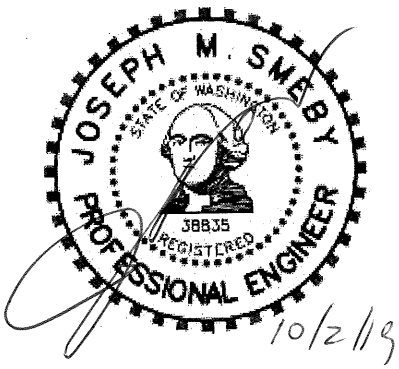
Received 10/31/2019

Drainage Report
Stanton Station
PFN: M2019-

for

Rick Hansen
P.O. Box 2289
Snohomish, WA 98291

SITE LOCATION:
XXXX 149th St SE
Monroe, WA 98272



Prepared by:
Rachel A. Weinberg, P.E

Checked by:
Joseph M. Smeby, P.E.

Job No: 19-0702
September 2019

TABLE OF CONTENTS

ITEM **PAGE**

LIST OF FIGURES

1. INTRODUCTION

This document is intended to provide engineering information necessary to support the preliminary plat application to the City of Monroe for a 22-unit townhome project proposed on this site located at the corner of 149th St SE and 179th Ave SE, refer to Figure 1 for a vicinity map. The site covers 0.90 acres, all of which is proposed to be disturbed as a result of this project. The site will take access from the existing road to the north (149th St SE) via a new private access road.

This project proposes to construct a new private access road off of 149th St SE. Some work within 179th Ace SE right-of-way will also be required to extend sewer and water services onto this property. This project will require the construction of driveways for each future townhome, stormwater facilities and other utilities.

This project proposes to construct more than 10,000 sf of new plus replaced impervious surfaces including private road, driveways and future townhomes. Therefore, Minimum requirements 1-9 apply to all of the new and replaced impervious surfaces for this project along with all the disturbed pervious surfaces. The drainage design has been laid out per the 2012 DOE Stormwater Management Manual for Western Washington. Runoff from the proposed impervious surfaces, as well as pervious lawn, will be infiltrated on-site. Water quality will be met using a soil treatment layer in the bottom of the infiltration trenches.

A geotechnical evaluation has been prepared by Nelson Geotechnical Associates. The existing on-site soils were found to be native alluvial material at a depth of approximately 2 feet below grade. Groundwater was encountered at approximately 8 feet below grade. Refer to the geotechnical report prepared by Nelson Geotechnical Associates, Inc.

2. DRAINAGE INFORMATION SUMMARY FORM

Project: **Stanton Station**
PFN: **M2019-**
Engineer: **Omega Engineering, Inc.**
2707 Wetmore Ave
Everett, WA 98201
Attention: Joseph Smeby, P.E.

Total site area: **0.90 acres**
Offsite area: **0.00 acres**
Disturbed area: **0.90 acres**

Applicant: **Hanson Homes**
P.O. Box 2289
Snohomish, WA 98291

Number of lots/units: **22**

Drainage Basin Information	**East Basin**
On-site Developed Area	0.90 acres
Off-site Improved Area	0.00 acres
Types of storage proposed	Infiltration Trenches
Approximate total storage volume	Varies
Soil Types	Type A/B
Basin Data	
Pre-developed run-off rates: 2-year	0.001 cfs
50-year	0.007 cfs
100-year	0.010 cfs
Post-developed run-off rates: 2-year	0.00 cfs
50-year	0.00 cfs
100-year	0.00 cfs

3. EXISTING SITE CONDITIONS

The site is located at the corner of 149th St SE and 179th Ave SE and will take access from 149th St SE, to the north. The project is located in Section 2, Township 27N, Range 6E, Willamette Meridian. See Figure 1 - Vicinity Map. The gross site area is approximately 0.90 acres.

Land use around the site is single-family residential directly to the south and west and commercial directly to the north and east. This site is currently vacant covered in lawn. Frontage improvements are existing and consist of curb, gutter and sidewalk along the north and east property boundaries within the right-of-way of 149th St SE and 179th Ave SE.

The existing site is irregular in shape approximately 159-feet long running north-south and 240-feet running east-west. The grades on the site are flat and average approximately 1% down to the northwest. The vegetation found on the existing property is a grass/lawn.

Grades on the site generally run from southeast to northwest. Per the geotechnical report prepared by Nelson Geotechnical Associates, the on-site soils were found to be highly permeable, consisting of native alluvial, gravelly sand. Groundwater was found at a depth of approximately 8 feet below grade. The project geotechnical engineer performed an on-site infiltration test and grain-size analyses to determine a design infiltration rate of 10 inches/hour. Please refer to the attached geotechnical report in Appendix C for further discussion of the existing on-site soils.

4. DEVELOPED SITE CONDITIONS

This development proposes to create 4 new buildings totaling 22-units for this project, along with a new private road and driveways. The runoff from the new impervious surfaces will be 100% infiltrated on-site. The infiltration systems will be designed to mitigate for all of the future impervious surfaces and landscaping proposed for this project via multiple infiltration trenches. The systems have been sized to meet the 2012 DOE stormwater flow control and water quality standards.

The new on-site access, parking, roof and landscaping areas will be collected in the on-site conveyance system and directed to multiple infiltration trenches spread around the site. The storm drainage system for this project has been designed to collect, treat and fully infiltrate all of the new landscaping and impervious areas on this site. Therefore, the proposed improvements will not increase the peak flow rates or durations in the developed conditions compared to the predeveloped conditions.

Based on the recommendations of the project geotechnical engineer and report, the proposed infiltration system has been designed with a long-term, design infiltration rate of 10 inches/hour and the bottom of the trenches will extend a minimum of 2-2.7 feet into the native, alluvial soils. Please refer to the attached geotechnical report in Appendix C for further discussion of the existing on-site soils. The infiltration and water quality system has been designed using the WWHM2012 software which meets the City standards.

A. DOE MINIMUM REQUIREMENTS

MINIMUM REQUIREMENT #1: PREPARATION OF STORMWATER SITE PLANS

This project proposes to construct new impervious surfaces in excess of the minimum threshold so a final storm water site plan is being prepared with the full engineering plans for this project.

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

A SWPPP narrative is required for this project and is provided in Section 5 of this r

MINIMUM REQUIREMENT #3: SOURCE CONTROL OF POLLUTANTS

The improvements proposed on this site will create 4 buildings with 22-units and new private access road and driveways. Residential townhomes do not require additional source control BMPS, but basic water quality is proposed on this site.

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

The runoff generated from the finished project will be fully infiltrated up to the 100-year storm event, therefore no downstream system is expected to be negatively affected.

MINIMUM REQUIREMENT #5: ON-SITE STORMWATER MANAGEMENT

Runoff from the new private access, driveways, roofs and landscaping will be collected in CBs or yard drains and conveyed to infiltration trenches spread around the site.

MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

A soil treatment layer will be provided in the bottom of all infiltration trenches receiving runoff from PGHS. This design meets the basic water quality treatment requirement for residential projects.

MINIMUM REQUIREMENT #7: FLOW CONTROL

The design and analysis for this project requires the construction of an infiltration system which was sized using the WWHM2012 software to fully infiltrate runoff up to the 100-year storm event.

MINIMUM REQUIREMENT #8: WETLAND PROTECTION

Full infiltration will recharge the groundwater and protect any downstream critical areas.

MINIMUM REQUIREMENT #9: BASIN/WATERSHED PLANNING

The scope of this project is too small to justify a Watershed Plan.

MINIMUM REQUIREMENT #10: OPERATION AND MAINTENANCE

A complete O&M manual will be provided with the full drainage report.

5. SWPPP NARRATIVE

The intent of this section is to provide the information necessary to support the engineering plans in order to implement a design that will; reduce, eliminate or prevent the discharge of stormwater pollutants, meet or exceed the water quality and sediment management standards for the City and State, and prevent adverse impacts to the receiving waters for this project. Note; this narrative is intended to support the SWPPP that is included with the Drainage Plans also a part of this submittal package to the City.

A. SITE GRADING/EROSION CONTROL RISK ASSESSMENT

Area proposed to be cleared/worked:	0.90 acres
Average slope for the site:	1%
Erosion Hazard of Soil	Low
Critical Areas downslope	No
Site is upstream of an ESA Stream	No

Based on the above information and the fact that the area of the site to be disturbed is flat and construction site runoff will pass through silt fencing or other perimeter filtration features prior to leaving the site, and that if site conditions warrant, additional BMP's can be implemented as corrective measures the Risk Category for this site is **Low Risk.**

B. SWPPP MINIMUM ELEMENTS

1: Mark Clearing Limits
One of the first steps in the "Construction Sequence" included on the clearing and grading plan sheets is for a surveyor to stake the limits of clearing and to have construction or silt fencing placed along the limits prior to any other construction activity.

2: Establish Construction Access
The SWPPP calls for the proposed construction entrance to be installed as the second step after the staking of clearing limits. A detail is provided on the plans.

3: Control Flow Rates
This project is below the thresholds requiring flow control for the project.

4: Install Sediment Controls
This site and SWPPP proposes to construct a construction entrance to collect and contain the sediment on this site. In addition, inlet filters will be installed in the existing catch basins adjacent to the site. and check dams will be installed in the on-site interceptor swales. The proposed on-site CBs will be installed with inlet filters but the outlet pipes connecting to infiltration trenches will be plugged until the site has been stabilized and the conveyance system flushed and cleaned. These features are intended to minimize the opportunity for sediment to leave the site via stormwater or on vehicles. The construction of these features is one of the first items required in the "Construction Sequence".

5: Stabilize Soils
The "Construction Sequence" and "TESC Notes" call for the stabilization of soils that remain unworked for certain lengths of time based on the time of year. Stabilization techniques may include but not limited to mulching, plastic sheeting or hydroseeding, notes have been added to the plan regarding protection for the stock pile area if necessary.

6: Protect Slopes
No slopes are expected on this site; however, any stockpile area will be protected as noted above.

7: Protect Drain Inlets
All existing & proposed catch basins and area drains will have inlet filters installed to protect the conveyance system.

8: Stabilize Channels and Outlets
No new channels or outlets are proposed for this site.

9: Control Pollutants
No outside chemicals are expected to be necessary for the construction of this project. All vehicles working on and around the site would need to meet the State requirements for emissions.

10: Control DeWatering
Dewatering is not expected for this project. However, any runoff will be infiltrated on-site. The contractor shall monitor the temporary system to ensure no erosion or excessive sedimentation occurs in the disposal areas.

11: Maintain BMPs
The construction supervisor will be responsible for maintaining all BMPs during construction and working with the City to relocate or add BMPs as necessary as site conditions change.

12: Manage the Project
It will be the responsibility of the Contractor and Developer to manage this project and coordinate with the City Inspector and Engineer.

Inspection and Monitoring:
Site inspections shall be done by a person who is knowledgeable in the principles and practices of erosion and sediment control. The person must have skills to first assess the site conditions and construction activities that could impact the quality of stormwater, and second assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

Maintaining an Updated Construction SWPPP:
The construction SWPPP shall be retained on-site or within reasonable access to the site. The SWPPP shall be modified whenever there is a change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state. The SWPPP shall be modified if, during inspections or investigations conducted by the owner/operator, or the applicable local or state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. The SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct problems identified. Revisions to the SWPPP shall be completed within seven days following inspection.

6. OFFSITE ANALYSIS AND MITIGATION

The development is expected to add an assumed 36,535 sf (0.83 ac) of impervious surfaces for driveways, roofs and roads. In the developed conditions, it was assumed that each lot will be covered with the maximum impervious surfaces with an assumed 400 sf of driveway per lot.

As previously mentioned, the runoff from the new impervious and pervious surfaces will be collected and infiltrated via multiple infiltration trenches. The proposed infiltration systems have been sized using the WWHM12 software and shown to fully infiltrate up to the 100-year event. Refer to Section 8 of this report for more details.

A. UPSTREAM ANALYSIS

During the site visit it was observed that there was no off-site area that drained toward the proposed project area. It was clear that all off-site flows will pass through or around this site and remain that way after construction. Based on the location of the proposed improvements the existing runoff from the upstream area will continue to flow unaffected around this site after the project has been constructed.

B. DOWNSTREAM ANALYSIS

The project site is very flat. Due to the highly permeable soils on-site, runoff appears to naturally infiltrate on-site. However, based on the on-site grades if runoff did leave the site, it would flow in the northwesterly direction over the north property line and be collected by the existing storm drainage system located within 149th St SE. The conveyance system consists of catch basins and pipes and appears to direct runoff to the west within the right-of-way.

Based on the fact that all of the new NPGIS and PGIS runoff will be 100% infiltrated on-site and the total net new effective impervious will actually be less than in the existing condition, the developed flows are expected to be less than in the existing conditions.

8. FLOW CONTROL

Current City code requires this site be analyzed using the 2012 DOE manual and the WWHM12 hydrology software. Since this site proposes using infiltration the software will be used to size the infiltration systems.

Since this site proposes using multiple infiltration systems to fully infiltrate the runoff from the developed site infiltration trenches have been sized to accommodate the developed conditions for this project up to the 100-year condition. The project Geotechnical engineer performed multiple soil logs and two sieve analyses in order to determine the long-term infiltration rate. The recommended long-term, design infiltration rate was found to be 10 inches/hour, per the geotechnical report. See Appendix C. The trenches were sized using thee WWHM12 and the recommended long-term infiltration rate.

Refer to appendix 'A' for the full output from the WWHM2012 software. Additional details may be provided in the full drainage report for construction review.

9. WATER QUALITY DESIGN

Water quality for this project will be provided in the form of a soil treatment layer in the bottom of any infiltration trench receiving runoff from PGHS. This meets the basic water quality requirements.

