Washington.

Photo S4 – Facing south on the east side of 62nd Ave SE approximately 60 feet from Photo N4. Onsite runoff sheet flows in the southwest direction toward the ditch above and is conveyed south to be combined with the south basin downstream conveyance system.

Photo S5 – Facing north on the east side of 62nd Ave SE approximately 365 feet from Photo S4. Onsite runoff sheet flows in the southwest direction toward the ditch above and in conveyed south to be combined with the south basin downstream conveyance system.

Photo S6 – Facing west along the north side of SE 30th St approximately 40 feet west of Photo S5 at the northwest corner of the intersection of SE 30th St and 62nd Ave SE. Runoff is conveyed west from this pipe outfall toward Lake Washington.

Photo S7 – Facing east along the north side of SE 30th St approximately 210 feet west of Photo S6 at the northeast corner of the intersection of SE 30th St and 61st Ave SE. Runoff is conveyed west toward Lake Washington.

Photo S8 – Facing west along the north side of SE 30th St approximately 30 feet west of Photo S7 at the northwest corner of the intersection of SE 30th St and 61st Ave SE. Runoff is conveyed west toward Lake Washington.

Photo S9 – Facing west along the north side of SE 30th St approximately 65 feet west of Photo S8. Runoff is conveyed west toward Lake Washington.

Photo S10 – Facing west along the north side of SE 30th St approximately 30 feet west of Photo S9. Runoff is conveyed west toward Lake Washington.

Photo S11 – Facing west along the north side of SE 30th St approximately 130 feet west of Photo S10 at the northeast corner of the intersection of SE 30th St and 60th Ave SE. Runoff is conveyed west toward Lake Washington.

Photo S12 – Facing west in front of the entrance to Garfield Landing approximately 35 feet west of Photo S11. Runoff is conveyed west toward Lake Washington.

Photo S13 – Facing west in Garfield Landing. Runoff is conveyed west to the outfall into Lake Washington.

Photo S14 – Facing east looking directly at the outfall to Lake Washington.

Section 4 Permanent Stormwater Control Plan

The permanent stormwater control plan includes water quality treatment facilities and storm conveyance system designed and sized according to the DOE Manual. The site is exempt from providing a flow control facility per Section 2.5.7 of the DOE Manual.

EXISTING CONDITIONS

The project site consists of a single 2.88-acre parcel (#217450-2425), and approximately 0.68-acres of frontage improvements along W Mercer Way, SE 28th St, SE 30th St, and 62nd Ave SE. The lot is currently developed with an existing building, parking areas and associated infrastructure. Vegetation is comprised primarily of lawn areas, with mature trees along the property boundaries of the site perimeter. Refer to the *Existing Conditions Exhibit* included on the following page. See below for existing conditions land cover.

EXISTING CONDITIONS		
Pervious		
Parcel	1.43	ac
Frontage	0.68	ac
Total Pervious (Soil Group C – Till)	**2.11**	**ac**
Impervious		
Parcel	1.45	ac
Total Impervious	**1.45**	**ac**
TOTAL EXISTING CONDITIONS	**3.56**	**ac**

