WESTERN ENGINEERS & SURVEYORS
SURVEYORS · ENGINEERS · LAND USE CONSULTANTS

9740 Evergreen Way • Everett, WA 98204

P: (425) 356-2700 F: (425) 356-2708 W: WESI.CO

TARGETED DRAINAGE REPORT

for

PROGRANITE DRAINAGE REVISION
12303 Cyrus Way
Mukilteo, WA 98275

PFN _____

ISSUE DATE: January 21, 2019
REVISION DATE:

PREPARED BY:
Eric M Haines, E.I.T.

REVIEWED BY:
JESSE A. JARRELL, P.E.

03-11-19

CLIENT
ProGranite Surfaces LLC
12303 Cyrus Way
Mukilteo, WA 98275

ENGINEER
Western Engineers & Surveyors, Inc.
Job # 15-1489-A

TABLE OF CONTENTS

Minimum Requirement # 1: Stormwater Site Plan

Executive Summary

On-site improvements consist entirely of replacing an existing piped stream located on-site along with potions located on the adjacent properties to the southeast and southwest along with portions located in the public R/W (Cyrus Way). Pipe replacement for the existing piped stream is expected to reduce the amount of overall piped stream length from approximately 612LF to about 585LF in addition to providing a larger pipe size for flow conveyance, more durable pipe material along with reducing 90 degree angles in pipe system to provide a more laminar flow. Total site disturbance estimated at approximately 5,200 sf. All disturbed surfaces are to be replaced in kind at approximately the same elevation.

No new/replaced hardscape is proposed by this project. Trenching for drainage improvements may disturb existing asphalt and gravel, but these areas will be restored with no alteration to existing grade or slope. Disturbed pervious areas will be amended per BMP T5.13. The project is to be designed to the 2012 (With 2014 Updates) WADOE Stormwater Design Manual, and 2017 City of Mukilteo Development Standard.

Existing Conditions Summary

The property is one tax parcel, containing commercial buildings, paved parking lot, and some commercial landscaping. The property is accessed via the east side of Cyrus Way, which lies to the southwest of the site. Vegetation on-site consists commercial landscaping. On-site slopes are moderate ranging from 2% to 30%. The sloping goes from the northeast to the southwest toward the Cyrus Way.

VICINITY MAP

MAP TAKEN FROM GOOGLE MAPS

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westernengineers.com

PROGRANITE
MUKILTEO, WA 98275

SCALE: 1" =~ 2350'	**DATE:** 11/07/18	**CHECKED:** JAJ
BY: EMH	**JOB NUMBER:** 15-1489-A	**FILE NAME:** 151489A/VICINITYMAP

Upstream Analysis

The topography of the surrounding area is moderately sloped. Sheet flows are expected from adjacent commercial properties on the northwest, northeast, and southeast side of the site. Runoff from the southwest of the site flows away from the site. The upstream basin to the site is approximately 28 acres, with 75% of that being impervious, 20% forested and 5% commercial landscaped. The runoff flows into a stream running into the southeast corner of the site. Upstream basins flow onsite through stream, adjacent properties to the north and east runoff sheet flow onsite directly, the property to the south flow into the stream along the south edge of the property. No other upstream flows appear to enter into the site and no sources of erosion were observed.

Downstream Analysis

A downstream analysis was provided by Eric Haines, E.I.T. of Western Engineers & Surveyors Inc., on November 8, 2018. Weather was overcast with a temperature around 40 degrees.

Runoff from the site appears to enter into the piped stream running along the southeast and southwest edges of the site. The piped stream is conveyed to the west and flows for approximately 280 feet in where it daylights and becomes an open stream, which is tributary to Picnic Point Creek. As Picnic Point Creek is the closest receiving body of water no further downstream analysis is required.

