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Preliminary Storm Drainage Report

Belmont Heights PRD
CPH Project No. 0035-18-027

Monroe, WA

Prepared for:

SSHI, LLC dba D.R. Horton
12910 Totem Lake Blvd NE,
Suite 220
Kirkland, WA 98034

Prepared by:

CPH Consultants
Matt Hough, PE
Casey Torres, EIT
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Redmond, WA 98052

January 31, 2019

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PRELIMINARY STORM DRAINAGE REPORT

FOR

BELMONT HEIGHTS PRD

MONROE, WA

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SECTION 1 – PROJECT OVERVIEW

This Preliminary Storm Drainage Report (SDR) describes the engineering analysis of the surface water conditions, proposed development improvements, and required storm drainage facilities for the *Belmont Heights PRD* project located in Monroe, Washington. The report summarizes the design criteria for the storm drainage collection systems, associated flow control (i.e. detention) and water quality facilities, and temporary construction Best Management Practices (BMPs) proposed for the project. Figure 1 (Vicinity Map) illustrates the general location of the project site. Figures 2 and 3 of this report (see *Figures* section) illustrate the existing (i.e., pre-developed) and proposed developed conditions of the project area, respectively.

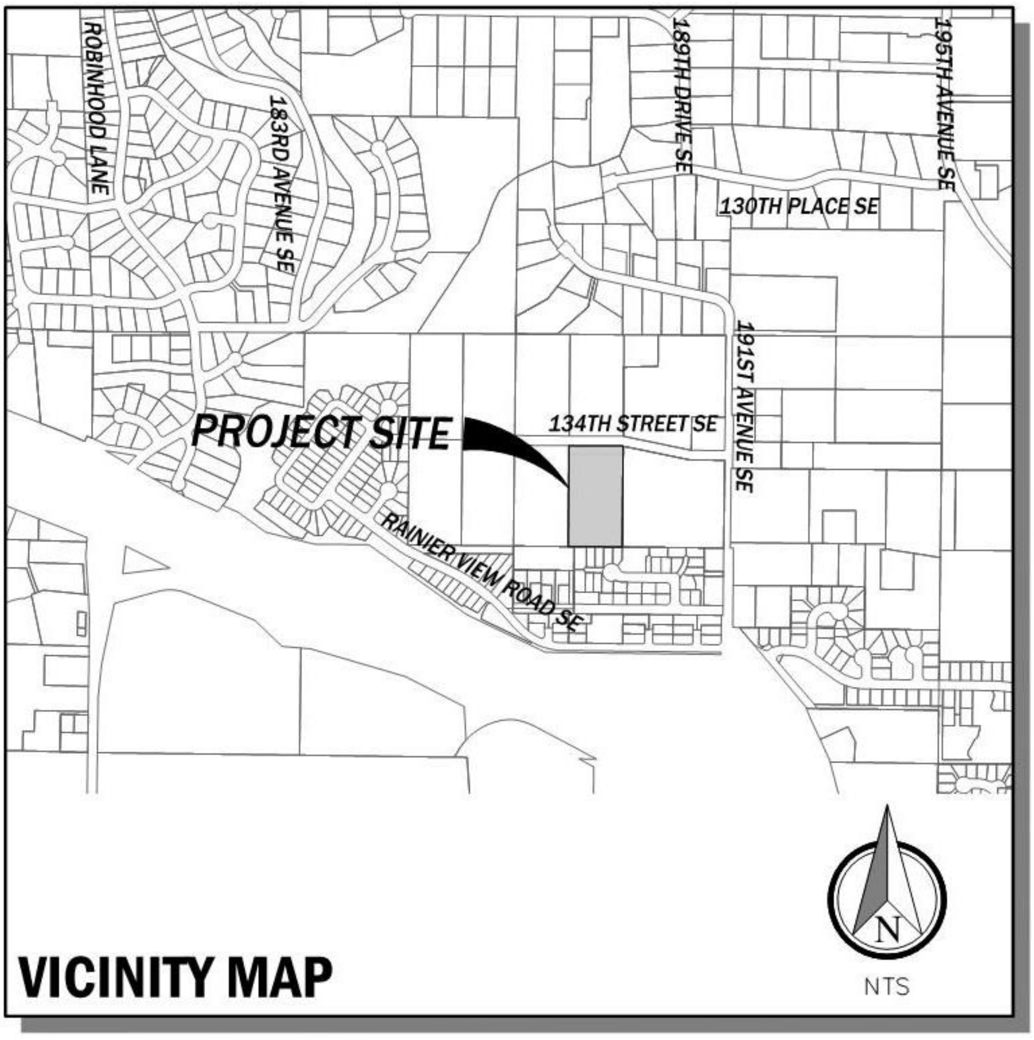


Figure 1 - Vicinity Map

The *Belmont Heights PRD* project proposes to develop 19 new single-family residential lots, per the requirements of UR9600 zoning, through the City of Monroe's planned residential development process (PRD). The development will include associated roadway, storm drainage, sewer, and water infrastructure improvements to serve these proposed lots. It will provide park and recreational open space onsite per PRD guidelines and will improve its 134th Street SE frontage with new pavement, curb and gutter, planter, and sidewalk. The project site is 4.75-acres and consists of one developed property containing a single-family residence and associated structures within the Monroe city limits. Existing access to the project site is provided via 134th Street SE along the northern boundary of the site. The site is more generally located in portions of the NW ¼ and NE ¼ of Section 36, Township 28 North, Range 6 East, W.M., Snohomish County, Washington.

The site generally descends from the northeastern property corner to the southwest with a total relief of approximately 75 feet. Surface runoff primarily sheet flows southwesterly across the property toward the adjacent parcels to the west and south. The parcels to the south contain a gravel trench along the north property boundaries which collects runoff from the project site and conveys it to a detention pond serving the Trombley Hill development. A downstream analysis has been completed as part of this report in Section 3 to confirm downstream capacity for developed site runoff.

SECTION 2 – EXISTING CONDITIONS SUMMARY