EXISTING CONDITIONS EXHIBIT

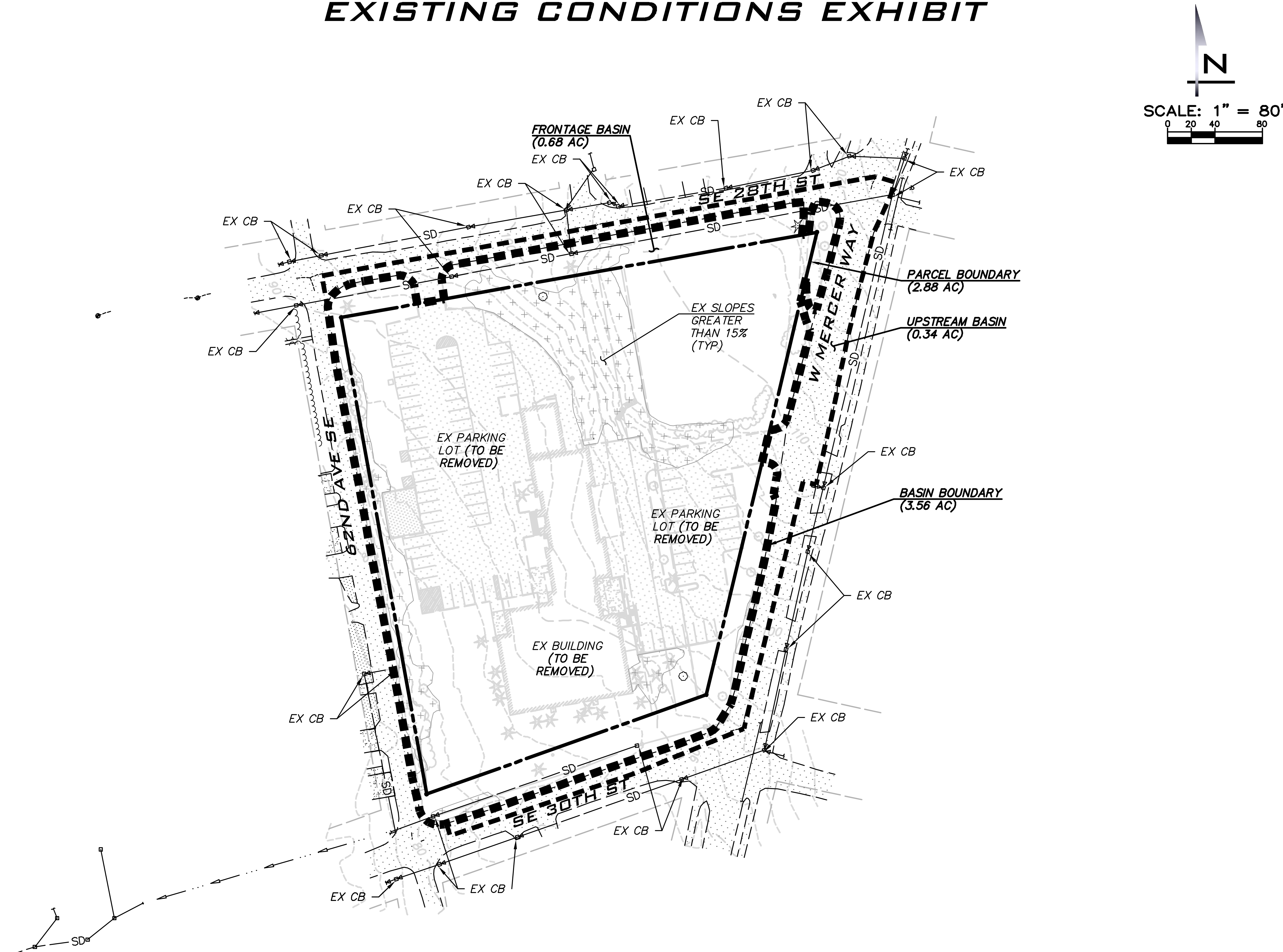

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FIGURE: EC

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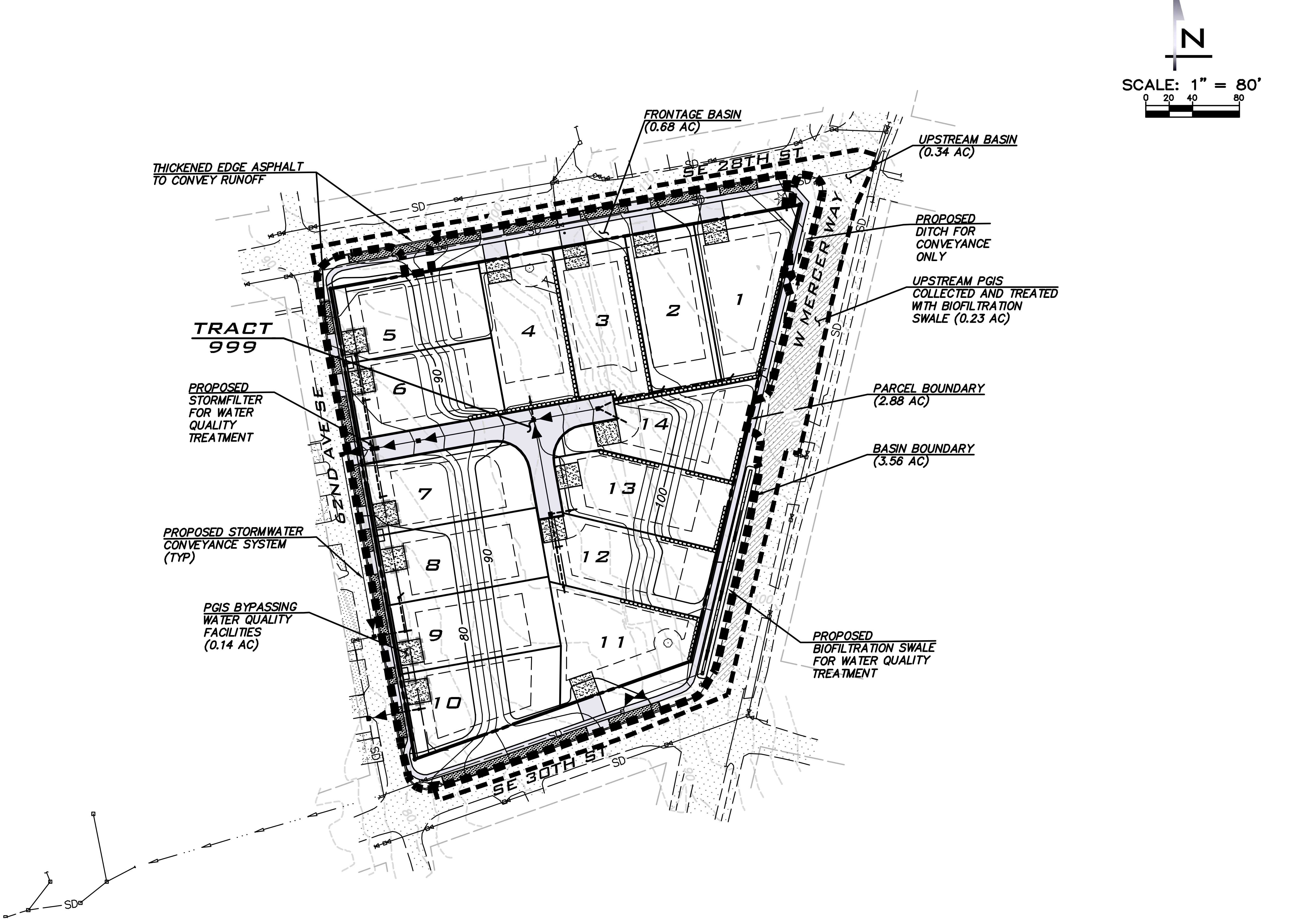
DEVELOPED CONDITIONS

The project site consists of a single 2.88-acre parcel (#217450-2425), and approximately 0.68-acres of frontage improvements along W Mercer Way, SE 28th St, SE 30th St, and 62nd Ave SE. The proposed development includes the construction of 14 single-family homes and associated roadways, parking stalls, and utilities. The site is split into a north and south subbasin, based on the proposed grading and stormwater conveyance systems. The site is exempt from providing a flow control facility. Treatment of runoff for basic water quality is proposed through a biofiltration swale and onsite StormFilter. Refer to the *Developed Conditions Exhibit* included on the following page. See below for existing conditions land cover.

DEVELOPED CONDITIONS		
Pervious		
Lot	1.39	ac
Frontage	0.36	ac
Total Impervious	**1.75**	**ac**
Impervious		
Lot	1.33	ac
Tract	0.16	ac
Frontage	0.32	ac
Total Pervious (Till - Soil Group C)	**1.81**	**ac**
TOTAL DEVELOPED CONDITIONS	**3.56**	**ac**

DEVELOPED CONDITION EXHIBIT



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DEVELOPED CONDITION EXHIBIT
2825 W MERCER WAY
PRELIMINARY STORM DRAINAGE REPORT

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DRAWN BY	GLORIA CONTRERAS, EIT.