10. CONVEYANCE CALCULATIONS

All of the proposed pipes designed for this project will receive much less than 2.5 cfs peak flows from the 100-year storm event. These pipes are designed as 12" pipes (S=0.5%, min.) with a peak flowing full capacity of over 2.7 cfs and therefore more than adequate capacity to handle the expected flows.

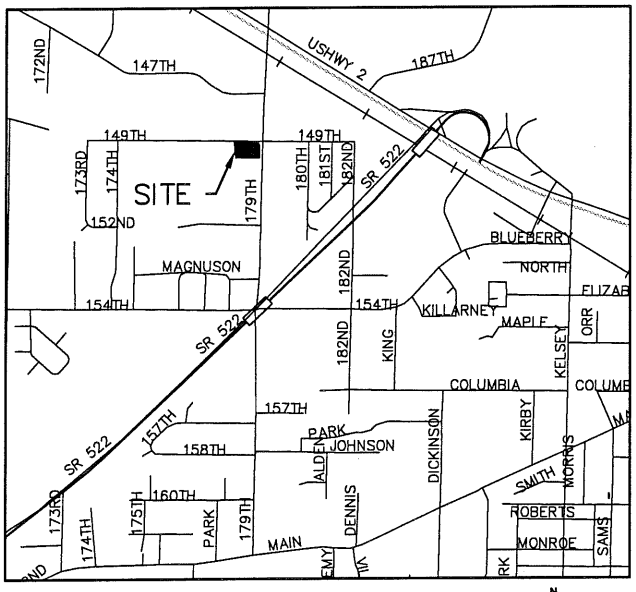
Therefore, all pipes designed for this project have more capacity then required based on the expected flow to each leg of the pipe system.

11. OPERATIONS AND MAINTENANCE MANUAL

The Property Owners and HOA will be responsible for maintaining the stormwater and landscaping facilities within this development. Included in this manual are checklists for each feature specific to this project. Copies should be made of the checklists as necessary during routine inspections and required maintenance. Specific problems can be recorded along with the appropriate action taken.

Routine inspections and maintenance will improve the long-term performance of the stormwater facilities. If at any time you are unsure if a problem exists or how to address a specific problem, contact a Professional Engineer.

Refer to Appendix B for a list of each facility to be maintained and the appropriate maintenance checklist.



VICINITY MAP

SCALE 1" = 2000'

FIG. 1

OMEGA
ENGINEERING, INC.
2707 WETMORE AVE.
Everett, WA 98201
(o)425.387.3820 (f) 425.259.1958

VICINITY MAP
STANTON STATION

DATE	JOB NO.	SCALE	SHEET
7/17/19	19-0702	1" = 2000'	1 OF 1

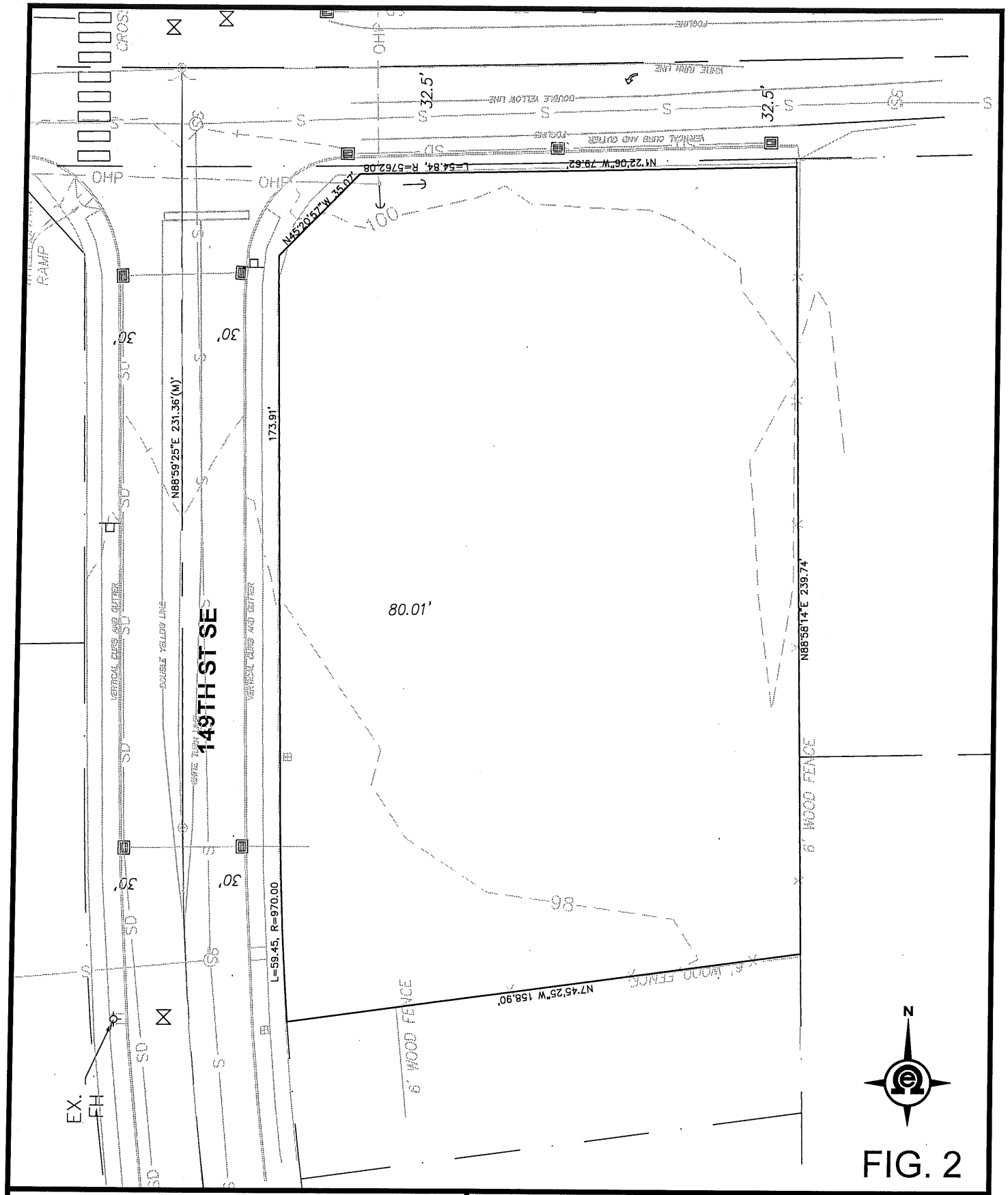


FIG. 2

OMEGA
ENGINEERING, INC.
2707 WETMORE AVE.
Everett, WA 98201
(o)425.387.3820 (f) 425.259.1958

EXISTING BASIN MAP
STANTON STATION

DATE	JOB NO.	SCALE	SHEET
7/17/19	19-0702	1" = 40'	1 OF 1

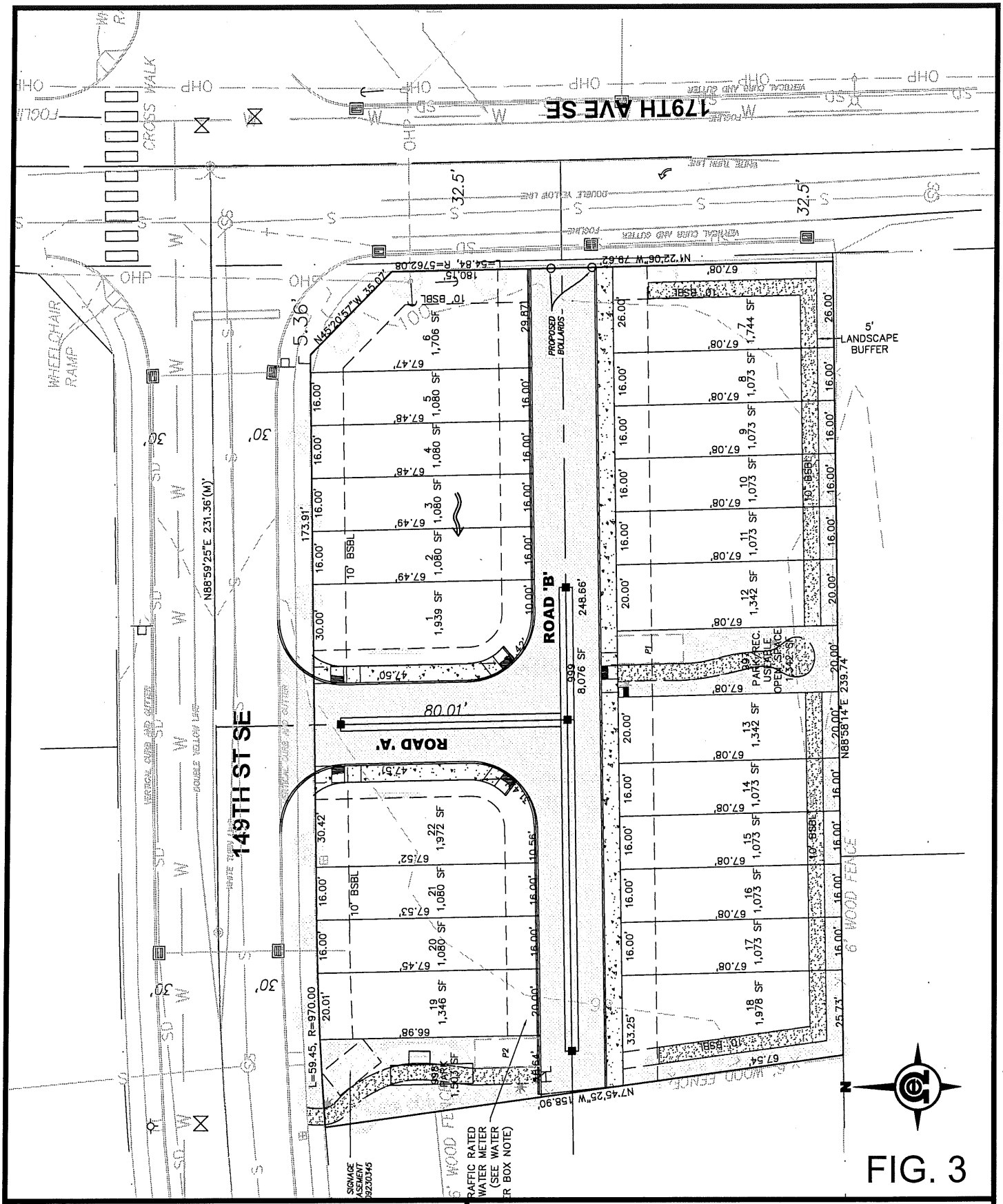


FIG. 3

OMEGA
ENGINEERING, INC.

2707 WETMORE AVE.
Everett, WA 98201
(o)425.387.3820 (f) 425.259.1958

DEVELOPED BASIN MAP
STANTON STATION

DATE	JOB NO.	SCALE	SHEET
7/17/19	19-0702	1" = 40'	1 OF 1

Soil Map—Snohomish County Area, Washington
(Stanton Station)

Sultan silt loam

Fig. 4

Map Scale: 1:547 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 5 10 20 30

Feet
0 25 50 100 150

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

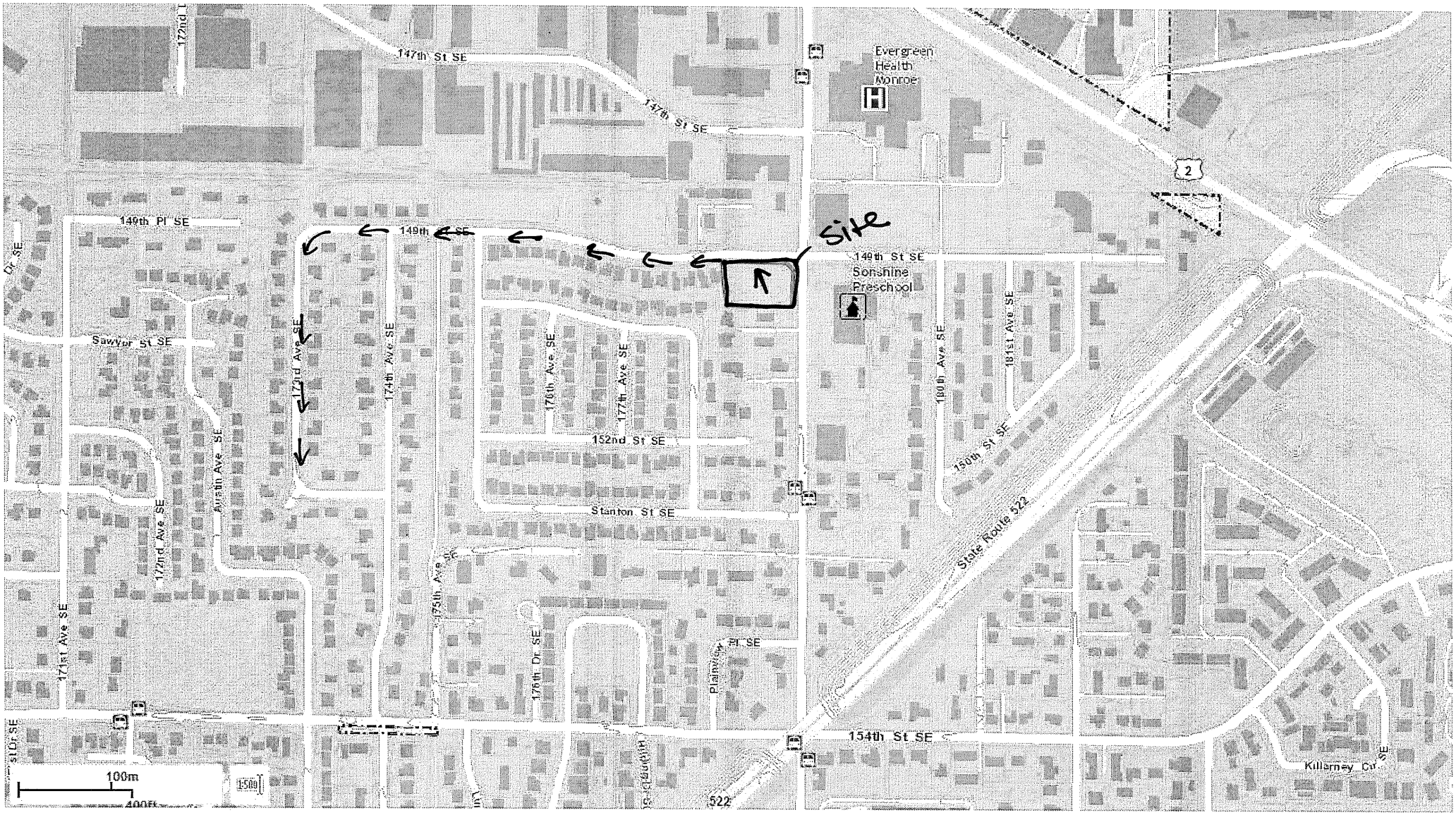

147th St SE
Evergreen Health Monroe
2
149th Pl SE
149th St SE
Site
149th St SE
Sonshine Preschool
Sawyer St SE
172nd Ave SE
174th Ave SE
176th Ave SE
177th Ave SE
180th Ave SE
181st Ave SE
152nd St SE
150th St SE
Stanton St SE
State Route 522
172nd Ave SE
173rd Ave SE
175th Ave SE
176th Dr SE
Plainview Pl SE
154th St SE
Killarney Cir SE
100m
400ft
1:500
522