The *Belmont Heights PRD* project site is comprised of one parcel (Tax Parcel # 28063600101900) with a total area of approximately 4.75 acres. It is located within the French Creek Drainage Basin, part of the Snohomish Watershed, WRIA 07. The site is bordered by single-family residences on all sides with access off of 134th Street SE to the north. The Toivo Ridge neighborhood borders the site to the south and provides a discharge point for stormwater runoff. The existing parcel contains a single-family residence and its associated structures. The parcel has a large, fenced lawn area adjacent to the frontage road. The southern portion of the parcel consists of unmaintained vegetation.

The general soil classification of the developable portion of the site is characterized by the Natural Resources Conservation Service (NRCS) as Tokul gravelly medial loam, with 0 to 15 percent slopes. A geotechnical engineering study was performed by Terra Associates, Inc. to evaluate the suitability of the site for the proposed development of a residential subdivision. They reported that observed soils were "glacial deposits comprised predominantly of medium dense to dense silty sand with gravel interpreted to be weathered till overlying unweathered till deposits consisting of dense to very dense, moderately- to strongly-cemented silty sand with gravel and occasional cobbles." The site is not a seismic hazard area and the developable portion of the site is not an erosion hazard area. Infiltration/LID measures are not feasible on this site due to the low permeability of the glacial till soils. Overall, it was determined that there are no geotechnical considerations that preclude development of the site as currently planned. A copy of the geotechnical report along with the NRCS Web Soil Survey data are provided in Appendix A.

The site generally descends from the northeastern property corner to the southwest with a total relief of about 75 feet. Surface runoff primarily sheet flows southwesterly across the property toward the adjacent parcels to the west and south. The parcels to the south (part of the Toivo Ridge deveopment) contain a gravel trench along the north property boundaries which collects runoff from the project site and conveys it southeast to a detention pond serving the Trombley Hill development. A downstream analysis has been completed as part of this report in Section 3 to confirm downstream capacity for developed site runoff. There are no wetlands or streams on-site. See Figure 2 for a map of existing site conditions.

SECTION 3 – OFF-SITE ANALYSIS

This section summarizes the analysis of the onsite and offsite drainage conditions for the project. The methodology of the analysis and reporting of these conditions is in general accordance with the Department of Ecology's 2014 Stormwater Management Manual for Western Washington (SWMM). This analysis includes research of available information, a site visit, an upstream analysis, and a downstream analysis. Research sources include aerial photography, GIS information, survey data, and as-built plans for the adjacent Toivo Ridge neighborhood provided by the City of Monroe.

Site Visit

A site visit was completed on January 23, 2019 at 12:00 PM to observe drainage conditions in the project vicinity and to inspect the downstream conveyance system and assess its capacity for mitigated site discharge. The weather was 48° and partly cloudy. There had been showers earlier in the day totaling 0.60" of precipitation and 0.42" of precipitation had fallen the previous day.