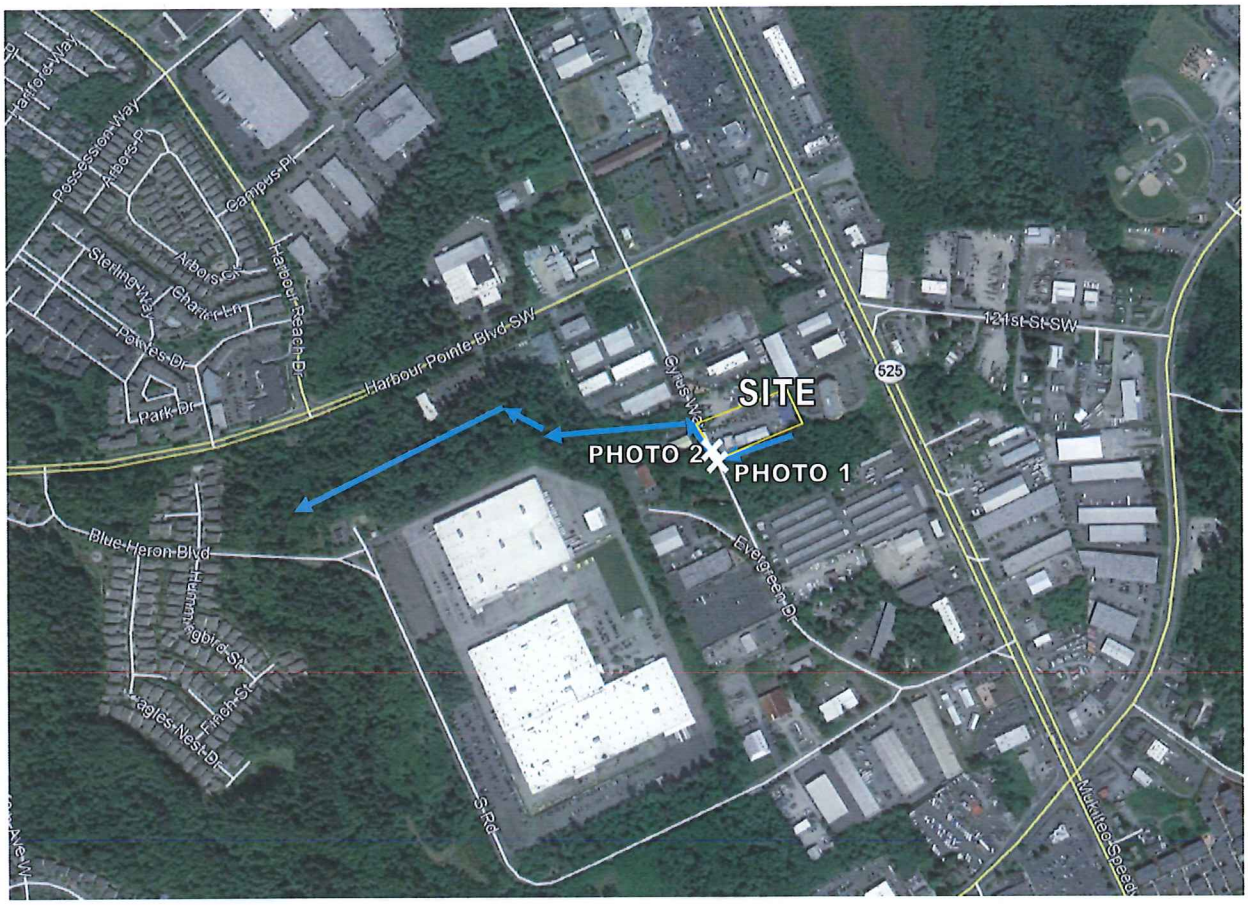
Drainage Complaints

There are no known drainage complaints for this site.

DOWNSTREAM AND AERIAL MAPS

DOWNSTREAM AND PHOTO MAP

Photo Taken from Google Earth



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PROGRANITE
MUKILTEO, WA 98275

SCALE: 1" = ~1000'	**DATE:** 11/07/18	**CHECKED:** JAJ
BY: EMH	**JOB NUMBER:** 15-1489-A	**FILE NAME:** Aerial Map

DOWNSTREAM PHOTOGRAPHS

DOWNSTREAM PHOTOGRAPHS

PHOTO 1:
Figure to the Left:
Looking easterly at the open stream in the southwest corner of the site

PHOTO 2:
Figure to the Right:
Looking north along Cyrus Way at the proposed flow

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PROGRANITE
MUKILTEO, WA 98275

SCALE: None	**DATE:** 11/07/18	**SHEET:** 1 OF 1	
BY: EMH	**JOB NUMBER:** 15-1489-A	**FILE NAME:** Downstream 1.DOC	

Minimum Requirement # 2: SWPPP Narrative

Element #1: Mark Clearing Limits

Clearing limits have been shown on the SWPPP Plan. Open streams and sensitive areas will be protected with well-marked clearing limits.

Element #2: Establish Construction Entrance

The existing concrete/asphalt drive aisle will serve as construction entrance. All vehicles shall be free of debris prior to leaving the site.

Element # 3: Control Flow Rates

Due to the limited disturbance area, flow rate during construction can likely be managed by wattles, especially for areas flowing toward open streams.

Element # 4: Install Sediment Controls

Sediment controls mainly consist of the installation of a wattle along the edge of the existing open stream area. In the southwest corner, east of the existing culvert inlet, additional wattles may need to be installed in areas adjacent to trenching if sedimentation is encounter in those areas.