PLOT DATE	March 1, 2019

JOB NUMBER:
13-118

FIGURE:
DC

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UPSTREAM AREA

In the existing condition, surface runoff from a portion of the adjacent streets (W Mercer Way, SE 28th St, and SE 30th St) surrounding the site sheet flows onto the site. These areas will be included in the analysis of the existing conveyance systems. Refer to the *Developed Conditions* provided on the following pages. In the developed condition, upstream runoff will be intercepted by ditches and catch basins along the project frontages.

TOTAL UPSTREAM AREA		
Impervious		
Upstream Area (Existing Roadway)	0.34	ac
Total Impervious	**0.34**	**ac**
TOTAL UPSTREAM AREA	**0.34**	**ac**

4.1 FLOW CONTROL ANALYSIS AND DESIGN

Per Section 2.5.7, Volume I of the DOE Manual, Flow Control is not required for projects that discharge directly to, or indirectly to Lake Washington subject to the following restrictions:

- Direct discharge to the exempt receiving water does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any category I, II, or III wetland
  The project is not proposing to divert drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any category I, II, or III wetland.

- Flow splitting devices or drainage BMP's are applied to route natural runoff volumes from the project site to any downstream Type 5 stream or category IV wetland:
  The project is not proposing to discharge to a downstream Type 5 stream or category IV wetland.