Upstream Analysis

Runoff from the northwest portion of the adjacent property to the east flows onto and through the project site toward the southwest as sheet flow or shallow, subsurface flow. This property is a large residential parcel consisting of a home, associated structures, and a large pasture area. The tributary basin is approximately 2.12 acres of pasture.

The 134th Street SE right-of-way fronts the northern property boundary of the site. The properties to the north of the right-of-way are part of the *Sweetbriar at Monroe* development. Runoff from these properties is collected and conveyed to a detention vault serving the development. Runoff from the property to the northeast is collected in a ditch along the north side of 134th Street SE and conveyed west until discharging to the stormwater system serving *Sweetbriar at Monroe*. 134th Street SE along the frontage of the property is currently a half-street road section which drains north into the Sweetbriar at Monroe stormwater system. Thus, there is no upstream runoff from properties to the north.

The properties to the west and south are at lower elevations than the project site and thus no upstream runoff from these areas flows onto the site.

Downstream Analysis

Site runoff is intercepted by a gravel trench with a perforated pipe located approximately 5 feet south of the southern property boundary. The trench was constructed as part of the Toivo Ridge development. The perforated pipe discharges to an existing catch basin near the southwest property corner. This structure is the connection point for mitigated project runoff. The structure discharges runoff south through a series of catch basins and underground conveyance pipes. The conveyance system continues to convey flows west in the 137th St SE right-of-way and then southeast in the Rainier View Rd SE right-of-way before discharging to the existing detention pond in Tract 955 of Trombley Hills through a rock armored outfall. The detention pond discharges to the southwest and outfalls to a wetland in a forested area which ultimately discharges to Cripple Creek. See Appendix D for photos, a downstream map, and a summary table of the downstream system.

The downstream conveyance system appears to be properly functioning with no observed evidence of erosion or insufficient capacity. Runoff from the project will meet flow control standards set forth by the Department of Ecology 2014 Stormwater Management Manual for Western Washington. This will result in decreased peak flows leaving the site for all major storm events and therefore is not expected to have an adverse impact on the downstream system.

SECTION 4 – Permanent Stormwater Control Plan

Performance Standards, Goals and Facility Proposals

The storm drainage analysis and facilities design for this project are proposed in general accordance with the 2012 Department of Ecology Stormwater Management Manual for Western Washington, as amended in December 2014, as specified by current Monroe Municipal Code (MMC), section 15.01.025. The project is classified as New Development and will result in greater than 5,000 square-feet of new impervious surface, therefore all nine Minimum Requirements for stormwater management specified by the manual are applicable.

The hydrologic analysis of the runoff conditions for the project site was performed using the Western Washington Hydrologic Model 2012 (WWHM) software to generate peak design flow rates and volumes. A combined detention/water quality pond is proposed in the southern portion of the site to treat and detain runoff. Appendix B contains the WWHM model results for the proposed stormwater controls and water quality facilities proposed for the project. See Figure 7 for the stormwater pond details.

Pre-developed Site Hydrology

There is upstream runoff from 2.12 acres that flows through the project site. This area is to the east of the project boundary and enters the site as sheet flow and shallow, subsurface flow. Runoff from this upstream area will be collected directly into the project's conveyance system, routed to the pond, treated, and detained along with the rest of the project's developed runoff. This basin will be modeled in its existing condition as there are no land cover modifications proposed. The total developed area for on-site and frontage improvement is 5.01 acres and will be modeled as forest for the pre-developed condition. Table 4.1 shows the pre-developed land use inputs used in the WWHM model and Table 4.2 summarizes the resulting peak design runoff rates. See Figure 4 for pre-developed drainage basins.

Table 4.1 – Pre-developed Drainage Sub-basins

Basin	Land Use Area (ac)				
	Forested	Grass	Pasture	Impervious	Total
Predeveloped Site	5.01	0.00	0.00	0.00	5.01
Upstream	0.00	0.00	2.12	0.00	2.12
Total Area (ac)	**5.01**	**0.00**	**2.12**	**0.00**	**7.13**