Element # 5: Stabilize Soils

All soils disturbed during site grading will be stabilized by use of the most appropriate BMP method available. These consist of short-term and long-term solutions. Short-term methods consist of compaction of the soils by vibratory roller or bulldozer. Long-term methods consist of straw covering over the soils (this is in the case of the project becoming dormant for greater than 1 month). At this time no wintertime grading or construction activities will occur. During construction periods longer than 1 working week (7 days) where the soils are exposed and un-worked will use the proscribed methods in the Storm Water Management Manual for Western Washington, and City of Mukilteo 2017 Development Standard Manual to reduce sedimentation transported offsite. If winter grading is conducted, all exposed soils shall be covered within 2 days.

Element # 6: Protect Slopes

There are no steep slopes being disturbed during construction, there is no need for slope protections.

Element # 7: Protect Drain Inlets

Catch basin inlets within the project vicinity will be protected with catch basin sediment inserts. Culvert inlets are located within stream areas and will be protected with wattles lining the edge of the stream area.

Element # 8: Stabilize Channels and Outlets

Channels and drainage outlets are not expected around the proposed development area on site. If alterations to existing channels are needed, disturbed channel areas will be protected with channel liner. Existing channels or drainage outlets located within 500-feet of the property should be routinely inspected for debris that may dam and/or aid erosion.

Element # 9: Control Pollutants

All pollutants from construction vehicles will be contained and disposed of in the approved manner consistent with state environmental policies. Any vehicle maintenance will be performed by authorized mechanics using drip pans and waste containment vessels. All pollutants will be disposed offsite at approved facilities.

Element # 10: Control De-Watering

De-watering of the site is not expected. If dewatering of the site is needed, all groundwater removed shall be retained and recharged into the ground or taken offsite via water truck and disposed at an approved site, after de-watering has been finalized.

Element # 11: Maintain BMP's

All Temporary Erosion and Sedimentation Control (TESC) devices and equipment will be inspected and maintained on a weekly basis if not sooner, based on storm events contributing to runoff. When construction is complete and the site is stabilized, any existing sediment will be removed and stabilized onsite.

Element # 12: Manage the Project

A general construction manager will manage the project for or by the owners. The construction manager shall maintain all of the above items in order to minimize sediment transport and turbid water leaving the site. His job will entail continual observation of the grading operations to ensure minimal effects to adjacent properties and offsite waterways.

Element # 13: Protect On-Site Stormwater Management BMPs

Soil amendment areas will be protected from compaction where feasible. No other stormwater BMP's proposed for development.

Minimal Requirement # 3: Water Pollution Source Control

All proposed development is to consist of drainage restoration type construction. No water pollution source control is needed.

Minimum Requirement # 4: Preservation of Natural Drainage Systems and Outfalls, and provisions of off-site mitigation

The project is proposing a revision of the alignment of the existing piped stream but, the outfalls are proposed to remain the same with this development. All proposed runoff from the project area is to enter into the existing system and piped to the tributary stream downstream, which is the natural drainage point of the site.

Minimum Requirement #5 On-Site Storm Water Management

The project results in less than 5,000 square feet of new/replaced hard surfaces and must evaluate Minimum Requirements 1 through 5 and select on-site stormwater BMPs according to List 1 for each proposed hard surface. Refer to List 2 below for appropriate BMP selection or infeasibility description:

Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth in accordance with BMP T5.13 in Chapter 5 of Volume V. (To be used in disturbed vegetated areas)

No impervious surface is being added to the site. No other on-site storm water management is required.

Minimum Requirement # 6: Runoff Treatment

Due to the site proposing less than 5,000 sf. of new/replaced pollution generating impervious surfaces, and less than ¾ acres of pollution generating pervious surfaces, runoff treatment is not required.

Minimum Requirement # 7: Flow Control

Due to the site proposing no new/replaced impervious surface, less than ¾ acres of forest to lawn conversion, less than 2.5 acres of forest to pasture conversion, flow control is not required.

Minimum Requirement # 8: Wetland Protection

The wetlands will be protected according to the mitigation plans. See mitigation plan.

Minimum Requirement # 9: Operation and Maintenance

BMP T5.13 Post-Construction Soil Quality and Depth

Maintenance

- Soil quality and depth should be established toward the end of construction and once established, should be protected from compaction, such as from large machinery use, and from erosion.
- Soil should be planted and mulched after installation.
- Plant debris or its equivalent should be left on the soil surface to replenish organic matter.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Sediment & Debris	Sediment, trash, and/or other debris material is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No sediment or debris is located immediately in front of catch basin or on grate opening.
		Sediment, trash, and/or other debris material (located in the catch basin) exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No sediment or debris is in the catch basin.
		Sediment, trash, and/or other debris material located in any inlet or outlet pipe is blocking more than 1/3 of its height.	Inlet and outlet pipes are free of sediment and debris.
		Dead animals or vegetation that impair catch basin function or that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation are present within the catch basin.
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is seeping into the catch basin).	Top slab is free of holes and cracks. No water and/or soil is seeping into the catch basin
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.	Catch basin is replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	Settlement of misalignment of the catch basin causes a safety, function, or design problem.	Catch basin is replaced or repaired to design standards.
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants Note: Coordinate removal/cleanup with local and/or state water quality response agency.	Contaminants or pollutants are removed.
Access Hole Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is fully in place
	Locking Mechanism Not Working	Locking mechanism cannot be opened or lock bolts cannot be removed by one maintenance person with proper hand tools.	Mechanism or lock bolts open with proper hand tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools. Intent is keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person with proper hand tools.