  - Design of flow splitting devices or drainage BMP's will be based on continuous hydrologic modeling analysis. The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
    Not applicable

  - Flow splitting devices or drainage BMP's that deliver flow to category IV wetlands will also be designed using continuous hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction
    Not applicable

- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water line of the exempt receiving water
  The project site drains to a conveyance system that is comprised entirely of manmade conveyance elements and extends to the ordinary high water line of the exempt receiving water.

- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected
  Improvements to the existing conveyance system are proposed in order to provide sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site and the existing condition from non-project areas from which runoff is or will be collected. Refer to discussion below regarding the proposed improvements.

- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.
  Existing ditches will be evaluated for stability as part of this project.

The City prepared the *East Seattle Neighborhood Storm Drainage Basin Study* to assess the capacity of the existing storm conveyance system. Refer to excerpts from the study provided in the Appendix. The downstream paths associated with this project were evaluated as part of the study.

The area and land cover tributary to the north downstream path are proposed to mimic the existing condition. As such, no improvements to the north downstream path are proposed.

The onsite impervious area tributary to the south downstream path (1.46 acres) is reasonably similar to the existing onsite impervious area (1.49 acres). Frontage improvements will result in an increase in impervious surface of approximately 0.50 acres. The conversion of approximately 0.53 acres of pervious to impervious area results in a 0.25 cfs increase as evaluated using the Western Washington Hydrology Model.

Per the *East Seattle Neighborhood Storm Drainage Basin Study*, the existing 12-inch pipe across 60th Ave SE on the north side of SE 30th St needs to be replaced. This can be accomplished without any changes to the pipes immediately downstream and upstream of this segment, provided the revised pipe grade would not be in conflict with any existing utilities. The second iteration upstream IE from the backwater spreadsheet is reflected in the preliminary plans.

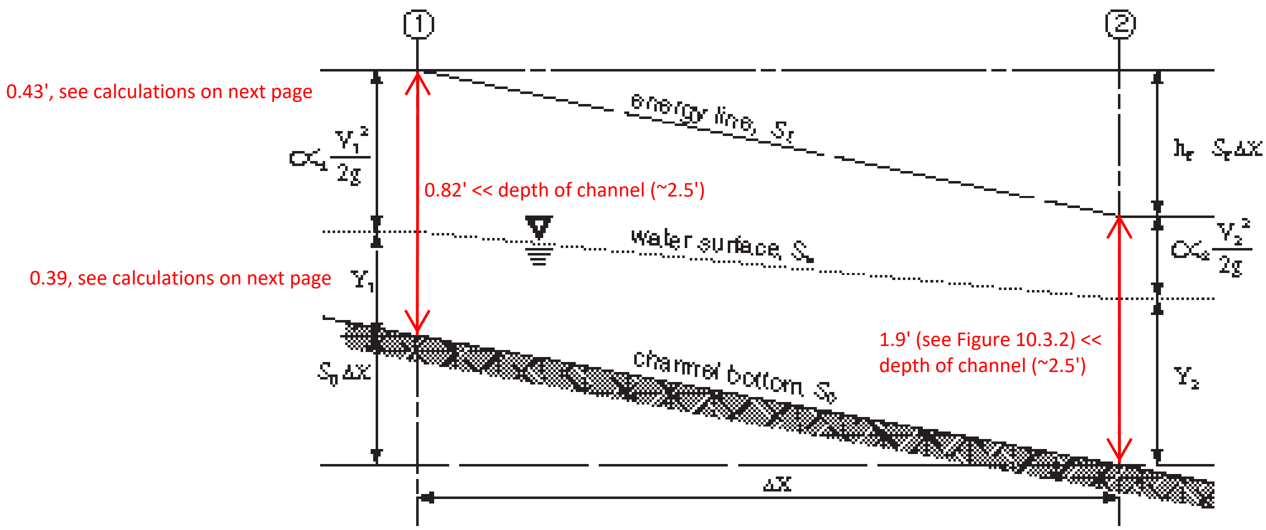
The existing ditch on the north side of SE 30th St between 62nd Ave SE and 61st Ave SE was evaluated in further detail to confirm that it has sufficient capacity. The 2016 King County Surface Water Manual (2016 KCSWDM) was used for additional guidance on open channel flow. The Direct Step backwater method was used to compute the backwater profile on the channel. The existing ditch will be evaluated as part of this project to ensure that it has the following minimum dimensions: 1' bottom width, 5.1% slope, and 2:1 side slopes. Refer to figures and calculations on the following pages.