Fig. 5

N

APPENDIX A

STORMWATER CALCULATIONS

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	infil - site-2
Site Name:	MEADOW BLOSSOM
Site Address:	149TH
City:	MONROE
Report Date:	9/18/2019
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.200
Version Date:	2017/04/14
Version:	4.2.13

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Flat	0.9
Pervious Total	0.9
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.9

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Lots 1-18, Tracts

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
A B, Lawn, Flat	0.04
Pervious Total	0.04

Impervious Land Use	acre
ROADS FLAT	0.17
ROOF TOPS FLAT	0.33
DRIVEWAYS FLAT	0.13
SIDEWALKS FLAT	0.08
Impervious Total	0.71
Basin Total	0.75

Element Flows To:

Surface	Interflow	Groundwater
Infiltration Trench '2'	Infiltration Trench '2'	

Lots 19-22

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
A B, Lawn, Flat	0.03
Pervious Total	0.03

Impervious Land Use	acre
ROOF TOPS FLAT	0.07
DRIVEWAYS FLAT	0.04
SIDEWALKS FLAT	0.01
Impervious Total	0.12
Basin Total	0.15

Element Flows To:

Surface	Interflow	Groundwater
Infiltration Trench '1'	Infiltration Trench '1'	

Routing Elements
Predeveloped Routing

Mitigated Routing

Infiltration Trench '2'

Bottom Length:	210.00 ft.
Bottom Width:	4.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	2
Pour Space of material for first layer:	0.35
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	10
Infiltration safety factor:	1
Total Volume Infiltrated (ac-ft.):	23.928
Total Volume Through Riser (ac-ft.):	0.001
Total Volume Through Facility (ac-ft.):	23.929
Percent Infiltrated:	100
Total Precip Applied to Facility:	0
Total Evap From Facility:	0
Discharge Structure	
Riser Height:	3.5 ft.
Riser Diameter:	8 in.
Element Flows To:	
Outlet 1	Outlet 2
Channel 1	

Gravel Trench Bed Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.019	0.000	0.000	0.000
0.0444	0.019	0.000	0.000	0.194
0.0889	0.019	0.000	0.000	0.194
0.1333	0.019	0.000	0.000	0.194
0.1778	0.019	0.001	0.000	0.194
0.2222	0.019	0.001	0.000	0.194
0.2667	0.019	0.001	0.000	0.194
0.3111	0.019	0.002	0.000	0.194
0.3556	0.019	0.002	0.000	0.194
0.4000	0.019	0.002	0.000	0.194
0.4444	0.019	0.003	0.000	0.194
0.4889	0.019	0.003	0.000	0.194
0.5333	0.019	0.003	0.000	0.194
0.5778	0.019	0.003	0.000	0.194
0.6222	0.019	0.004	0.000	0.194
0.6667	0.019	0.004	0.000	0.194
0.7111	0.019	0.004	0.000	0.194
0.7556	0.019	0.005	0.000	0.194
0.8000	0.019	0.005	0.000	0.194
0.8444	0.019	0.005	0.000	0.194
0.8889	0.019	0.006	0.000	0.194
0.9333	0.019	0.006	0.000	0.194
0.9778	0.019	0.006	0.000	0.194
1.0222	0.019	0.006	0.000	0.194

1.0667	0.019	0.007	0.000	0.194
1.1111	0.019	0.007	0.000	0.194
1.1556	0.019	0.007	0.000	0.194
1.2000	0.019	0.008	0.000	0.194
1.2444	0.019	0.008	0.000	0.194
1.2889	0.019	0.008	0.000	0.194
1.3333	0.019	0.009	0.000	0.194
1.3778	0.019	0.009	0.000	0.194
1.4222	0.019	0.009	0.000	0.194
1.4667	0.019	0.009	0.000	0.194
1.5111	0.019	0.010	0.000	0.194
1.5556	0.019	0.010	0.000	0.194
1.6000	0.019	0.010	0.000	0.194
1.6444	0.019	0.011	0.000	0.194
1.6889	0.019	0.011	0.000	0.194
1.7333	0.019	0.011	0.000	0.194
1.7778	0.019	0.012	0.000	0.194
1.8222	0.019	0.012	0.000	0.194
1.8667	0.019	0.012	0.000	0.194
1.9111	0.019	0.012	0.000	0.194
1.9556	0.019	0.013	0.000	0.194
2.0000	0.019	0.014	0.000	0.194
2.0444	0.019	0.014	0.000	0.194
2.0889	0.019	0.015	0.000	0.194
2.1333	0.019	0.016	0.000	0.194
2.1778	0.019	0.017	0.000	0.194
2.2222	0.019	0.018	0.000	0.194
2.2667	0.019	0.019	0.000	0.194
2.3111	0.019	0.020	0.000	0.194
2.3556	0.019	0.020	0.000	0.194
2.4000	0.019	0.021	0.000	0.194
2.4444	0.019	0.022	0.000	0.194
2.4889	0.019	0.023	0.000	0.194
2.5333	0.019	0.024	0.000	0.194
2.5778	0.019	0.025	0.000	0.194
2.6222	0.019	0.026	0.000	0.194
2.6667	0.019	0.026	0.000	0.194
2.7111	0.019	0.027	0.000	0.194
2.7556	0.019	0.028	0.000	0.194
2.8000	0.019	0.029	0.000	0.194
2.8444	0.019	0.030	0.000	0.194
2.8889	0.019	0.031	0.000	0.194
2.9333	0.019	0.032	0.000	0.194
2.9778	0.019	0.032	0.000	0.194
3.0222	0.019	0.033	0.000	0.194
3.0667	0.019	0.034	0.000	0.194
3.1111	0.019	0.035	0.000	0.194
3.1556	0.019	0.036	0.000	0.194
3.2000	0.019	0.037	0.000	0.194
3.2444	0.019	0.038	0.000	0.194
3.2889	0.019	0.038	0.000	0.194
3.3333	0.019	0.039	0.000	0.194
3.3778	0.019	0.040	0.000	0.194
3.4222	0.019	0.041	0.000	0.194
3.4667	0.019	0.042	0.000	0.194
3.5111	0.019	0.043	0.008	0.194
3.5556	0.019	0.044	0.092	0.194
3.6000	0.019	0.044	0.219	0.194

3.6444	0.019	0.045	0.367	0.194
3.6889	0.019	0.046	0.513	0.194
3.7333	0.019	0.047	0.639	0.194
3.7778	0.019	0.048	0.730	0.194
3.8222	0.019	0.049	0.788	0.194
3.8667	0.019	0.050	0.847	0.194
3.9111	0.019	0.050	0.897	0.194
3.9556	0.019	0.051	0.944	0.194
4.0000	0.019	0.052	0.989	0.194

Channel 1

Bottom Length:	2.00 ft.
Bottom Width:	1.00 ft.
Manning's n:	0.03
Channel bottom slope 1:	0.1 To 1
Channel Left side slope 0:	0 To 1
Channel right side slope 2:	0 To 1
Discharge Structure	
Riser Height:	0 ft.
Riser Diameter:	0 in.
Element Flows To:	
Outlet 1	Outlet 2

Channel Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.000046	0.000000	0.000	0.000
0.0111	0.000046	0.000001	0.008	0.000
0.0222	0.000046	0.000001	0.026	0.000
0.0333	0.000046	0.000002	0.051	0.000
0.0444	0.000046	0.000002	0.082	0.000
0.0556	0.000046	0.000003	0.118	0.000
0.0667	0.000046	0.000003	0.158	0.000
0.0778	0.000046	0.000004	0.202	0.000
0.0889	0.000046	0.000004	0.249	0.000
0.1000	0.000046	0.000005	0.299	0.000
0.1111	0.000046	0.000005	0.352	0.000
0.1222	0.000046	0.000006	0.408	0.000
0.1333	0.000047	0.000006	0.466	0.000
0.1444	0.000047	0.000007	0.527	0.000
0.1556	0.000047	0.000007	0.589	0.000
0.1667	0.000047	0.000008	0.654	0.000
0.1778	0.000047	0.000008	0.720	0.000
0.1889	0.000047	0.000009	0.788	0.000
0.2000	0.000047	0.000009	0.858	0.000
0.2111	0.000047	0.000010	0.929	0.000
0.2222	0.000047	0.000010	1.002	0.000
0.2333	0.000047	0.000011	1.076	0.000
0.2444	0.000047	0.000011	1.151	0.000
0.2556	0.000047	0.000012	1.227	0.000
0.2667	0.000047	0.000012	1.304	0.000
0.2778	0.000047	0.000013	1.383	0.000
0.2889	0.000047	0.000013	1.463	0.000
0.3000	0.000047	0.000014	1.543	0.000
0.3111	0.000047	0.000015	1.625	0.000
0.3222	0.000047	0.000015	1.707	0.000
0.3333	0.000047	0.000016	1.790	0.000
0.3444	0.000047	0.000016	1.874	0.000
0.3556	0.000048	0.000017	1.959	0.000
0.3667	0.000048	0.000017	2.044	0.000
0.3778	0.000048	0.000018	2.130	0.000
0.3889	0.000048	0.000018	2.217	0.000
0.4000	0.000048	0.000019	2.304	0.000
0.4111	0.000048	0.000019	2.392	0.000
0.4222	0.000048	0.000020	2.481	0.000
0.4333	0.000048	0.000020	2.570	0.000

0.4444	0.000048	0.000021	2.660	0.000
0.4556	0.000048	0.000021	2.750	0.000
0.4667	0.000048	0.000022	2.841	0.000
0.4778	0.000048	0.000022	2.932	0.000
0.4889	0.000048	0.000023	3.024	0.000
0.5000	0.000048	0.000024	3.116	0.000
0.5111	0.000048	0.000024	3.209	0.000
0.5222	0.000048	0.000025	3.302	0.000
0.5333	0.000048	0.000025	3.395	0.000
0.5444	0.000048	0.000026	3.489	0.000
0.5556	0.000048	0.000026	3.583	0.000
0.5667	0.000049	0.000027	3.677	0.000
0.5778	0.000049	0.000027	3.772	0.000
0.5889	0.000049	0.000028	3.867	0.000
0.6000	0.000049	0.000028	3.963	0.000
0.6111	0.000049	0.000029	4.058	0.000
0.6222	0.000049	0.000029	4.155	0.000
0.6333	0.000049	0.000030	4.251	0.000
0.6444	0.000049	0.000031	4.348	0.000
0.6556	0.000049	0.000031	4.445	0.000
0.6667	0.000049	0.000032	4.542	0.000
0.6778	0.000049	0.000032	4.639	0.000
0.6889	0.000049	0.000033	4.737	0.000
0.7000	0.000049	0.000033	4.835	0.000
0.7111	0.000049	0.000034	4.933	0.000
0.7222	0.000049	0.000034	5.031	0.000
0.7333	0.000049	0.000035	5.130	0.000
0.7444	0.000049	0.000035	5.229	0.000
0.7556	0.000049	0.000036	5.328	0.000
0.7667	0.000049	0.000037	5.427	0.000
0.7778	0.000049	0.000037	5.527	0.000
0.7889	0.000050	0.000038	5.626	0.000
0.8000	0.000050	0.000038	5.726	0.000
0.8111	0.000050	0.000039	5.826	0.000
0.8222	0.000050	0.000039	5.926	0.000
0.8333	0.000050	0.000040	6.027	0.000
0.8444	0.000050	0.000040	6.127	0.000
0.8556	0.000050	0.000041	6.228	0.000
0.8667	0.000050	0.000042	6.329	0.000
0.8778	0.000050	0.000042	6.430	0.000
0.8889	0.000050	0.000043	6.531	0.000
0.9000	0.000050	0.000043	6.632	0.000
0.9111	0.000050	0.000044	6.734	0.000
0.9222	0.000050	0.000044	6.835	0.000
0.9333	0.000050	0.000045	6.937	0.000
0.9444	0.000050	0.000045	7.039	0.000
0.9556	0.000050	0.000046	7.141	0.000
0.9667	0.000050	0.000047	7.243	0.000
0.9778	0.000050	0.000047	7.345	0.000
0.9889	0.000050	0.000048	7.448	0.000
1.0000	0.000051	0.000048	7.550	0.000
1.0111	0.000051	0.000049	7.653	0.000

Infiltration Trench '1'