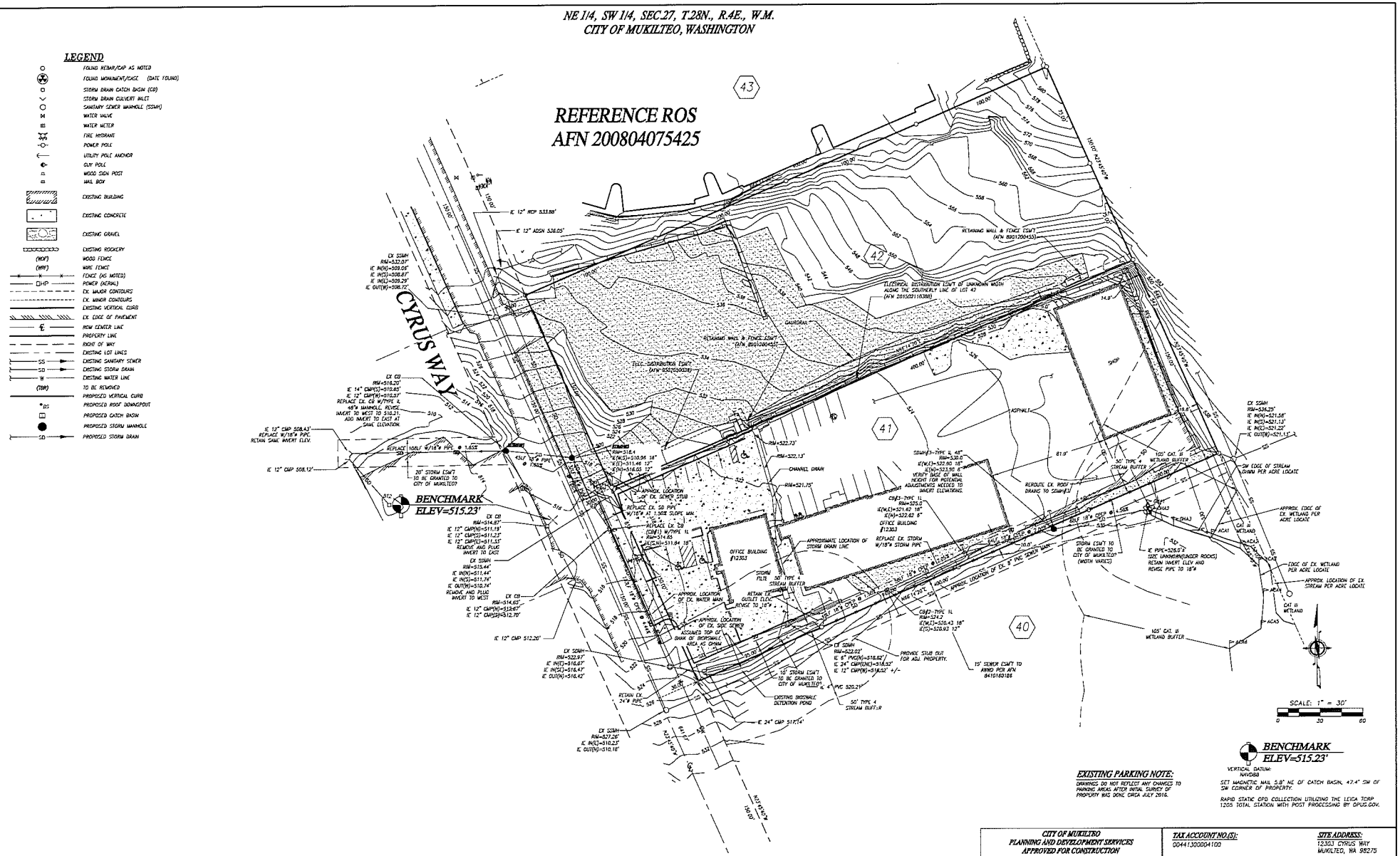
No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, cracked/broken rungs, rungs not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