Direct Step Backwater Method

The Direct Step backwater method may be used to compute backwater profiles on prismatic channel reaches (i.e., reaches having uniform cross section and slope) where a backwater condition or restriction to normal flow is known to exist. The method may be applied to a series of prismatic channel reaches in secession beginning at the downstream end of the channel and computing the profile upstream.

Calculating the coordinates of the water surface profile using this method is an iterative process achieved by choosing a range of flow depths, beginning at the downstream end, and proceeding incrementally up to the point of interest or to the point of normal flow depth. This is best accomplished by the use of a table (see Figure 4.4.1.G, p. 4-69) or computer programs (as discussed on page 4-64, "Computer Applications").

To illustrate analysis of a single reach, consider the following diagram:



Equating the total head at cross sections 1 and 2, the following equation may be written:

$$S_o\Delta x + y_1 + \alpha_1 \frac{V_1^2}{2g} = y_2 + \alpha_2 \frac{V_2^2}{2g} + S_f\Delta x \qquad (4\text{-}10)$$

where, Δx = distance between cross sections (ft)
y_1, y_2 = depth of flow (ft) at cross sections 1 and 2
V_1, V_2 = velocity (fps) at cross sections 1 and 2
α_1, α_2 = energy coefficient at cross sections 1 and 2
S_o = bottom slope (ft/ft)
S_f = friction slope = $(n^2V^2)/(2.21R^{1.33})$
g = acceleration due to gravity, (32.2 ft/sec^2)

If the specific energy E at any one cross-section is defined as follows:

$$E = y + \alpha\frac{V^2}{2g} \qquad (4\text{-}11)$$

HW/D=1.9'
HW=D*HW=1*1.9'=1.9

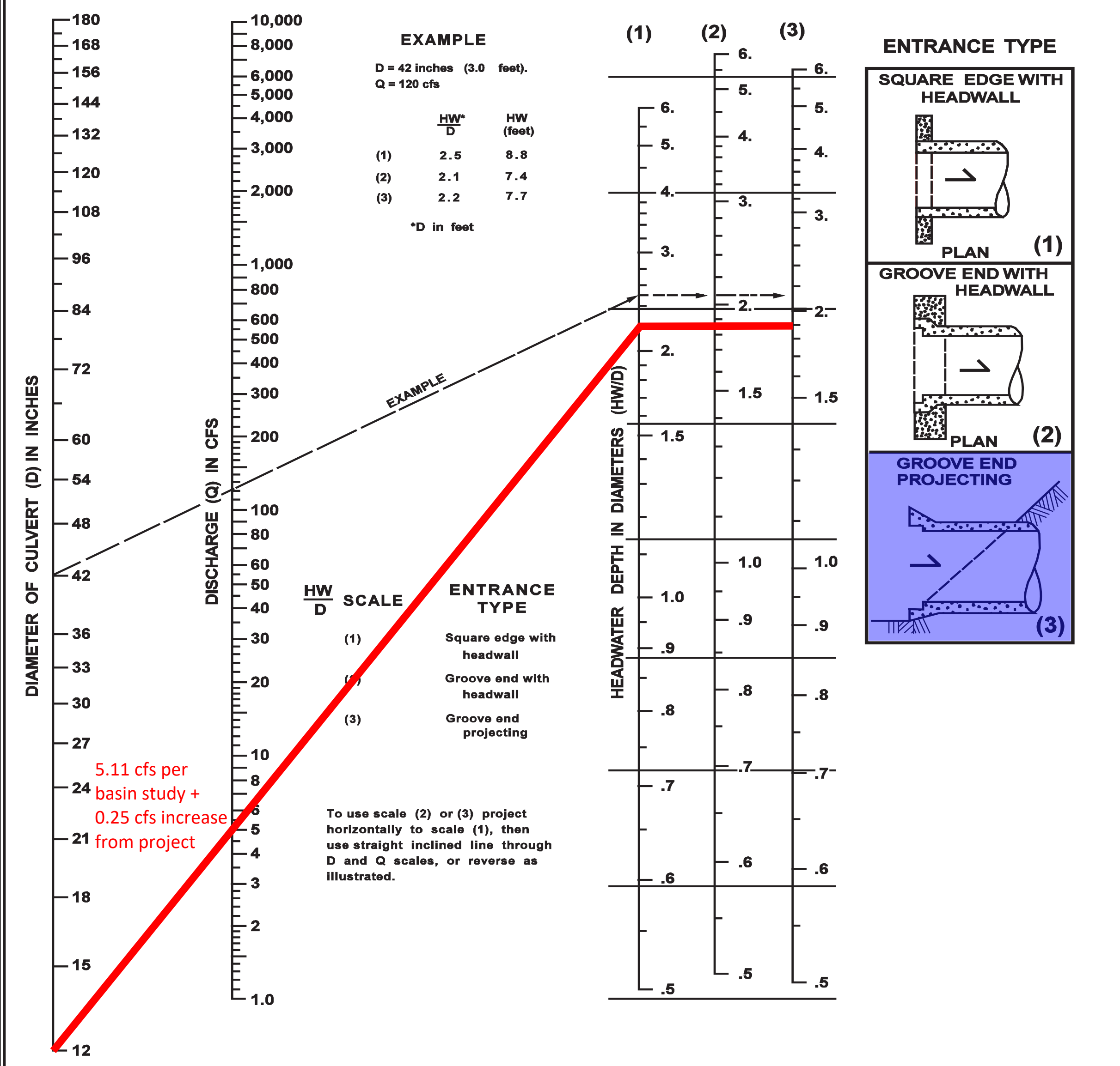


Figure 10.3.2 – Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control

Equations for Direct Step Backwater Method at upstream end of ditch:

Manning's equation to solve for y: Q = 1.486*A*(R^2/3)*(S^1/2)/n

Q = 3.24 cfs per basin study + 0.25 cfs increase from project = 3.49 cfs

S = 5.1% (0.051)

n = 0.027 for constructed channels with short grass, few weeds per Table 4.4.1.B of the 2016 KCSWDM (see following pages)

A = (b + zy)y

R = ((b + zy)y)/(b+2y*(1+z^2)^1/2)

3.49 = 1.486* (1 + 2y)y*(((1 + 2y)y)/(1+2y*(1+2^2)^1/2))^2/3*(0.051^1/2)/0.027, **y = 0.39'**

V = 1.486*(R^2/3)*(S^1/2)/n

R = ((1 + 2*0.39)*0.39)/(1+2*0.39*(1+2^2)^1/2) = 0.25

V = 1.486*(0.25^2/3)*(0.051^1/2)/0.027 = 4.93 fps

Velocity head = α(V^2)/(2*g)

α = 1.15 for channels, regular section per Section 4.4.1.2 of the 2016 KCSWDM (see following pages)

g = 32.2 ft2/s

Velocity head = 1.15(4.93^2)/(2*32.2) = **0.43'**

TABLE 4.4.1.B VALUES OF ROUGHNESS COEFFICIENT "*n*" FOR OPEN CHANNELS

Type of Channel and Description	Manning's "*n*"* (Normal)
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as #2, highest stage	0.070
of flow	0.100
4. Dense brush, high stage	
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	0.030
1. Clean, straight, full stage no	
rifts or deep pools	0.035
2. Same as #1, but more	
stones and weeds	0.040
3. Clean, winding, some pools	
and shoals	0.040
4. Same as #3, but some	
weeds	0.050
5. Same as #4, but more stones	
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Floodplains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as #2, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as #4, but with flood stage reaching branches	0.120

* *Note: These "n" values are "normal" values for use in analysis of channels. For conservative design of channel capacity, the maximum values listed in other references should be considered. For channel bank stability, the minimum values should be considered.*

and assuming $\alpha = \alpha_1 = \alpha_2$ where α is the energy coefficient that corrects for the non-uniform distribution of velocity over the channel cross section, Equations (4-10) and (4-11) can be combined and rearranged to solve for Δx as follows:

$$\Delta x = (E_2 - E_1)/(S_o - S_f) = \Delta E/(S_o - S_f) \tag{4-12}$$

Typical values of the energy coefficient α are as follows:

Channels, regular section	1.15
Natural streams	1.3
Shallow vegetated flood fringes (includes channel)	1.75

For a given flow, channel slope, Manning's "*n*," and energy coefficient α, together with a beginning water surface elevation y_2, the values of Δx may be calculated for arbitrarily chosen values of y_1. The coordinates defining the water surface profile are obtained from the cumulative sum of Δx and corresponding values of y.

The **normal flow depth**, y_n, should first be calculated from Manning's equation to establish the upper limit of the backwater effect.

Standard Step Backwater Method

The Standard Step Backwater Method is a variation of the Direct Step Backwater Method and may be used to compute backwater profiles on both prismatic and non-prismatic channels. In this method, stations are established along the channel where cross section data is known or has been determined through field survey. The computation is carried out in steps from station to station rather than throughout a given channel reach as is done in the Direct Step method. As a result, the analysis involves significantly more trial-and-error calculation in order to determine the flow depth at each station.