Bottom Length:	25.00 ft.
Bottom Width:	6.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	2
Pour Space of material for first layer:	0.35
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	10
Infiltration safety factor:	1
Total Volume Infiltrated (ac-ft.):	4.006
Total Volume Through Riser (ac-ft.):	0
Total Volume Through Facility (ac-ft.):	4.006
Percent Infiltrated:	100
Total Precip Applied to Facility:	0
Total Evap From Facility:	0
Discharge Structure	
Riser Height:	3.5 ft.
Riser Diameter:	8 in.
Element Flows To:	
Outlet 1	Outlet 2
Channel 1	

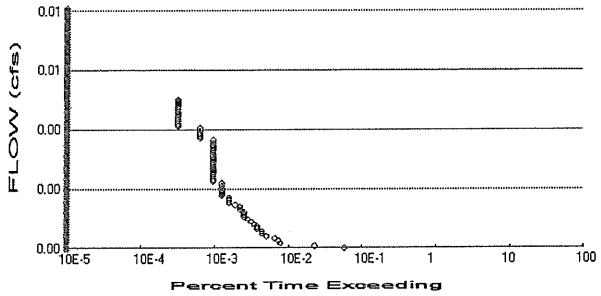
Gravel Trench Bed Hydraulic Table

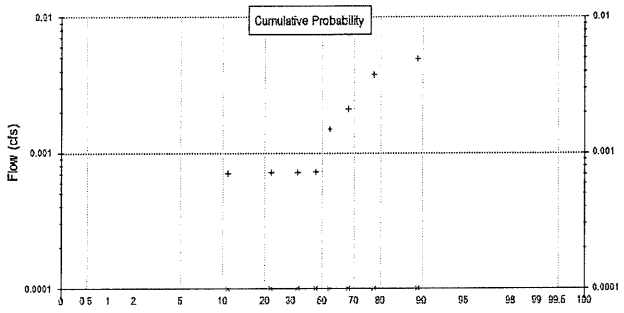
Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.003	0.000	0.000	0.000
0.0444	0.003	0.000	0.000	0.034
0.0889	0.003	0.000	0.000	0.034
0.1333	0.003	0.000	0.000	0.034
0.1778	0.003	0.000	0.000	0.034
0.2222	0.003	0.000	0.000	0.034
0.2667	0.003	0.000	0.000	0.034
0.3111	0.003	0.000	0.000	0.034
0.3556	0.003	0.000	0.000	0.034
0.4000	0.003	0.000	0.000	0.034
0.4444	0.003	0.000	0.000	0.034
0.4889	0.003	0.000	0.000	0.034
0.5333	0.003	0.000	0.000	0.034
0.5778	0.003	0.000	0.000	0.034
0.6222	0.003	0.000	0.000	0.034
0.6667	0.003	0.000	0.000	0.034
0.7111	0.003	0.000	0.000	0.034
0.7556	0.003	0.000	0.000	0.034
0.8000	0.003	0.001	0.000	0.034
0.8444	0.003	0.001	0.000	0.034
0.8889	0.003	0.001	0.000	0.034
0.9333	0.003	0.001	0.000	0.034
0.9778	0.003	0.001	0.000	0.034
1.0222	0.003	0.001	0.000	0.034
1.0667	0.003	0.001	0.000	0.034
1.1111	0.003	0.001	0.000	0.034

1.1556	0.003	0.001	0.000	0.034
1.2000	0.003	0.001	0.000	0.034
1.2444	0.003	0.001	0.000	0.034
1.2889	0.003	0.001	0.000	0.034
1.3333	0.003	0.001	0.000	0.034
1.3778	0.003	0.001	0.000	0.034
1.4222	0.003	0.001	0.000	0.034
1.4667	0.003	0.001	0.000	0.034
1.5111	0.003	0.001	0.000	0.034
1.5556	0.003	0.001	0.000	0.034
1.6000	0.003	0.001	0.000	0.034
1.6444	0.003	0.002	0.000	0.034
1.6889	0.003	0.002	0.000	0.034
1.7333	0.003	0.002	0.000	0.034
1.7778	0.003	0.002	0.000	0.034
1.8222	0.003	0.002	0.000	0.034
1.8667	0.003	0.002	0.000	0.034
1.9111	0.003	0.002	0.000	0.034
1.9556	0.003	0.002	0.000	0.034
2.0000	0.003	0.002	0.000	0.034
2.0444	0.003	0.002	0.000	0.034
2.0889	0.003	0.002	0.000	0.034
2.1333	0.003	0.003	0.000	0.034
2.1778	0.003	0.003	0.000	0.034
2.2222	0.003	0.003	0.000	0.034
2.2667	0.003	0.003	0.000	0.034
2.3111	0.003	0.003	0.000	0.034
2.3556	0.003	0.003	0.000	0.034
2.4000	0.003	0.003	0.000	0.034
2.4444	0.003	0.004	0.000	0.034
2.4889	0.003	0.004	0.000	0.034
2.5333	0.003	0.004	0.000	0.034
2.5778	0.003	0.004	0.000	0.034
2.6222	0.003	0.004	0.000	0.034
2.6667	0.003	0.004	0.000	0.034
2.7111	0.003	0.005	0.000	0.034
2.7556	0.003	0.005	0.000	0.034
2.8000	0.003	0.005	0.000	0.034
2.8444	0.003	0.005	0.000	0.034
2.8889	0.003	0.005	0.000	0.034
2.9333	0.003	0.005	0.000	0.034
2.9778	0.003	0.005	0.000	0.034
3.0222	0.003	0.006	0.000	0.034
3.0667	0.003	0.006	0.000	0.034
3.1111	0.003	0.006	0.000	0.034
3.1556	0.003	0.006	0.000	0.034
3.2000	0.003	0.006	0.000	0.034
3.2444	0.003	0.006	0.000	0.034
3.2889	0.003	0.006	0.000	0.034
3.3333	0.003	0.007	0.000	0.034
3.3778	0.003	0.007	0.000	0.034
3.4222	0.003	0.007	0.000	0.034
3.4667	0.003	0.007	0.000	0.034
3.5111	0.003	0.007	0.008	0.034
3.5556	0.003	0.007	0.092	0.034
3.6000	0.003	0.008	0.219	0.034
3.6444	0.003	0.008	0.367	0.034
3.6889	0.003	0.008	0.513	0.034

3.7333	0.003	0.008	0.639	0.034
3.7778	0.003	0.008	0.730	0.034
3.8222	0.003	0.008	0.788	0.034
3.8667	0.003	0.008	0.847	0.034
3.9111	0.003	0.009	0.897	0.034
3.9556	0.003	0.009	0.944	0.034
4.0000	0.003	0.009	0.989	0.034

Analysis Results
POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.9
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.07
Total Impervious Area: 0.83

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.001252
5 year	0.002494
10 year	0.003657
25 year	0.005598
50 year	0.007443
100 year	0.00968

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.001	0.000
1950	0.002	0.000
1951	0.001	0.000
1952	0.001	0.000
1953	0.001	0.000
1954	0.005	0.000
1955	0.004	0.000
1956	0.001	0.000
1957	0.001	0.000

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0050	0.0000
2	0.0038	0.0000
3	0.0021	0.0000
4	0.0015	0.0000
5	0.0007	0.0000
6	0.0007	0.0000
7	0.0007	0.0000
8	0.0007	0.0000
9	0.0007	0.0000

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0006	184	0	0	Pass
0.0007	73	0	0	Pass
0.0008	25	0	0	Pass
0.0008	23	0	0	Pass
0.0009	21	0	0	Pass
0.0010	16	0	0	Pass
0.0010	14	0	0	Pass
0.0011	14	0	0	Pass
0.0012	12	0	0	Pass
0.0012	12	0	0	Pass
0.0013	11	0	0	Pass
0.0014	10	0	0	Pass
0.0015	9	0	0	Pass
0.0015	8	0	0	Pass
0.0016	8	0	0	Pass
0.0017	8	0	0	Pass
0.0017	7	0	0	Pass
0.0018	7	0	0	Pass
0.0019	6	0	0	Pass
0.0019	5	0	0	Pass
0.0020	5	0	0	Pass
0.0021	5	0	0	Pass
0.0021	4	0	0	Pass
0.0022	4	0	0	Pass
0.0023	4	0	0	Pass
0.0023	4	0	0	Pass
0.0024	4	0	0	Pass
0.0025	4	0	0	Pass
0.0026	3	0	0	Pass
0.0026	3	0	0	Pass
0.0027	3	0	0	Pass
0.0028	3	0	0	Pass
0.0028	3	0	0	Pass
0.0029	3	0	0	Pass
0.0030	3	0	0	Pass
0.0030	3	0	0	Pass
0.0031	3	0	0	Pass
0.0032	3	0	0	Pass
0.0032	3	0	0	Pass
0.0033	3	0	0	Pass
0.0034	3	0	0	Pass
0.0034	3	0	0	Pass
0.0035	3	0	0	Pass
0.0036	3	0	0	Pass
0.0037	3	0	0	Pass
0.0037	3	0	0	Pass
0.0038	2	0	0	Pass
0.0039	2	0	0	Pass
0.0039	2	0	0	Pass
0.0040	2	0	0	Pass
0.0041	2	0	0	Pass
0.0041	1	0	0	Pass
0.0042	1	0	0	Pass

0.0043	1	0	0	Pass
0.0043	1	0	0	Pass
0.0044	1	0	0	Pass
0.0045	1	0	0	Pass
0.0046	1	0	0	Pass
0.0046	1	0	0	Pass
0.0047	1	0	0	Pass
0.0048	1	0	0	Pass
0.0048	1	0	0	Pass
0.0049	1	0	0	Pass
0.0050	0	0	0	Pass
0.0050	0	0	0	Pass
0.0051	0	0	0	Pass
0.0052	0	0	0	Pass
0.0052	0	0	0	Pass
0.0053	0	0	0	Pass
0.0054	0	0	0	Pass
0.0054	0	0	0	Pass
0.0055	0	0	0	Pass
0.0056	0	0	0	Pass
0.0057	0	0	0	Pass
0.0057	0	0	0	Pass
0.0058	0	0	0	Pass
0.0059	0	0	0	Pass
0.0059	0	0	0	Pass
0.0060	0	0	0	Pass
0.0061	0	0	0	Pass
0.0061	0	0	0	Pass
0.0062	0	0	0	Pass
0.0063	0	0	0	Pass
0.0063	0	0	0	Pass
0.0064	0	0	0	Pass
0.0065	0	0	0	Pass
0.0065	0	0	0	Pass
0.0066	0	0	0	Pass
0.0067	0	0	0	Pass
0.0068	0	0	0	Pass
0.0068	0	0	0	Pass
0.0069	0	0	0	Pass
0.0070	0	0	0	Pass
0.0070	0	0	0	Pass
0.0071	0	0	0	Pass
0.0072	0	0	0	Pass
0.0072	0	0	0	Pass
0.0073	0	0	0	Pass
0.0074	0	0	0	Pass
0.0074	0	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Channel 1 POC	☐	0.01			☐	0.00			
Infiltration Trench '2'	☐	125.23			☐	99.67			
Infiltration Trench '1'	☐	21.18			☐	98.57			
Total Volume Infiltrated		146.42	0.00	0.00		99.51	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

Model Default Modifications

Total of 0 changes have been made.

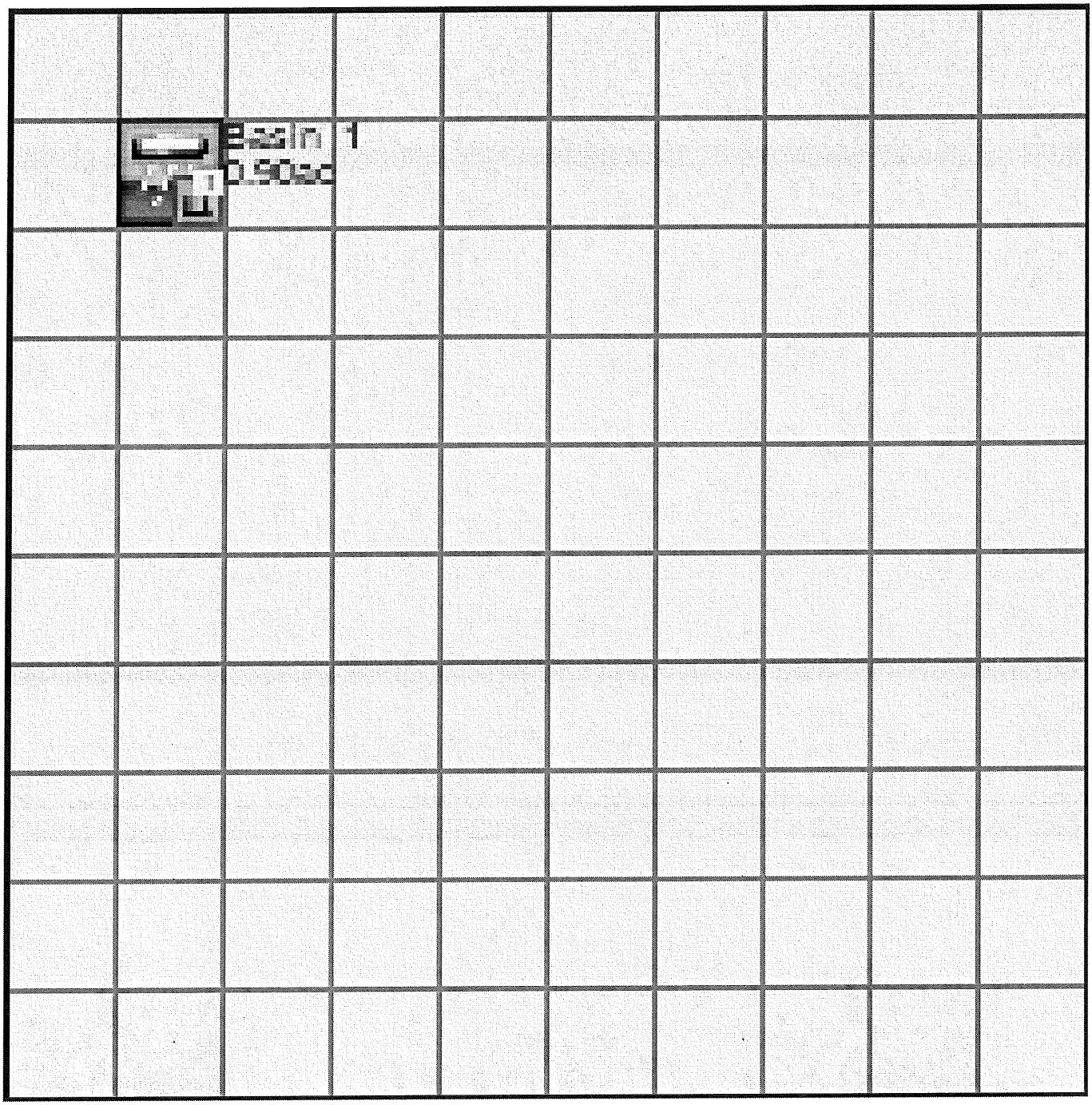
PERLND Changes

No PERLND changes have been made.