APPENDIX I

Drainage Plan

NE 1/4, SW 1/4, SEC.27, T.28N., R.4E., W.M.
CITY OF MUKILTEO, WASHINGTON



CITY OF MUKILTEO
PLANNING AND DEVELOPMENT SERVICES
APPROVED FOR CONSTRUCTION

BY: _____

NAME: _____

R/W PERMIT NUMBER: _____

TAX ACCOUNT NO.(S): 00441300004100

SITE ADDRESS: 12303 CYRUS WAY MUKILTEO, WA 98275

PPR-2018-____

UTILITY CONFLICT NOTE:

CAUTION:

THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE LOCATION, DIMENSION, AND DEPTH OF ALL EXISTING UTILITIES WHETHER SHOWN ON THESE PLANS OR NOT, BY POTHOLING THE UTILITIES AND SURVEYING THE HORIZONTAL AND VERTICAL LOCATION PRIOR TO CONSTRUCTION. THIS SHALL INCLUDE CALLING UTILITY LOCATE @ 8-1-1 AND THEN POTHOLING ALL OF THE EXISTING UTILITIES AT LOCATIONS OF NEW UTILITY CROSSINGS TO PHYSICALLY VERIFY WHETHER OR NOT CONFLICTS EXIST. LOCATIONS OF SAID UTILITIES AS SHOWN ON THESE PLANS ARE BASED UPON THE UNVERIFIED PUBLIC INFORMATION AND ARE SUBJECT TO VARIATION. IF CONFLICTS SHOULD OCCUR, THE CONTRACTOR SHALL CONSULT WESTERN ENGINEERS & SURVEYORS, INC. TO RESOLVE ALL PHYSICAL CONFLICTS PRIOR TO PROCEEDING WITH CONSTRUCTION.

CALL TWO (2) BUSINESS DAYS BEFORE YOU DIG 1-800-424-5555

JESSE A. JARRELL — STATE OF WASHINGTON — 15849 — REGISTERED PROFESSIONAL ENGINEER

Western Engineers & Surveyors (425) 356-2700
SURVEYORS • PLANNERS • ENGINEERS
LAND USE CONSULTANTS
CIVIL ENGINEERS • LAND SURVEYORS
*** 9740 EVERGREEN WAY * EVERETT * WA * 98204 ***

PRELIMINARY DRAINAGE PLAN FOR:
PROGRANITE DRAINAGE REVISION
SE 1/4, NW 1/4, SEC. 27, TWP.28N., RGE.04E., W.M.
CITY OF MUKILTEO, WASHINGTON

DRAWN BY	DATE	REV. BY	DATE	PROJECT MANAGER	SCALE
JAJ	05/07/18			J. JARRELL	1"=30'
DRAWING FILE NAME		CHK. BY	F.B. NO.	JOB NO.	SHT. NO.
151489ABASC.DWG			–	15-1489-A	2 OF 3

APPENDIX II

SOIL INFORMATION


Search
Map Unit Legend
Snohomish County Area, Washington (WA661)
Snohomish County Area, Washington (WA661)
Map Unit Symbol
Map Unit Name
Acres in AOI
Percent of AOI
19
Everett very gravelly sandy loam, 15 to 30 percent slopes
1.6
100.0%
Totals for Area of Interest
1.6
100.0%
Soil Map
Scale


N

19—Everett very gravelly sandy loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2t62c
Elevation: 30 to 900 feet
Mean annual precipitation: 35 to 91 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Everett and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Everett

Setting

Landform: Kames, eskers, moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy and gravelly glacial outwash

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 3 inches: very gravelly sandy loam
Bw - 3 to 24 inches: very gravelly sandy loam
C1 - 24 to 35 inches: very gravelly loamy sand
C2 - 35 to 60 inches: extremely cobbly coarse sand

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Forage suitability group: Droughty Soils (G002XS401WA), Droughty Soils (G002XN402WA)
Hydric soil rating: No