Computer Applications

Because of the iterative calculations involved, use of a computer to perform the analysis is recommended. The **King County Backwater (KCBW) computer program** included in the software package available with this manual includes a subroutine, **BWCHAN**, based on the Standard Step backwater method, which may be used for all channel capacity analysis. It can also be combined with the **BWPIPE** and **BWCULV** subroutines to analyze an entire drainage conveyance system. A schematic description of the nomenclature used in the **BWCHAN** subroutine is provided in Figure 4.4.1.H (p. 4-70). See the KCBW program documentation for further information.

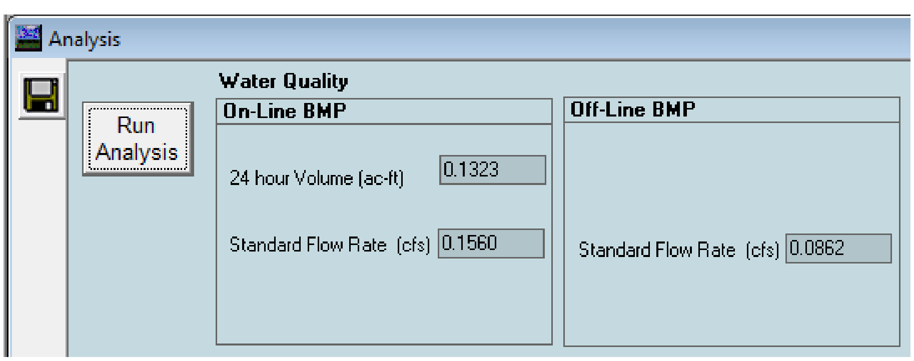
There are a number of commercial software programs for use on personal computers that use variations of the Standard Step backwater method for determining water surface profiles. The most common and widely accepted program is called HEC-RAS, published and supported by the United States Army Corps of Engineers Hydraulic Engineering Center. It is one of the models accepted by FEMA for use in performing flood hazard studies for preparing flood insurance maps.

4.2 WATER QUALITY ANALYSIS AND DESIGN

The total PGHS for the project exceeds 5,000 SF, and therefore, will provide runoff treatment via biofiltration swale and StormFilter. A portion of targeted pollution-generating impervious surface runoff from the frontage improvements on 62nd Ave SE, the tract road, and driveways serving lots 5-10 (6,039 SF) cannot be physically routed to the proposed water quality facilities. The project will utilize a treatment trade to maintain an equivalent net effect at the downstream point of compliance. The untreated target areas will be offset by existing non-targeted pollution-generating impervious surface of equivalent or larger size. Approximately 10,106 SF of non-target impervious area within the W Mercer Way right-of-way will be collected and routed to a biofiltration swale for treatment.

A Contech StormFilter is proposed to be located within the access tract onsite and is intended to treat PGHS from the tract and driveways on lots 12-14. The StormFilter will be sized based on the total area tributary to it and includes NPGHS (roof and lawn). The StormFilter using ZPG Media has GULD approval from DOE for basic treatment. Per the approval, the water quality flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model (WWMH) or other Ecology-approved continuous runoff model. The water quality flow rate (0.156 cfs). The StormFilter size and configuration will be assessed at final engineering. See below for tributary areas and WWHM flows.

STORMFILTER TRIBUTARY		
Impervious		
Lots	0.73	ac
Access Tract	0.15	ac
Total Impervious	**0.88**	**ac**
Pervious		
Lots	0.80	ac
Total Pervious (Till - Soil Group C)	**0.80**	**ac**
TOTAL STORMFILTER TRIBUTARY	**1.68**	**ac**

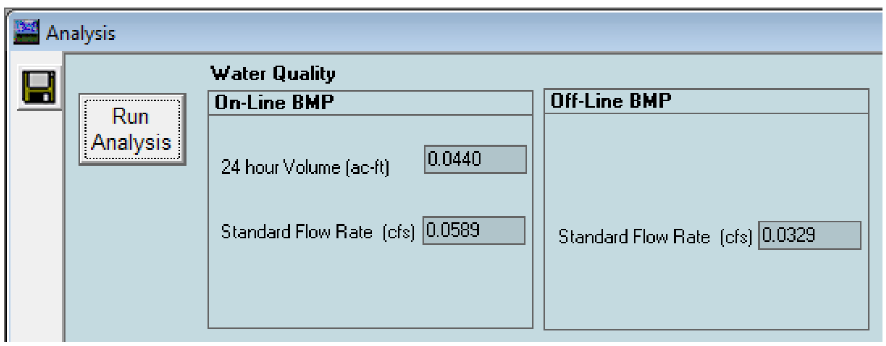


A biofiltration swale is proposed to be located along W Mercer Way and is intended to treat non-target PGHS for a treatment trade. The swale will be sized based on the total area tributary to it and includes NPGHS (frontage improvements). The calculated bottom width and length of the swale fall below the minimums required per