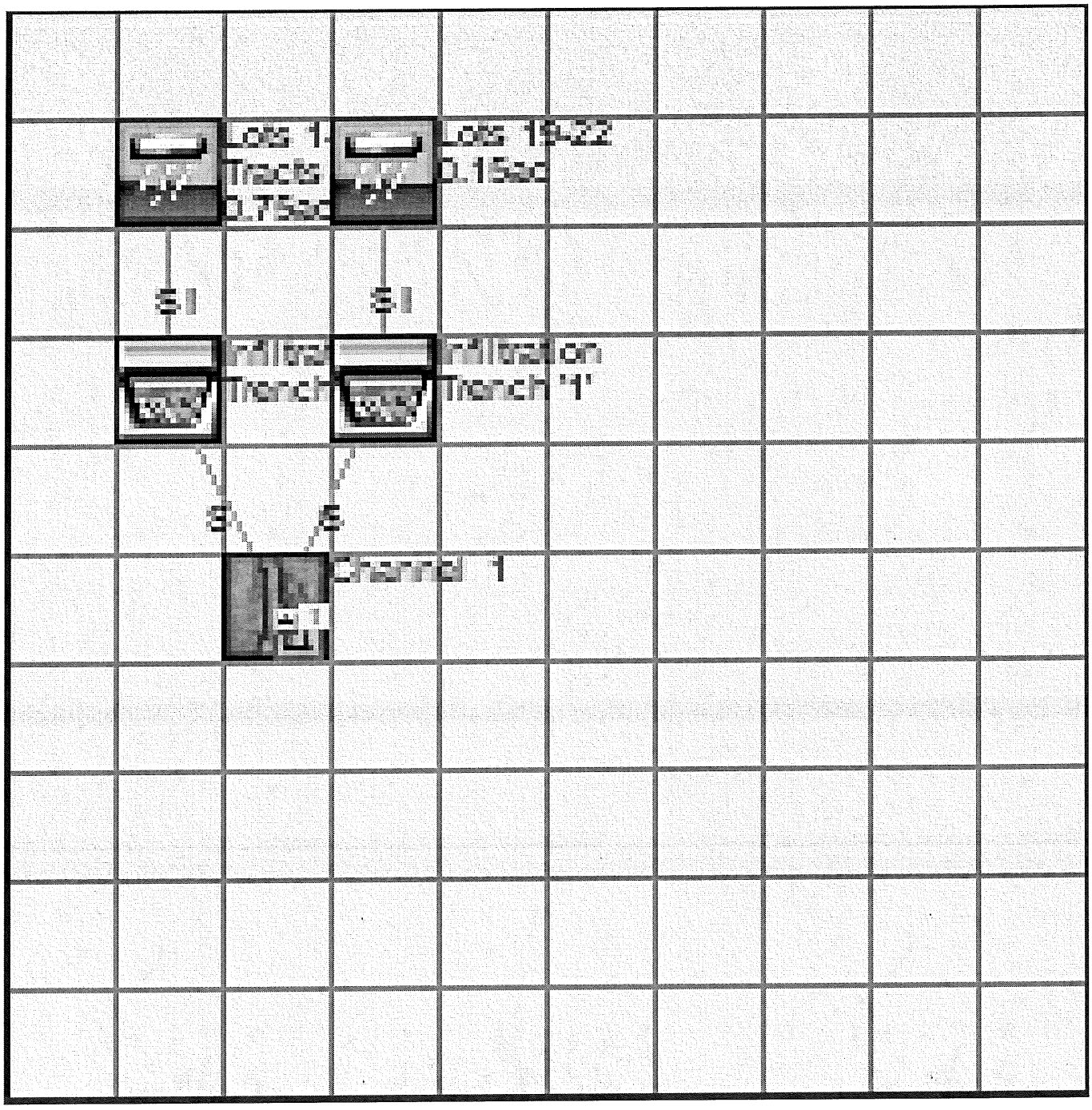
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Disclaimer

Legal Notice

Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

APPENDIX B

MAINTENANCE & OPERATIONS MANUAL

No. 2 – Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Poisonous/Noxious Vegetation	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Contaminants and Pollution	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Rodent Holes	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1)
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Piping	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway	Rock Missing	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that 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 trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that 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 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in 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 running into basin).	Top slab is free of holes and cracks.
		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	Maintenance person judges that structure is unsound.	Basin 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	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing 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)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	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.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 18 – Catchbasin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

APPENDIX C

GEOTECHNICAL REPORT

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS

Main Office
17311 – 135th Ave NE, A-500
Woodinville, WA 98072
(425) 486-1669 · FAX (425) 481-2510

Engineering-Geology Branch
5526 Industry Lane, #2
East Wenatchee, WA 98802
(509) 665-7696 · FAX (509) 665-7692

April 30, 2019

Mr. Rick Hanson
Hanson Homes
P.O. Box 2289
Snohomish, Washington 98291
VIA Email: 2011hansonhomes@gmail.com

Geotechnical Engineering Evaluation
Stanton Meadows Residential Development
149th Street SE and 179th Avenue SE
Monroe, Washington
NGA File No. 1085919

Dear Mr. Hanson:

We are pleased to submit the attached report titled **"Geotechnical Engineering Evaluation –Stanton Meadows Residential Development – 149th Street SE and 179th Avenue SE – Monroe, Washington."** This report summarizes our observations of the existing surface and subsurface conditions within the site, and provides general recommendations for the proposed site development. Our services were completed in general accordance with the proposal signed by you on April 1, 2019.

The site is 0.9 acres in size and currently vacant and is mainly covered with grass. The ground surface throughout the site is relatively level to gently sloping. We understand that the proposed development will likely include subdividing the property into 18 separate lots along with associated access roadways. We also understand that new residence structures along with underground utilities would be constructed in the individual lots and roadways, respectively. Specific grading and stormwater handling plans were not available at the time this report was prepared. However, we do understand that stormwater generated within the property may be directed to onsite infiltrations systems, if feasible.

We monitored the excavation of four test pit explorations within the site on April 5, 2019. Our explorations indicated that the site was underlain by gravelly fine to coarse sand with trace silt with interbedded fine to coarse sands at depth across the entire site.

We have concluded that the site planned development is feasible. We have recommended that the new structures be founded on the medium dense or better native soil or structural fill extending to these soils, for bearing capacity and settlement considerations. These soils should generally be encountered approximately two to four feet below the existing ground surface, based on our explorations. Deeper areas of loose soil and/or undocumented fill could exist within unexplored portions of the site. If unsuitable soils are encountered at the proposed subgrade elevations, we recommended that these soils be overexcavated to expose competent native soils and the foundations either be founded directly on these soils or on structural fill extending down to these soils.

We also performed grain size sieve analyses testing in accordance with the 2012 Department of Ecology Stormwater Management Manual for Western Washington, as amended in 2014 (2014 SWMMWW). The subsurface soils generally consisted of medium dense or better gravelly fine to medium sand with silt that we interpreted as native alluvial soils. Based on our sieve analysis results, we have concluded that traditional stormwater infiltration is feasible at this site. We have provided long-term design infiltration rates in the conclusions section of this report.

In the attached report, we have also provided general recommendations for foundations, site grading, slabs-on-grade, structural fill placement, retaining walls, erosion control, and drainage. We should be retained to review and comment on final development plans and observe the earthwork phase of construction. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

It has been a pleasure to provide service to you on this project. Please contact us if you have any questions regarding this report or require further information.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Khaled M. Shawish, PE
Principal

TABLE OF CONTENTS

LIST OF FIGURES

Geotechnical Engineering Evaluation
Stanton Meadows Residential Development
149th Street SE and 179th Avenue SE
Monroe, Washington

INTRODUCTION

This report presents the results of our geotechnical engineering investigation and evaluation of the planned Wyndham Highlands Subdivision Development in the Sultan area of Snohomish County, Washington. The project site is located at the intersection of 149th Street SE and 179th Avenue SE in Monroe, Washington, as shown on the Vicinity Map in Figure 1. The parcel number for this site is 00847600099500. The purpose of this study is to explore and characterize the site's surface and subsurface conditions and to provide geotechnical recommendations for the proposed site development, specifically grading.

The site is currently vacant and is mainly covered with grass. The ground surface throughout the site is relatively level to gently sloping. We understand that the proposed development will likely include subdividing the property into 18 separate lots along with associated access roadways. We also understand that new residence structures along with underground utilities would be constructed in the individual lots and roadways, respectively. However, we do understand that stormwater generated within the property may be directed to onsite infiltrations systems, if feasible. The existing site layout is shown on the Site Plan in Figure 2.

For our use in preparing this report, we were provided with a site plan titled "Preliminary Subdivision of Stanton Meadows," dated November 8, 2018, and produced by ORCA Land Surveying and Land Resolutions, Inc.

SCOPE

The purpose of this study is to explore and characterize the site surface and subsurface conditions, and provide general recommendations for site development. Specifically, our scope of services included the following:

1. Review available soil and geologic maps of the area.
2. Explore the subsurface soil and groundwater conditions within the site with trackhoe-excavated test pits. Trackhoe was provided by the client.
3. Conduct laboratory analyses on selected soil samples.
4. Provide recommendations for earthwork, foundation support, retaining walls, and slab-on-grade subgrades.
5. Provide recommendations for pavement subgrade preparation.
6. Provide recommendations for temporary and permanent slopes.

7. Determine feasibility of on-site stormwater infiltration.
8. Provide long-term design infiltration rates based on grain-size analysis per the 2014 DOE Stormwater Manual.
9. Provide recommendations for infiltration system installation.
10. Provide recommendations for site drainage and erosion control.
11. Document the results of our findings, conclusions, and recommendations in a written geotechnical report.

SITE CONDITIONS

Surface Conditions

The site is 0.9 acres in size and currently vacant and is mainly covered with grass. The property is bordered to the west and south by moderately spaced residential properties and bordered to the north and east by 149th Street SE and 179th Avenue SE, respectively. The ground surface throughout the site is relatively level to gently sloping. Vegetation on the site primarily consists of grassland, with a small patch of a few deciduous trees located on the southeastern portion of the site. We did not observe surface water within the site during our site visit.

Subsurface Conditions

Geology: The geologic units for this area are shown in the Geologic Map of the Monroe 7.5-minute Quadrangle, King and Snohomish Counties, Washington, by Joe D. Dragovich, et al. (WADNR, 2011). The site is mapped as surficial deposits of stream-derived alluvium (Qa). The alluvium deposits are described as sand, silt, cobbley gravel, gravelly sand, sandy pebble gravel, peat and other organic sediments derived from overbank flood sediments from the Snoqualmie and Skykomish rivers and alluvial fan (deltaic) deposits. Our explorations generally encountered a surficial layer of silty fine to medium sand fill underlain by native gravelly fine to coarse sand, with occasional silt lenses and trace cobbles at depth, which is consistent with the mapped alluvial soils.

Explorations: The subsurface conditions within the site were explored on April 5, 2019 by excavating four test pits around the property, on the northern, eastern, southern, and western property lines of the site. Explorations were completed to depths ranging from 7.9 to 8.2 feet below the existing ground surface. The approximate locations of our explorations are shown on the Site Plan in Figure 2. A geologist from NGA was present during the explorations, examined soils and geologic conditions encountered, obtained samples of different soil types, and maintained exploration logs.

The soils were visually classified in general accordance with the Unified Soil Classification System, presented in Figure 3. The logs of our test pits are attached to this report and are presented as Figures 4 through 5. We present a summary of the subsurface conditions in the following paragraph. For a detailed description of the subsurface conditions, the exploration logs should be reviewed.

Explorations were consistent across the site. In general, explorations uncovered 2.0 to 2.7 feet of surficial organic rich silty fine to medium sand with roots, which we interpreted as fill/topsoil. Underlying the topsoil in all explorations, test pits revealed fine to coarse sand with gravel and cobbles, with iron oxide rinds and occasional silty fine to medium sand lenses. The fine to coarse sand with gravel and cobbles encountered was in a medium dense condition or better. We interpreted it to be the mapped alluvial deposits, remnants of the ancient Skykomish River, due to some stratification and lensing observed in excavation sidewalls.

Hydrogeologic Conditions

Groundwater seepage was observed in all of the explorations on the site, approximately around 8.0 feet. We interpret it to be perched water. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of a relatively low permeability material. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of perched groundwater to decrease during drier times of the year and increase during wetter periods.

SENSITIVE AREA EVALUATION

Seismic Hazard

We reviewed the 2018 International Building Code (IBC) for seismic site classification for this project. Since medium dense or better soils are interpreted to underlie the site at depth, the site best fits the IBC description for Site Class D.

Table 1 below provides seismic design parameters for the site that are in conformance with the 2018 IBC, which specifies a design earthquake having a 2 percent probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps.