Minor Components

Alderwood

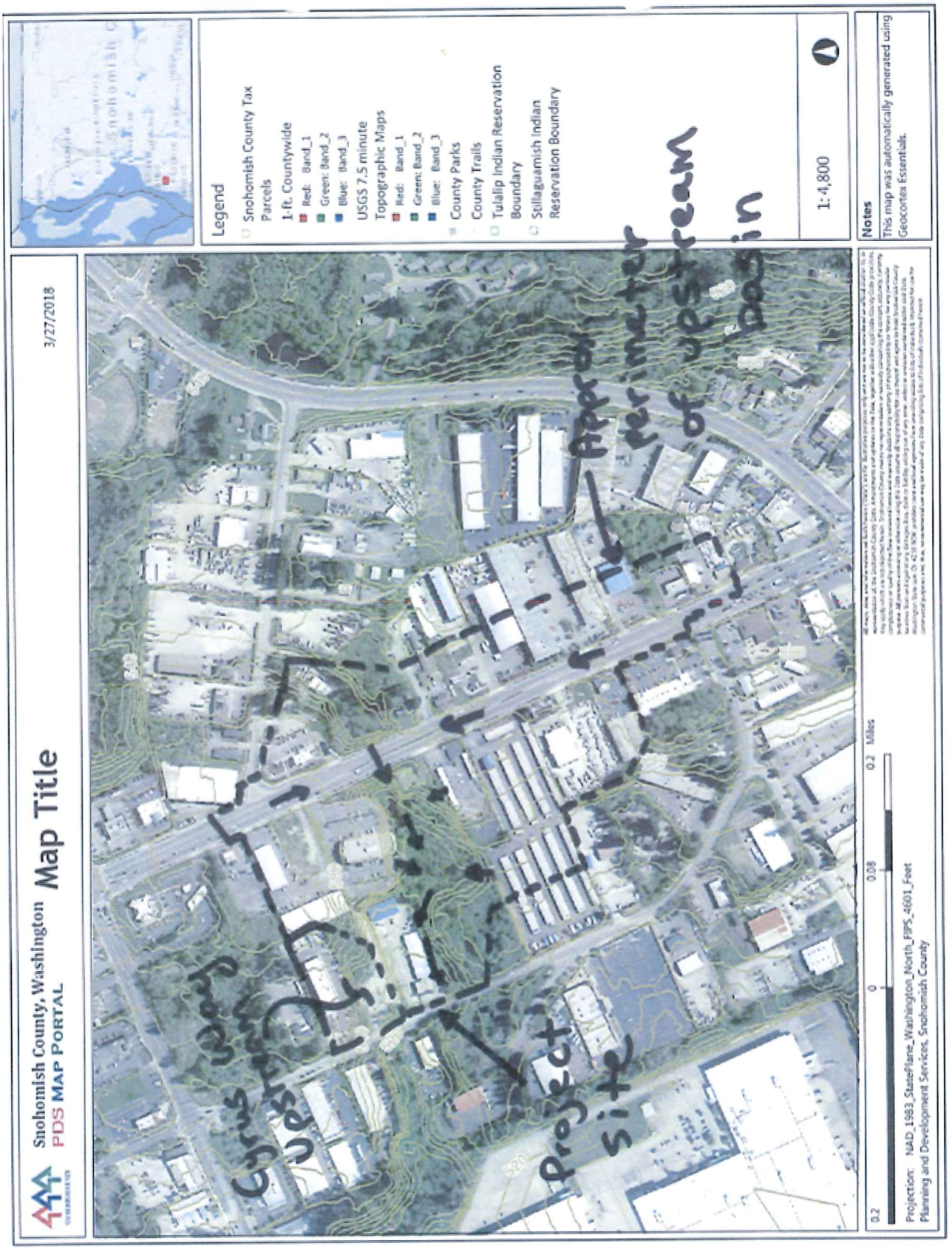
Percent of map unit: 10 percent
Landform: Ridges, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, nose slope, talf
Down-slope shape: Linear, convex
Across-slope shape: Convex
Hydric soil rating: No

Indianola

Percent of map unit: 10 percent
Landform: Eskers, kames, terraces
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

APPENDIX III

BASIN AND PIPE CONVEYANCE CALCULATIONS


Snohomish County, Washington
PDS MAP PORTAL
Map Title
3/27/2018
Legend
Snohomish County Tax Parcels
1-ft. Countywide
Red: Band_1
Green: Band_2
Blue: Band_3
USGS 7.5 minute Topographic Maps
Red: Band_1
Green: Band_2
Blue: Band_3
County Parks
County Trails
Tulalip Indian Reservation Boundary
Stillaguamish Indian Reservation Boundary
1: 4,800
Notes
This map was automatically generated using Geocortex Essentials.
Projection: NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet
Planning and Development Services, Snohomish County
0.2
0
0.2 Miles
Project site
Approximate perimeter of western basin

NW Upstream Basin Runoff Estimate

Rational Method equation: $Q_{100} = CI_{100}A$

Q_{100} = 100-year flow rate; C = estimated runoff coefficient ;
I_{100} = peak rainfall intensity for 100-year return frequency ; A = drainage sub-basin area (acres)

Calculate Basin Area "A1"

Basin Total Upstream Area: 28 Ac.