BMP T9.10, Chapter 9, Volume V of the DOE Manual. As such, the bottom width of the swale will be a minimum of 2 feet wide and the length of the swale will be a minimum of 100 feet long. Section See below for tributary areas, WWHM flows and calculations.

BIOFILTRATION SWALE TRIBUTARY

Pervious		
ROW	0.11	ac
Total Pervious (Till - Soil Group C)	**0.11**	**ac**
Impervious		
ROW	0.33	ac
Total Impervious	**0.33**	**ac**
TOTAL SWALE TRIBUTARY	**0.44**	**ac**



Manning's equation to solve for b: Q = 1.486*A*(R^2/3)*(S^1/2)/n

A = (b + zy)y

R = ((b + zy)y)/(b+2y*(1+z^2)^1/2)

Values for slope (0.015 min), water depth (0.33'), and manning's n (0.24) were determined based on Table 9.4.1

Proposed side slope = 3H:1V

Q = 1.486*(b + 3*0.33)*0.33 *(((b + 2*0.33)*0.33)/(b+2*0.33*(1+3^2)^1/2))^2/3*(0.015^1/2)/0.24, **b = 0.21**

****As the value for b is less than 2', the minimum bottom width will be 2'**

V = Q/A

A = (b + zy)y = (2 + 3*0.33)0.33 = 1 sf

V = 0.0589/1 = **0.0589 fps < 1fps**

L = V*t*60sec/min

A = (b + zy)y = (2 + 3*0.33)0.33 = 1 sf

L = 0.0589*9min*60sec/min **= 31.81'**

****As the value for L is less than 2', the minimum length will be 100'**

4.3 LID FEASIBILITY ANALYSIS

Projects qualifying as flow control exempt in accordance with Section 2.5.7, Volume I of the DOE Manual do not have to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List #1 or List #2. However, those projects must implement BMP T5.13; BMPs T5.10A, B, or C; and BMP T5.11or T5.12, if feasible. See below for feasibility evaluation of these BMPs.

BMP T5.13 Post-Construction Soil Quality and Depth
BMP T5.13 will be applied to landscaped areas on the project site.

BMP T5.10A Downspout Full Infiltration
Per *Figure 3. Low impact development infiltration feasibility on Mercer Island.*, the project site falls within an area where infiltrating LID facilities are not permitted. As such, this BMP will not be implemented.

BMP T5.10B Downspout Dispersion Systems
BMP T5.10B will not be implemented as the available flow path does not meet BMP design criteria.

BMP T5.10C Perforated Stub-out Connections
Per *Figure 3. Low impact development infiltration feasibility on Mercer Island.*, the project site falls within an area where infiltrating LID facilities are not permitted. As such, this BMP will not be implemented.

BMP T5.11 Concentrated Flow Dispersion
BMP T5.10B will not be implemented as the available flow path does not meet BMP design criteria.

BMP T5.12 Sheet Flow Dispersion
BMP T5.10B will not be implemented as the available flow path does not meet BMP design criteria.

4.4 CONVEYANCE SYSTEM ANALYSIS AND DESIGN

The conveyance system will be designed in accordance with the DOE Manual. Conveyance system analysis and design will be provided at final engineering.

Section 5 Stormwater Pollution Prevention Plan

Design of the SWPPP will be completed in accordance with the DOE Manual. The SWPPP will be provided with the final engineering submittal.

Section 6 Special Reports and Studies

Additional reports and studies within this section include the following:

- Geotechnical Engineering Study, dated November 29, 2018, prepared by Earth Solutions NW, LLC.

- Critical Area Reconnaissance Memorandum, dated January 18, 2019, prepared by The Watershed Company.

These reports are included on the following pages.

[INSERT Reports]

Section 7 Other Permits

No other permits are required at this time.

Section 8 Operations and Maintenance

Operations and maintenance guidelines will be included with the final engineering submittal.

Section 9 Bond Quantities

A bond quantity worksheet will be provided with the final engineering submittal, if required.