Table 1 – 2018 IBC Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. (g) S_s	Spectral Acceleration at 1.0 sec. (g) S_1	Site Coefficients		Design Spectral Response Parameters	
			F_a	F_v	S_{DS}	S_{D1}
D	1.211	0.458	1.016	1.542	0.820	0.471

The spectral response accelerations were obtained from the USGS Earthquake Hazards Program Interpolated Probabilistic Ground Motion website (2008 data) for the project latitude and longitude.

The site is located within the Cherry Creek Fault Zone (CCFZ): an active, shallow region of seismicity conjugate to the southern Whidbey Island fault zone, shown in information published by Washington State Department of Natural Resources in 2011. This information also suggests that the Cherry Creek fault zone produced the magnitude 5.2 Duvall earthquake in 1996. The nearest strands of the fault zone have been mapped approximately half a mile to the east and to the west of the site, but offset is concealed by surficial glacial deposits. Based on best available information, it is our opinion that potential for surface rupture on the site from seismicity associated with the fault zone mapped within the vicinity of the properties is low.

Hazards associated with seismic activity include liquefaction potential and amplification of ground motion. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. It is our opinion that the medium dense or better glacial deposits interpreted to underlie the site have a low potential for liquefaction or amplification of ground motion.

Erosion Hazard

The criteria used for determination of the erosion hazard for affected areas include soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The Soil Survey of Snohomish County Area, Washington by the Natural Resources Conservation Service (NRCS) classifies the site as Sultan silt loam, 0 to 2 percent slopes. The erosion hazard listed for the soils on the property is slight. It is our opinion that the erosion hazard for site soils should be low in areas where vegetation is not disturbed.

LABORATORY ANALYSIS

We performed two grain size sieve analyses with moisture contents on selected soil samples collected from the site. Samples processed in sieve analyses include those taken from Test Pit 3 at a depth of 4.0 feet, and Test Pit 4 at a depth of 4.6 feet below the existing ground surface. The soil tested from both test pits are classified on the USDA textural triangle as sand. The results of sieve analyses are presented as Figures 6 through 7.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion from a geotechnical standpoint that the planned residential development is feasible. Our explorations indicated that the site was underlain by a surficial layer of topsoil, with an intermediate layer of glacial soils consisting of medium dense or better silty, fine to medium sand, and an underlying layer of alluvial, gravelly sand at depth. Native soils should provide adequate support for foundation, slab, and pavement loads. We recommend that the new structures be designed utilizing shallow foundations. Footings should extend through any loose soil, and be founded on the underlying medium dense or better native bearing soil, or structural fill extending to these soils. The competent soil should typically be encountered approximately two to four feet below the existing surface throughout the site, based on our explorations. Deeper, localized areas of undocumented fill may also exist in unexplored areas of the site. This condition, if encountered, would require deeper excavations in foundation, slab, and pavement areas to remove the unsuitable soils.

We also performed on-site infiltration testing in accordance with the 2012 Stormwater Management Manual for Western Washington, as amended in 2014. We completed two grain-size distribution analyses on the alluvial materials to establish a design infiltration rate. Feasibility for infiltration is based on permeability among a number of other factors, including groundwater separation. Based on the grain-size analyses, it is our opinion that on-site stormwater infiltration is feasible within this site. This is further discussed in the **Stormwater Infiltration** subsection of this report.

The surficial soils encountered on this site are considered moisture-sensitive and may disturb easily when wet. We recommend that construction take place during the drier summer months, if possible. If construction is to take place during wet weather, the soils may disturb and additional expenses and delays may be expected due to the wet conditions. Additional expenses could include the need for placing a blanket of rock spalls to protect exposed subgrades and construction traffic areas.

Some of the native on-site soils may be suitable for use as structural fill depending on the moisture content of the soil during construction. NGA should be retained to determine if the on-site soils can be used as structural fill material during construction.

Erosion Control

The erosion hazard for the on-site soils is interpreted to be slight for exposed soils, but actual erosion potential will be dependent on how the site is graded and how water is allowed to concentrate. Best Management Practices (BMPs) should be used to control erosion. Areas disturbed during construction should be protected from erosion. Erosion control measures may include diverting surface water away from the stripped or disturbed areas. Silt fences and/or straw bales should be erected to prevent muddy water from leaving the site. Disturbed areas should be planted as soon as practical and the vegetation should be maintained until it is established. Erosion potential of areas not stripped of vegetation should be low.

Site Preparation and Grading

After erosion control measures are implemented, site preparation should consist of removing loose soils, topsoil, and any undocumented fill from foundations, slab, and pavement areas, to expose medium dense or better native soils at depth. The stripped soil should be removed from the site or stockpiled for later use as a landscaping fill. Based on our observations, we anticipate native, medium dense or better soil to be encountered at approximately two to four feet throughout explored areas of the site. We should note that additional deeper areas of unsuitable soils and/or undocumented fill could be encountered in unexplored areas of the site. This condition, if encountered, would require deeper excavations in foundation, slab, and pavement areas to remove the unsuitable soils.

After site preparation, if the exposed subgrade is deemed loose, it should be compacted to a non-yielding condition and then proof-rolled with a heavy, rubber-tired piece of equipment. Areas observed to pump or weave during the proof-roll test should be reworked to structural fill specifications or over-excavated and replaced with properly compacted structural fill or rock spalls. If loose soils are encountered in the foundation areas, the loose soils should be removed and replaced with rock spalls. If significant surface water flow is encountered during construction, this flow should be diverted around the work areas, and the exposed subgrades should be maintained in a semi-dry condition.

If wet conditions are encountered, alternative site grading techniques might be necessary. These could include using large excavators equipped with wide tracks and a smooth bucket to complete site grading, and covering exposed subgrade with a layer of crushed rock for protection. If construction is attempted in wet weather, the subgrade should not be compacted, as this could cause further subgrade disturbance. In wet conditions, it may be necessary to cover the exposed subgrade with a layer of crushed rock as soon as it is exposed to protect the moisture sensitive soils from disturbance by machine or foot traffic during construction. The prepared subgrade should be protected from construction traffic and surface water should be diverted around areas of prepared subgrade.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, including the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable, temporary, cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations at all times as indicated in OSHA guidelines for cut slopes.

The following information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Nelson Geotechnical Associates, Inc. assumes responsibility for job site safety. Job site safety is the sole responsibility of the project contractor.

For planning purposes, we recommend that temporary cuts in the upper soils should be no steeper than 2 Horizontal to 1 Vertical (2H:1V). If significant groundwater seepage or surface water flow were encountered, we would expect that flatter inclinations would be necessary. We recommend that cut slopes be protected from erosion. The slope protection measures may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to appropriate OSHA/WISHA regulations. Permanent cut and fill slopes should be no steeper than 2H:1V. However, flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be vegetated and the vegetative cover maintained until established.

Foundations

Conventional shallow spread foundations should be placed on medium dense or better native bearing soils, or be supported on structural fill or rock spalls extending to those soils. Medium dense bearing soils should be encountered approximately two to four feet below ground surface within the proposed residence footprint areas, based on our explorations. Additional areas of unsuitable soils and/or undocumented fill could be encountered in unexplored areas of the site. Where undocumented fill or less dense soils are encountered at footing bearing elevation, the subgrade should be over-excavated to expose suitable bearing soil. The over-excavation may be filled with structural fill, or the footing may be extended down to the competent native bearing soils. If footings are supported on structural fill, the fill zone should extend outside the edges of the footing a distance equal to one half of the depth of the over-excavation below the bottom of the footing.

Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection and bearing capacity considerations. Foundations should be designed in accordance with the 2018 IBC. Footing widths should be based on the anticipated loads and allowable soil bearing pressure.

Water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

For foundations constructed as outlined above, we recommend an allowable bearing pressure of not more than 2,000 pounds per square foot (psf) be used for the design of footings founded on the medium dense or better native bearing soils or rock spalls extending to the competent native bearing material. The foundation bearing soil should be evaluated by a representative of NGA. We should be consulted if higher bearing pressures are needed. Current IBC guidelines should be used when considering increased allowable bearing pressure for short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than 1-inch total and ½-inch differential between adjacent footings or across a distance of about 20 feet, based on our experience with similar projects.

Lateral loads may be resisted by friction on the base of the footing and passive resistance against the subsurface portions of the foundation. A coefficient of friction of 0.35 may be used to calculate the base friction and should be applied to the vertical dead load only. Passive resistance may be calculated as a triangular equivalent fluid pressure distribution. An equivalent fluid density of 200 pounds per cubic foot (pcf) should be used for passive resistance design for a level ground surface adjacent to the footing. This level surface should extend a distance equal to at least three times the footing depth. These recommended values incorporate safety factors of 1.5 and 2.0 applied to the estimated ultimate values for frictional and passive resistance, respectively. To achieve this value of passive resistance, the foundations should be poured "neat" against the native medium dense soils or compacted fill should be used as backfill against the front of the footing. We recommend that the upper one foot of soil be neglected when calculating the passive resistance.

Retaining Walls

We do not anticipate the need for retaining walls on this site; however, should any walls be utilized, they should be designed and constructed as outlined above and hereon. The lateral pressure acting on retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement which can occur as backfill is placed, wall drainage conditions, and the inclination of the backfill. For walls that are free to yield at the top at least one thousandth of the height of the wall (active condition), soil pressures will be less than if movement is limited by such factors as wall stiffness or bracing (at-rest condition). We recommend that walls supporting horizontal backfill and not subjected to hydrostatic forces, be designed using a triangular earth pressure distribution equivalent to that exerted by a fluid with a density of 40 pcf for yielding (active condition) walls, and 60 pcf for non-yielding (at-rest condition) walls. In addition, we recommend a uniform seismic design loading of 8H be used, where "H" is the total height of the wall.

These recommended lateral earth pressures are for a drained granular backfill and assume a horizontal ground surface behind the wall for a distance of at least the height of the wall, not accounting for surcharge loads. Additional lateral earth pressures should be considered for surcharge loads acting adjacent to walls and within a distance equal to the height of the wall. This includes the effects of surcharges such as traffic loads, floor slab loads, slopes, or other surface loads. We could consult with the structural engineer regarding additional loads on retaining walls during design, if needed.

The lateral pressures on walls may be resisted by friction between the foundation and subgrade soil, and by passive resistance acting on the below-grade portion of the foundation. Recommendations for frictional and passive resistance to lateral loads are presented in the **Foundations** subsection of this report.

All wall backfill should be well compacted as outlined in the **Structural Fill** subsection of this report. Care should be taken to prevent the buildup of excess lateral soil pressures due to over-compaction of the wall backfill. This can be accomplished by placing wall backfill in 8-inch loose lifts and compacting the backfill with small, hand-operated compactors within a distance behind the wall equal to at least one-half the height of the wall. The thickness of the loose lifts should be reduced to accommodate the lower compactive energy of the hand-operated equipment. The recommended level of compaction should still be maintained.

Permanent drainage systems should be installed for retaining walls. Recommendations for these systems are found in the **Subsurface Drainage** subsection of this report. We recommend that we be retained to evaluate the proposed wall drain backfill material and observe installation of the drainage systems.

Structural Fill

General: Fill placed beneath foundations, pavement, or other settlement-sensitive structures should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is monitored by an experienced geotechnical professional or soils technician. Field monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction. The area to receive the fill should be suitably prepared as described in the **Site Preparation and Grading** subsection prior to beginning fill placement. Sloping areas to receive fill should be benched using a minimum 8-foot wide horizontal benches keyed into competent soils.

Materials: Structural fill should consist of a good quality, granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about three inches. All-weather fill should contain no more than five-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). Some of the more granular on-site soils may be suitable for use as structural fill; however, this will be highly dependent on the moisture content of the soil during construction. The use of

the on-site soils as structural fill during wet weather will be very difficult, if not impossible. We should be retained to evaluate all proposed structural fill material prior to placement.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to eight inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas and pavement subgrade should be compacted to a minimum of 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D-1557 Compaction Test procedure. The moisture content of the soils to be compacted should be within about two percent of optimum so that a readily compactable condition exists. It may be necessary to over-excavate and remove wet soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction and should be tested.

Slab-on-Grade

Slabs-on-grade should be supported on subgrade soils prepared as described in the **Site Preparation and Grading** subsection of this report. We recommend that all floor slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight of the material passing Sieve #200 for use as a capillary break. We recommend that the capillary break be hydraulically connected to the footing drain system to allow free drainage from under the slab.

A suitable vapor barrier, such as heavy plastic sheeting (6-mil minimum), should be placed over the capillary break material. An additional 2-inch-thick moist sand layer may be used to cover the vapor barrier. This sand layer is optional, and is intended to be used to protect the vapor barrier membrane and to aid in curing the concrete.

Pavements

Pavement subgrade preparation and structural filling where required, should be completed as recommended in the **Site Preparation and Grading** and **Structural Fill** subsections of this report. The pavement subgrade should be proof-rolled with a heavy, rubber-tired piece of equipment, to identify soft or yielding areas that require repair. The pavement section should be underlain by a minimum of six inches of clean granular pit run or crushed rock. We should be retained to observe the proof-rolling and recommend subgrade repairs prior to placement of the asphalt or hard surfaces.

Utilities

We recommend that underground utilities be bedded with a minimum six inches of pea gravel prior to backfilling the trench with on-site or imported material. Trenches within settlement sensitive areas should be compacted to 95% of the modified proctor as described in the **Structural Fill** subsection of this report. Trenches located in non-structural areas should be compacted to a minimum 90% of the maximum dry density. Trench backfill compaction should be tested.

Stormwater Infiltration

General: We performed two grain-size analyses on selected soil samples obtained within the site in accordance with The Stormwater Management Manual for Western Washington, as amended in 2014. Grain size analyses were performed on selected samples from Test Pit Three and Test Pit Four at 4.0 feet and 4.6 feet, respectively. The results of the sieve analyses are presented as figures 6 and 7. Based on the laboratory analysis, the soils encountered in our explorations within the proposed infiltration area meet the classification of sand in the USDA Textural Triangle.