Basin Impervious Area: 21.0 Ac. (A_1) – Assumed 75% basin coverage
Basin Lawn/Landscape Area: 1.4 Ac. (A_2) – Assumed 5% coverage
Basin Forest Area: 5.6 Ac. (A_3) – Assumed 20% coverage

Calculate "C" Value

$C_C = C_1A_1 + C_2A_2 + C_3A_3$

C_1 = 0.90 (Pavement)
C_2 = 0.25 (Lawn)
C_3 = 0.15 (Light Forest)

$C_C = [(21*0.90) + (1.40*0.25) + (5.6*0.15)] / (28) =$ **0.7175**

Calculate Time of Concentration "T_C"

$T_C = T_1 + T_2 + T_3 + \ldots T_n$; travel time across consecutive flow path segments

$T_t = L / (60* k_R \sqrt{(s_O)})$

T_t = travel time across a given segment ; L = distance of flow across a given segment ;
k_R = time of concentration velocity factor from Table 3.2.1.C of the KCSWDM ;
s_O = slope of flow path

$T_1 = 1000' / (60*2.5*\sqrt{(0.02)}) = 47.1$ minutes (forest flow path)
$T_2 = 1400' / (60*20*\sqrt{(0.02)}) = 8.2$ minutes (paved flow path)

$T_C = 47.1 + 8.2 =$ **55.3 minutes**

Calculate Peak Rainfall Intensity "I_{100}"

$I_{100} = (P_{100})(i_{100})$;

I_{100} = peak rainfall intensity for a 100-year return frequency;
P_{100} = 24-hour precipitation for a 100-year rainfall event;
i_{100} = unit peak rainfall intensity factor for a 100-year return frequency

$i_{100} = (a_{100})(T_C)^{(-b_{100})}$; a_{100} , b_{100} = coefficients from Table 3.2.1.B of the KCSWDM ;
T_C = total time of concentration

a_{100} = 2.61 (from table)
b_{100} = 0.63 (from table)
T_C = 55.3 minutes

Therefore, i_{100} = 2.61*(55.3^-0.63) = **0.208**

P_{100} = 3.1 (from Isopluvial Map for 100-year event)

Therefore, I_{100} = (3.1)*(0.208) = **0.645 inches per hour**

Calculate Off-Site Basin A1 Peak Flow "Q_{100}"

$Q_{100} = CI_{100}A$

Q_{100} = 0.7175 *0.645 in/ hr * 28 acres = **12.97 cfs**

Check minimum pipe size necessary to convey calculated basin flow:

Using Manning's Equation: Q = (1.49/n)*A*(R^(2/3))* √(S)

Where;

Q = Flow Rate (cfs) ; A = Flow Area ; n = roughness coefficient ;
R = Hydraulic Radius ; S = Pipe Slope

Assume a 24" diameter interior corrugated metal pipe with a 0.85% slope flowing at 94% full:

A = 3.14 ft^2
n = 0.022
R = 0.579 ft
S = 0.0085 ft/ft

Q = (1.49/0.022)*3.14*(0.579^(2/3))* √(0.0085) = **13.25 cfs**

13.25 cfs > 12.97 cfs

Q > Q_{100}; therefore a 24" diameter interior corrugated pipe sloped at 0.85% should have the capacity to convey the 100 year storm for the Upstream Basin.

Or

Assume a 18" diameter interior corrugated metal pipe with a 4.00% slope flowing at 94% full:

A = 3.14 ft^2
n = 0.022
R = 0.579 ft
S = 0.040 ft/ft

Q = (1.49/0.022)*3.14*(0.579^(2/3))* √(0.040) = **13.35 cfs**

12.98 cfs > 12.97 cfs

Q > Q_{100}; therefore a 18" diameter interior corrugated pipe sloped at 4.00% should have the capacity to convey the 100 year storm for the Upstream Basin.

Or

Assume a 18" diameter smooth interior plastic pipe with a 1.15% slope flowing at 94% full:

$A = 3.14\ ft^2$
$n = 0.012$
$R = 0.579$ ft
$S = 0.0115$ ft/ft

$Q = (1.49/0.012)*3.14*(0.579^{(2/3)})* \sqrt{(0.0115)} =$ **13.13 cfs**

13.13 cfs > 12.97 cfs

$Q > Q_{100}$; therefore a 18" diameter pipe sloped at 1.15% should have the capacity to convey the 100 year storm for the Upstream Basin.

NE Upstream Basin Runoff Estimate (Connects to site runoff W of site)

Rational Method equation: $Q_{100} = CI_{100}A$

Q_{100} = 100-year flow rate; C = estimated runoff coefficient ;
I_{100} = peak rainfall intensity for 100-year return frequency ; A = drainage sub-basin area (acres)

Calculate Basin Area "A1"

Basin Total Upstream Area: 3.0 Ac.

Basin Impervious Area: 1.0 Ac. (A_1)
Basin Lawn/Landscape Area: 2.0 Ac. (A_2)

Note parcel number 00441300004300 was constructed circa 2009 and is assumed to have a detention facility designed to control runoff for a forested condition. For design purposes, a developed lawn condition has been used for runoff from this parcel.

Calculate "C" Value

$C_C = C_1A_1 + C_2A_2 + C_3A_3$

$C_1 = 0.90$ (Pavement)
$C_2 = 0.25$ (Lawn)
$C_3 = 0.15$ (Light Forest)

$C_C = [(1*0.90) + (2.0*0.25) + (0)] / (3) =$ **0.466**

Calculate Time of Concentration "T_C"

$T_C = T_1 + T_2 + T_3 + \ldots T_n$; travel time across consecutive flow path segments

$T_t = L / (60* k_R \sqrt{(s_O)})$

T_t = travel time across a given segment ; L = distance of flow across a given segment ;
k_R = time of concentration velocity factor from Table 3.2.1.C of the KCSWDM ;
s_O = slope of flow path

For design purposes, a minimum of 8 minutes has been assumed for Tc

Calculate Peak Rainfall Intensity "I_{100}"

$I_{100} = (P_{100})(i_{100})$;

I_{100} = peak rainfall intensity for a 100-year return frequency;
P_{100} = 24-hour precipitation for a 100-year rainfall event;
i_{100} = unit peak rainfall intensity factor for a 100-year return frequency

$i_{100} = (a_{100})(T_C)^{(-b_{100})}$; a_{100} , b_{100} = coefficients from Table 3.2.1.B of the KCSWDM ;
T_C = total time of concentration

a_{100} = 2.61 (from table)
b_{100} = 0.63 (from table)
T_C = 6.30 minutes

Therefore, i_{100} = 2.61*(55.3^-0.63) = **0.208**

P_{100} = 3.1 (from Isopluvial Map for 100-year event)

Therefore, I_{100} = (3.1)*(0.208) = **0.645 inches per hour**

Calculate Off-Site Basin A1 Peak Flow "Q_{100}"

$Q_{100} = CI_{100}A$

Q_{100} = 0.466 *0.645 in/ hr * 3 acres = **0.90 cfs**

Total combined Upstream flows in Cyrus Way near NW corner of site:

⇨ **12.97 cfs. + 0.90 cfs. = 13.87 cfs.**

Check minimum pipe size necessary to convey calculated combined upstream basin flows:

Using Manning's Equation: Q = (1.49/n)*A*(R^(2/3))* √(S)

Where;

Q = Flow Rate (cfs) ; A = Flow Area ; n = roughness coefficient ;
R = Hydraulic Radius ; S = Pipe Slope

Assume a 18" diameter smooth interior plastic pipe with a 1.3% slope flowing at 94% full:

A = 3.14 ft^2
n = 0.012
R = 0.579 ft
S = 0.0130 ft/ft

Q = (1.49/0.012)*3.14*(0.579^(2/3))* √(0.0130) = **13.96 cfs**

13.96 cfs > 13.87 cfs

Q > Q_{100}; therefore a 18" diameter pipe sloped at 1.30% should have the capacity to convey the 100 year storm for the combined Upstream Basin located westerly of the site.

Rainfall Data

Table of rainfall depths for 24-hour in Snohomish County (continued)

Sec/	2 yr	5 yr	10 yr	25 yr	50 yr	100
27-28-4 S. Paine Field & Muk.Spd.	1.4	1.8	2.1	2.6	3.0	3.1
28-31-5 Smokey Point	1.8	2.3	2.6	3.1	3.3	3.7
29-30-5 Quilceda Crk & Tulalip Rd	1.7	2.0	2.3	2.7	2.9	3.2
30-28-5 McCollum Park	1.6	2.0	2.3	2.8	3.1	3.5
32-31-5 BN RR & Fire Trail Rd	1.7	2.2	2.4	3.0	3.2	3.5
33-31-5 152nd & Smokey Pnt	1.8	2.2	2.4	2.8	3.0	3.4
34-27-5	1.8	2.2	2.6	3.0	3.3	3.7
34-28-4 SE Cor. Lk Serene	1.5	1.9	2.1	2.6	3.0	3.3
35-28-4 Lk Stickney	1.5	1.9	2.2	2.6	3.0	3.2

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HawsEDC Calculators Hydraulics Language

Manning Formula Uniform Pipe Flow at Given Slope and Depth

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Check out our newest spreadsheet update: Download Spreadsheet Open Google Sheets version View All Spreadsheets
--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Printable Title

Printable Subtitle

Set units: m mm ft in

Pipe diameter, d_0	1.5	ft
Manning roughness, n ?	.012	
Pressure slope (possibly ? equal to pipe slope), S_0	1.3	% rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	.94	fraction

Results

Flow, Q	13.9558	cfs
Velocity, v	8.0958	ft/sec
Velocity head, h_v	1.0186	ft
Flow area	1.7239	ft^2
Wetted perimeter	3.9700	ft
Hydraulic radius	0.4342	ft
Top width, T	0.7125	ft
Froude number, F	0.92	
Shear stress (tractive force), tau	0.3525	psf