Long-Term Infiltration Rate: An equation provided in Section 3.3.6.3 of the 2012 Stormwater Management Manual for Western Washington, as Amended in December 2014, was used to determine the infiltration capabilities of the site soil utilizing data from the grain-size analyses. Based on this equation and information obtained from the grain-size analyses, calculated initial short-term infiltration rates were 92.1 and 126 inches per hour for the native alluvial soils at depth. We also referenced Table 3.3.1 of the manual to provide an adequate correction factor to infiltration rates obtained from the above equation to calculate a long-term design rate. Correction factors of 0.90, 0.40, and 0.80 were utilized in this equation for CF_v, CF_t, CF_m, respectively. A total correction factor of 0.36 was applied to the most conservative sieve analysis calculated rate to determine the long-term design infiltration rate. The 92.1 inches per hour rate obtained from Sieve Two was utilized as the overall calculated infiltration rate.

Using the above correction factor, we calculated a long-term design infiltration rate of approximately 33.1 inches per hour for the native material encountered at the site. The alluvial gravelly fine to coarse sand soils encountered throughout the site should support a long-term infiltration rate of 33.1 inches per hour, however, we recommend that the long-term design rate shall not exceed 10 inches per hour. In our opinion, a design infiltration rate of 10 inches per hour could be utilized to design the on-site infiltration systems within the native alluvial site soils. We recommend that the base of any on-site infiltration systems be terminated within the native, granular soils. We anticipate that the infiltration systems should encounter these soils within approximately 2.0 to 2.7 feet below existing ground surface throughout the site. We should be retained during construction to evaluate the soils exposed in the infiltration systems to verify that the soils are appropriate for infiltration.

The stormwater manual recommends a minimum three-foot separation between the base of an infiltration system and any underlying bedrock, impermeable horizon, or groundwater. Groundwater was encountered in each of our explorations at depths of approximately 8.0 feet below the existing surface. Groundwater may impact the design and performance of infiltration systems on this site depending on design. If infiltration systems are proposed within five feet of the inferred groundwater table, mounding analyses should be completed to verify appropriate sizing.

We recommend that any proposed infiltration systems be placed as to not negatively impact any proposed or existing nearby structures and also meet all required setbacks from existing property lines, structures, and sensitive areas as discussed in the drainage manual. In general, infiltration systems should not be located within proposed fill areas within the site associated with site grading or retaining wall backfill as such condition could lead to failures of the placed fills and/or retaining structures. We should be retained to evaluate the infiltration system design and installation during construction.

Site Drainage

Surface Drainage: The finished ground surface should be graded such that stormwater is directed to an approved stormwater collection system. Water should not be allowed to stand in any areas where footings, slabs, or pavements are to be constructed. Final site grades should allow for drainage away from the residences. We suggest that the finished ground be sloped downward at a minimum gradient of three percent, for a distance of at least 10 feet away from the residences. Surface water should be collected by permanent catch basins and drain lines, and be discharged into an approproved discharge system away from the structures, property boundaries, or any sloping ground.

Subsurface Drainage: If groundwater seepage is encountered during construction, we recommend that the contractor slope the bottom of the excavation and collect the water into ditches and small sump pits where the water can be pumped out and routed into a permanent storm drain.

We recommend the use of footing drains around the structures. Footing drains should be installed at least one foot below planned finished floor elevation. The drains should consist of a minimum 4-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric. We recommend that the free-draining material consist of an 18-inch-wide zone of clean (less than three-percent fines), granular material placed along the back of walls. Pea gravel is an acceptable drain material. The free-draining material should extend up the wall to one foot below the finished surface. The top foot of backfill should consist of impermeable soil placed over plastic sheeting or building paper to minimize surface water or fines migration into the footing drain. Footing drains should discharge into tightlines leading to an approved collection and discharge point with convenient cleanouts to prolong the useful life of the drains. Roof drains should not be connected to wall or footing drains.

CONSTRUCTION MONITORING

We should be retained to provide construction monitoring services during the earthwork phase of the project to evaluate subgrade conditions, temporary cut conditions, fill compaction, and drainage system installation.

USE OF THIS REPORT

NGA has prepared this report for Mr. Rick Hanson and his agents, for use in the planning and design of the development on this site only. The scope of our work does not include services related to construction safety precautions and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. There are possible variations in subsurface conditions between the explorations and also with time. Our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule.

We recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

o-o-o

It has been a pleasure to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

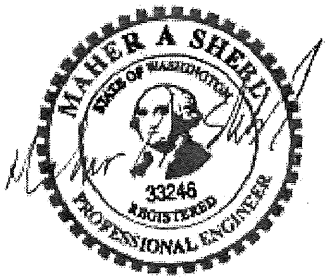
NELSON GEOTECHNICAL ASSOCIATES, INC.

Katie Brower

Katelyn S. Brower, GIT
Staff Geologist I

Carston Curd

Carston T. Curd, GIT
Staff Geologist II



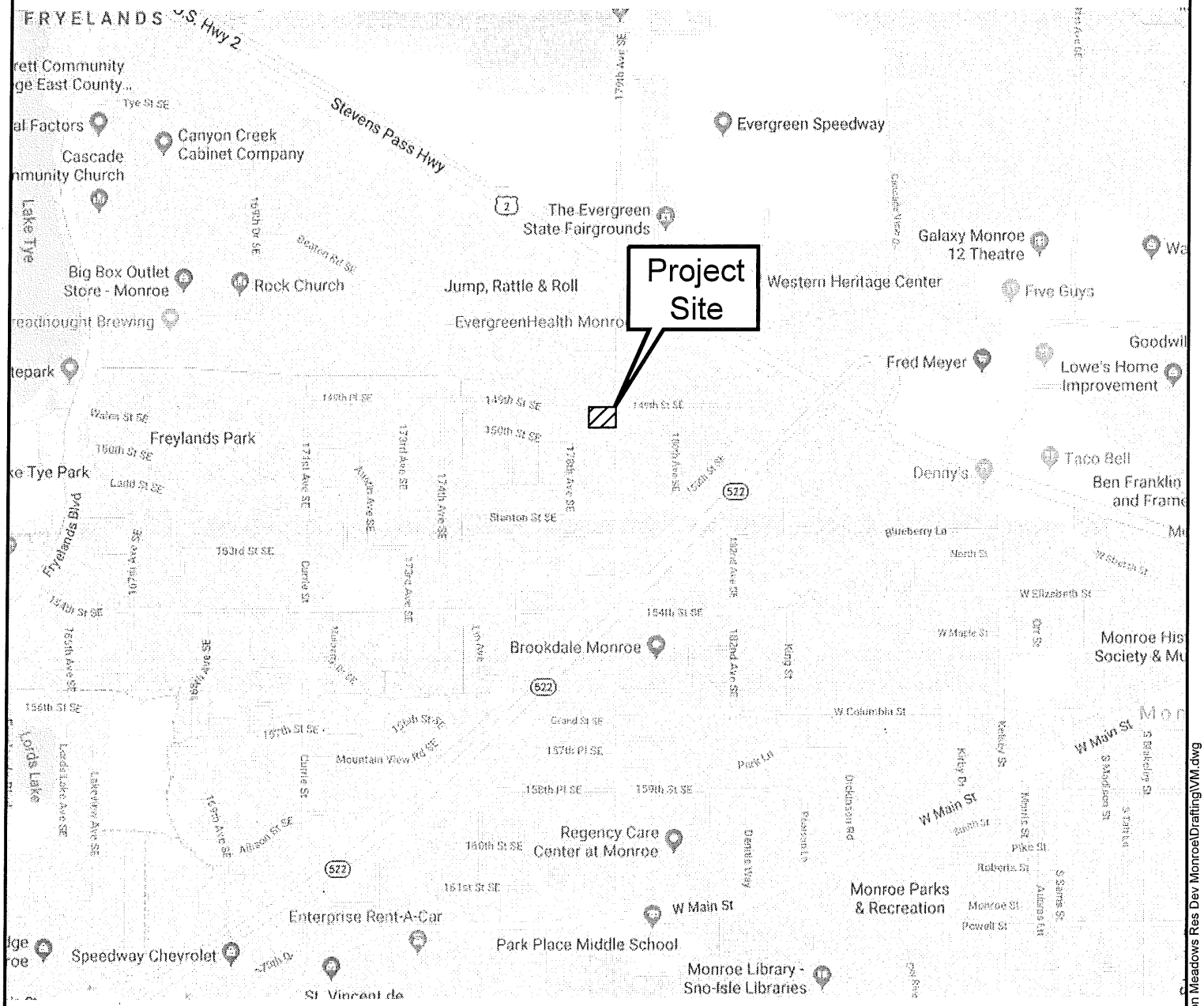
Maher A. Shebl, PhD, PE, M.ASCE
Senior Engineer

KSB:CTC:MAS:dy

Seven Figures Attached

VICINITY MAP

Not to Scale

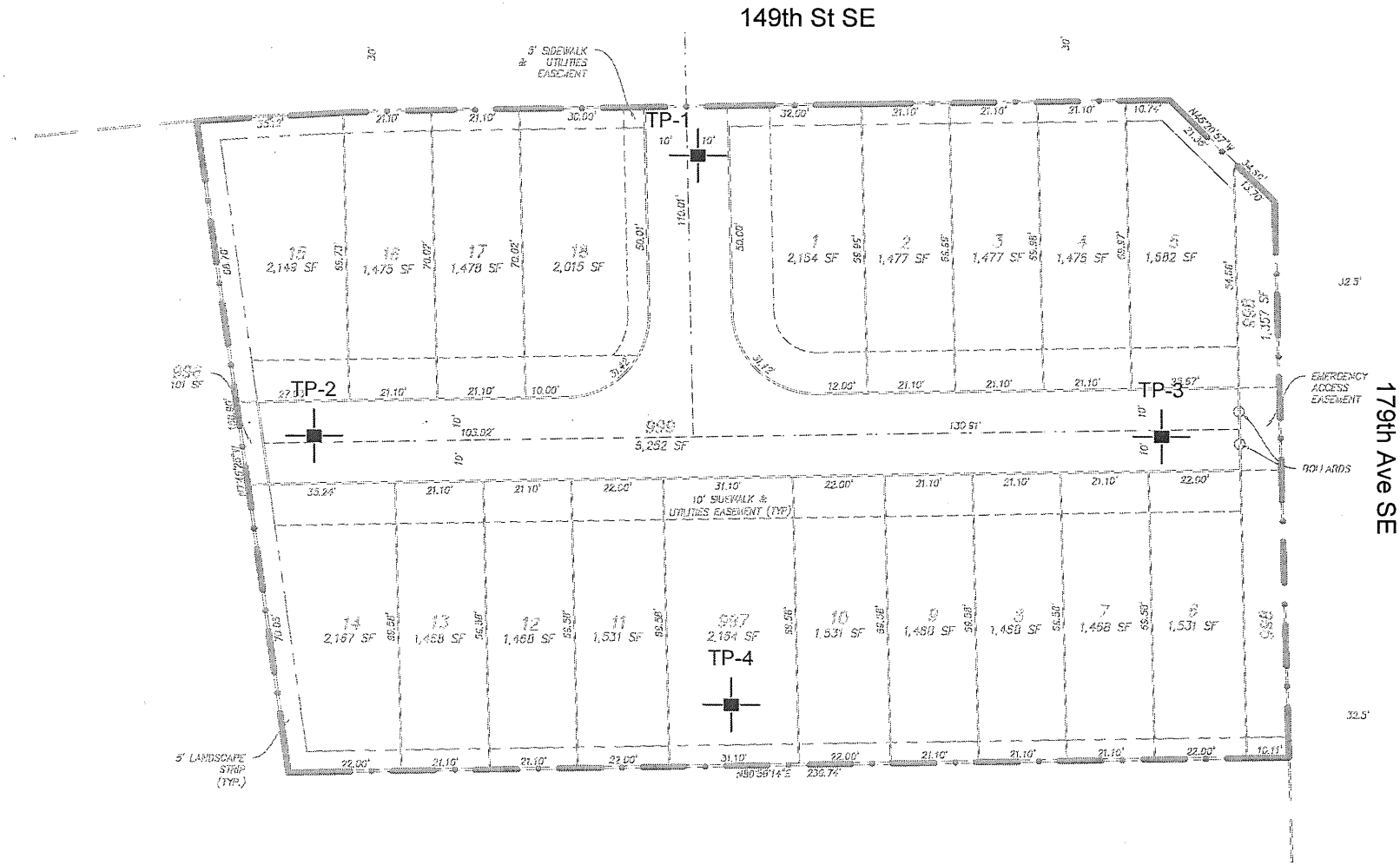


Monroe, WA

Project Number 1085919	Stanton Meadows Development Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS Woodinville Office 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax: 481-2510 www.nelsongeotech.com East Wenatchee Office 5526 Industry Lane, #2 East Wenatchee, WA 98802 (509) 665-7696 / Fax: 665-7692	No.	Date	Revision	By	CK
Figure 1			1	4/22/19	Original	DPN	CTC

\\hillcompany\2019 NGA Project Folders\110859-19 Stanton Meadows Res Dev Monroe\Drafting\VM.dwg

Site Plan



LEGEND

Property line

TP-1

Number and approximate location of test pit

0 40 80

Approximate Scale: 1 inch = 40 feet

Reference: Site plan based on a plan dated November 8, 2018 titled "Preliminary Subdivision of Stanton Meadows," prepared by Land Resolutions.

No.	Date	Revision	By	CK
1	4/22/19	Original	DPN	CTC

Project Number 1085919

Figure 2

Stanton Meadows Development Site Plan

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2310
East Wenatchee Office
5528 Industry Lane, #2
East Wenatchee, WA 98802
(509) 665-7696 / Fax: 665-7692
www.nelsongeotech.com

\\hill\company\2019 NGA Project Folders\10859-19 Stanton Meadows Res Dev Monroe\Drafting\SP.dwg

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.
2) Soil classification using laboratory tests is based on ASTM D 2488-93.
3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water.

Wet - Visible free water or saturated, usually soil is obtained from below water table

Project Number 1085919	Stanton Meadows Development Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS
Figure 3		Woodinville Office: 17311-135th Ave, NE, A-500, Woodinville, WA 98072, (425) 486-1669 / Fax: 481-2510 — East Wenatchee Office: 5526 Industry Lane, #2, East Wenatchee, WA 98802, (509) 665-7698 / Fax: 665-7692 — www.nelsongeotech.com

No.	Date	Revision	By	CK
1	4/22/19	Original	DPN	CTC

\\hillcompany\2019 NGA Project Folders\10859-19 Stanton Meadows Res Dev Monroe\Drafting\SC.dwg

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 0.5		GRASS UNDERLAIN BY DARK BROWN ORGANIC RICH, SILTY FINE TO MEDIUM SAND WITH ROOTS AND ORGANICS (LOOSE, MOIST) (**FILL**)
0.5 – 2.7		LIGHT BROWN TO BROWN GRAVELLY FINE TO COARSE SAND WITH TRACE IRON OXIDE MOTTLING. (LOOSE, MOIST) (**FILL**)
2.7 – 8.2	GP	GRAY GRAVEL AND FINE TO COARSE SAND WITH TRACE SILT, COBBLES, AND IRON OXIDE RIND (MEDIUM DENSE TO DENSE, MOIST TO WET)
		SAMPLES WERE COLLECTED AT 2.5, 3.0, 6.0, 7.2, AND 8.2 FEET GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 8.2 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 8.2 FEET ON 4/5/2019
TEST PIT TWO		
0.0 – 0.7		GRASS UNDERLAIN BY DARK BROWN, SILTY FINE TO MEDIUM SAND WITH ROOTS AND ORGANICS (LOOSE, MOIST) (**FILL**)
0.7 – 2.7		REDISH-BROWN SILTY FINE TO MEDUM SAND (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
2.7 – 3.6	ML	GRAY TO LIGHT BROWN SILT WITH INTERBEDDED FINE TO MEDIUM SAND AND CLAY (MEDIUM DENSE, MOIST TO WET)
3.6 – 8.0	GP	GRAY, GRAVEL AND COARSE SAND WITH COBBLES, INTERBEDDED WITH FINE TO COARSE SAND, IRON OXIDE RIND ENCOUNTERED AT 5.1 FEET (MEDIUM DENSE TO DENSE, WET)
		SAMPLES WERE COLLECTED AT 1.5, 2.7, 4.5, 6.0 AND 8.0 FEET GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 7.9 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 8.0 FEET ON 4/5/2019
TEST PIT THREE		
0.0 – 0.4		GRASS UNDERLAIN BY DARK BROWN, SILTY FINE TO MEDIUM SAND WITH ROOTS AND ORGANICS (LOOSE, MOIST) (**FILL**)
0.4 – 2.0		BROWN, SILTY FINE TO MEDIUM SAND WITH TRACE CLAY (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
2.0 – 3.3	SM	LIGHT GRAY TO TAN SILTY FINE SAND WITH TRACE CLAY (LOOSE TO MEDIUM DENSE, MOIST TO WET)
3.3 – 3.5	SP-SM	BLUE GRAY TO GRAY FINE SAND WITH SILT AND IRON OXIDE RIND AT 3.5 FEET (LOOSE TO MEDIUM DENSE, MOIST)
3.5 – 8.0	GP	GRAY GRAVEL AND FINE TO COARSE SAND WITH TRACE SILT (DENSE TO VERY DENSE, WET)
		SAMPLES WERE COLLECTED AT 1.0, 2.5, 4.0 AND 8.0 FEET GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 8.0 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 8.0 FEET ON 4/5/2019

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT FOUR		
0.0 – 0.6		GRASS UNDERLAIN BY DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, AND ORGANICS (LOOSE, MOIST) (**FILL**)
0.6 – 2.7		BROWN, SILTY FINE TO MEDIUM SAND WITH TRACE CLAY (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
2.7 – 6.9	GP	LIGHT GRAY TO TAN GRAVEL AND FINE TO COARSE SAND WITH TRACE SILT, IRON OXIDE MOTTLING AND CLAY. (DENSE TO VERY DENSE, MOIST TO WET)
6.9 – 7.9	SM	GRAY, SILTY FINE TO MEDIUM SAND WITH GRAVEL AND COBBLES (DENSE TO VERY DENSE, WET)
		SAMPLES WERE COLLECTED AT 1.5, 3.0, 4.6, AND 7.5 FEET GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 7.9 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 7.9 FEET ON 4/5/2019

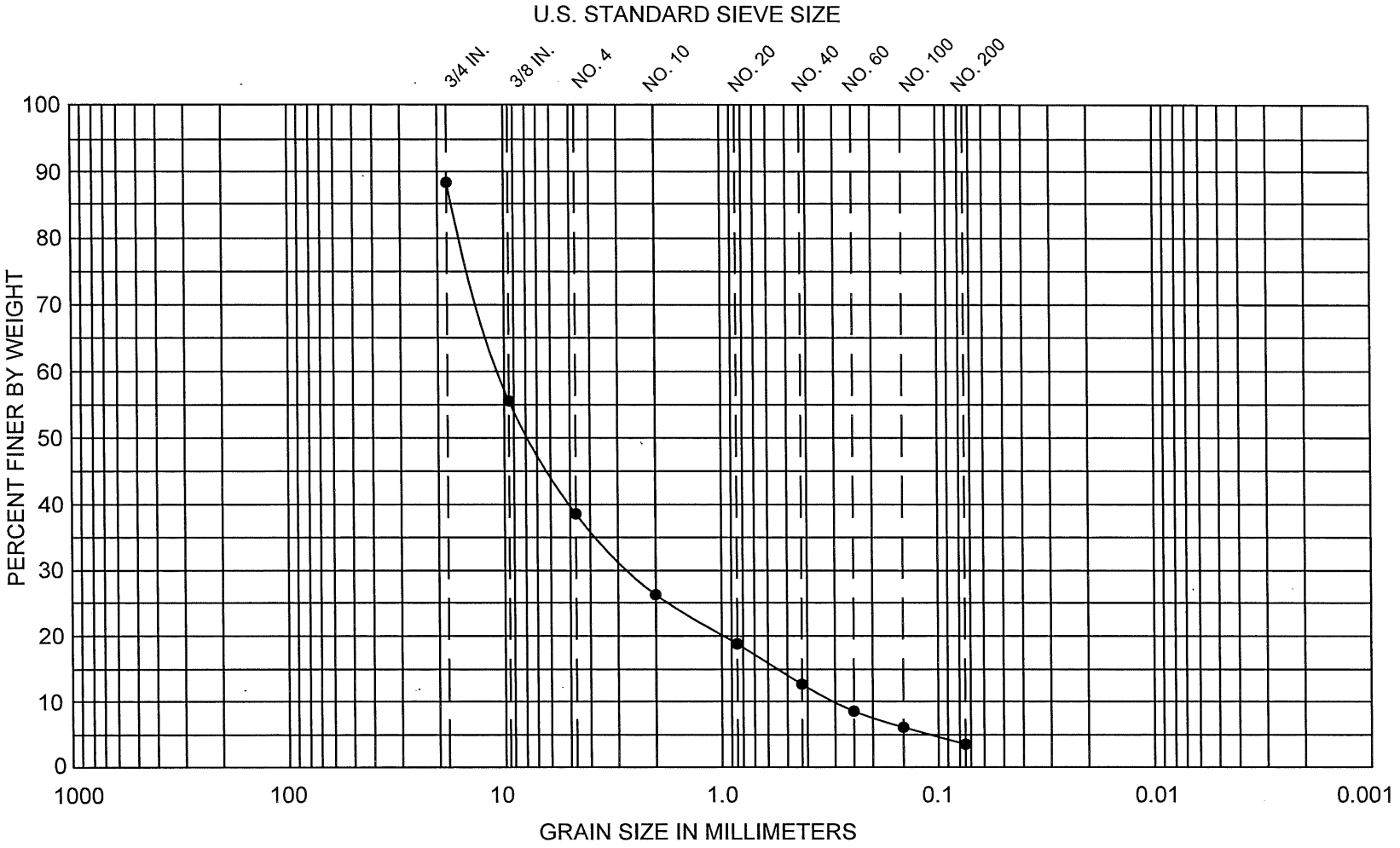
Project Number
1085919

Figure 6

Stanton Meadows
Development
Sieve Analysis

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2510
East Wenatchee Office
5526 Industry Lane, #2
East Wenatchee, WA 98802
(509) 665-7696 / Fax: 665-7692
www.nelsongeotech.com

No.	Date	Revision	By	CK
1	4/26/19	Original	DPN	CTC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

U.S.C. SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION	SOIL DISTRIBUTION
●GP	TP-3	4.0 feet	Gravel with fine to coarse sand and trace silt	Gravel = 62% Sand = 35% Silt/Clay = 3%

\\hill\company\2019 NGA Project Folders\10859-19 Stanton Meadows Res Dev Monroe\Drafting\Sieve.dwg

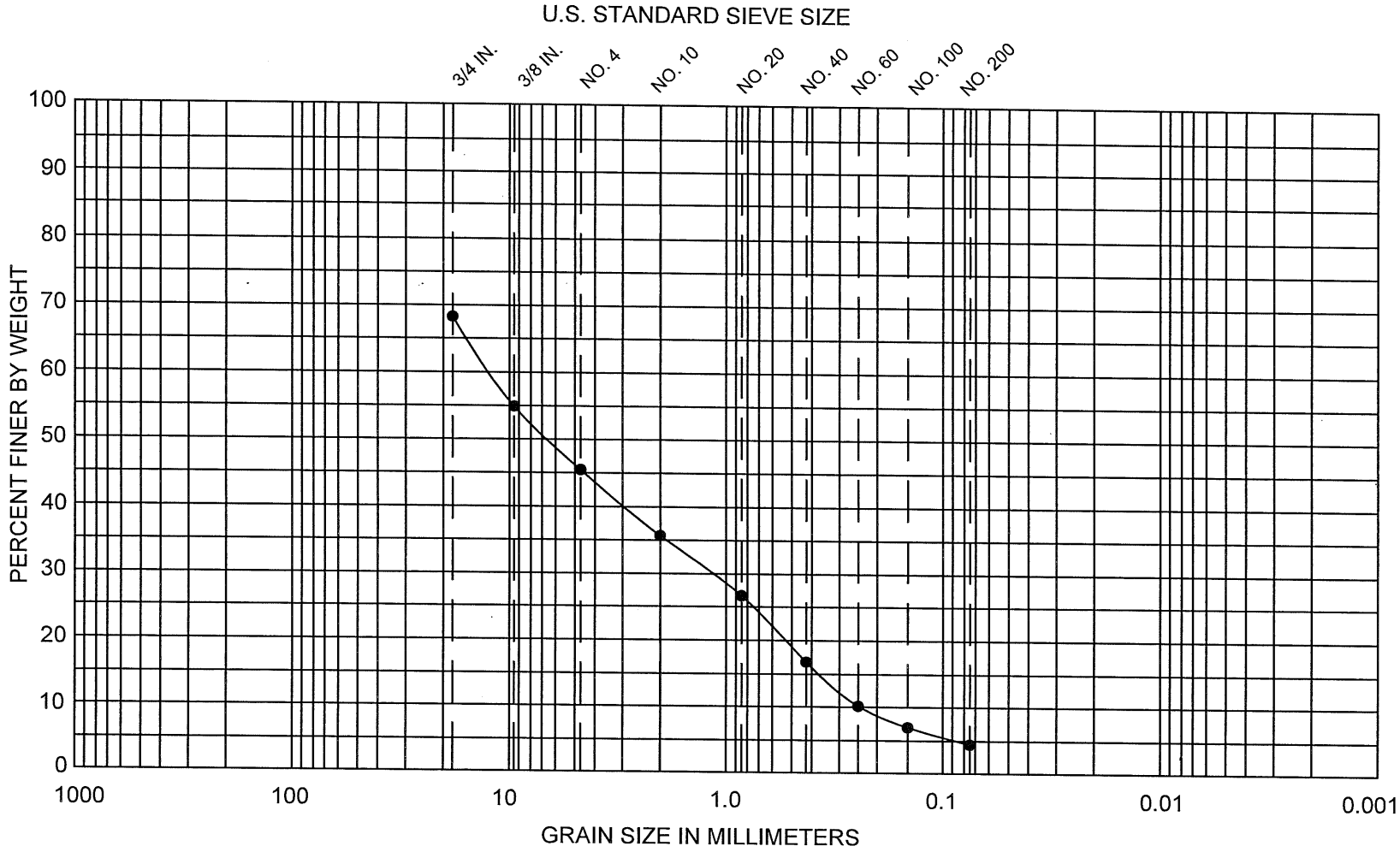
Project Number
1085919

Figure 7

Stanton Meadows
Development
Sieve Analysis

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2310
East Wenatchee Office
5526 Industry Lane, #2
East Wenatchee, WA 98802
(509) 665-7696 / Fax: 665-7692
www.nelsongeotech.com

No.	Date	Revision	By	CK
1	4/26/19	Original	DPN	CTC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

U.S.C. SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION	SOIL DISTRIBUTION
●GP	TP-4	4.6 feet	Fine to coarse, sandy gravel with trace silt	Gravel = 55% Sand = 40% Silt/Clay = 5%

\\hill\company\2019 NGA Project Folders\10859-19 Stanton Meadows Res Dev Monroe\Drafting\Sieve.dwg