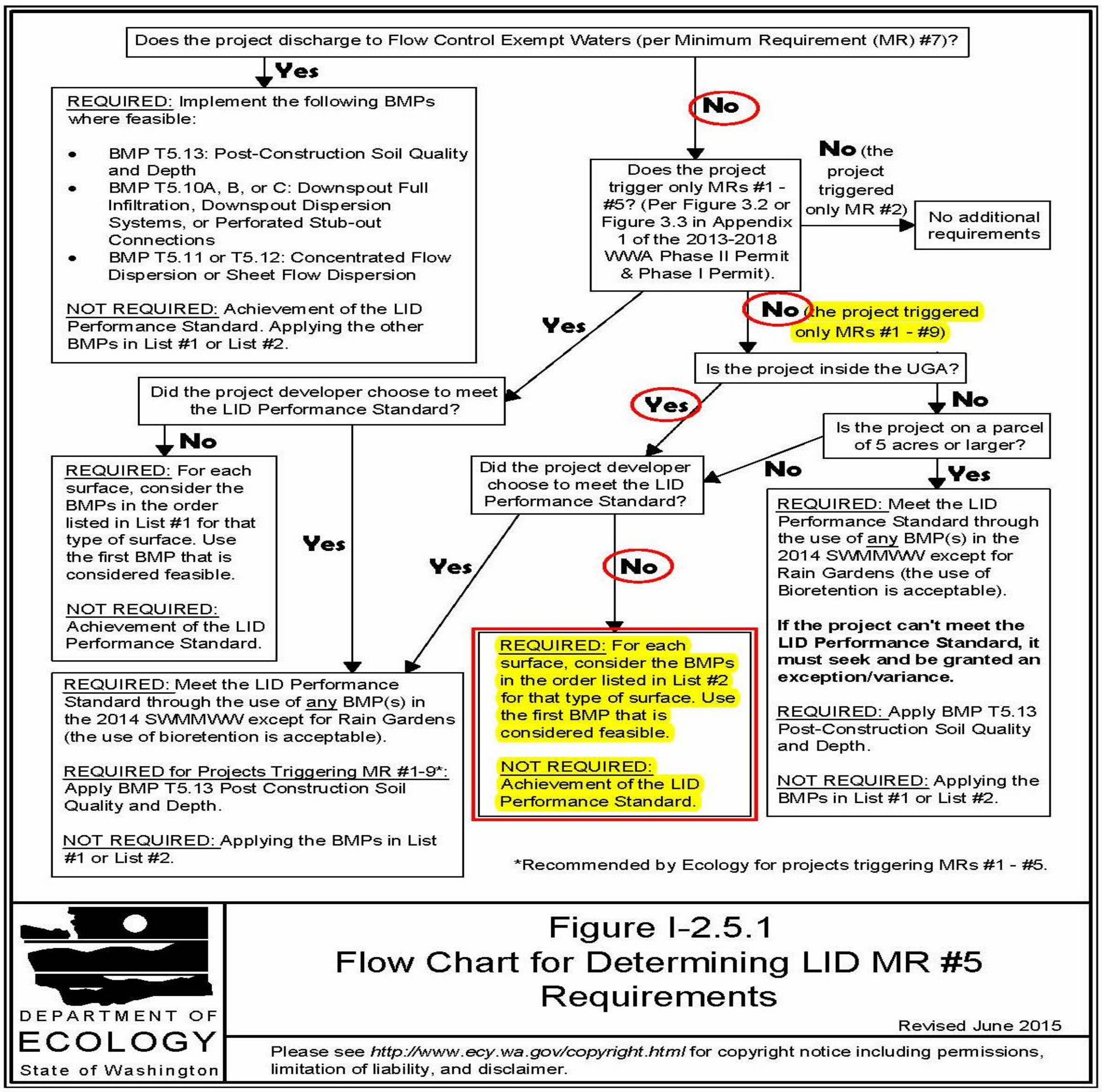
Table 4.2 – Pre-developed Peak Flows (at WWHM point of compliance)

Event	Flow Rate (cfs)
2-yr	0.27
10-yr	0.59
25-yr	0.81
50-yr	1.00
100-yr	1.22

On-Site Stormwater Management

Minimum Requirement #5 addresses the application of on-site stormwater management BMPs with the intent to "infiltrate, disperse, and retain stormwater runoff on-site to the extent feasible without causing flooding or erosion impacts." Requirements for this project are specified on Table I-2.5.1 and Figure I-2.5.1. These are included here with the relevant text highlighted.

Figure I-2.5.1 Flow Chart for Determining LID MR #5 Requirements



2014 Stormwater Management Manual for Western Washington

Volume I - Chapter 2 - Page 60

Table I-2.5.1 On-Site Stormwater Management Requirements for Projects Triggering Minimum Requirements #1 - #9

Project Type and Location	Requirement
New development on any parcel inside the UGA, or new development outside the UGA on a parcel less than 5 acres	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911); or List #2 (applicant option).
New development outside the UGA on a parcel of 5 acres or larger	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911).
Redevelopment on any parcel inside the UGA, or redevelopment outside the UGA on a parcel less than 5 acres	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911); or List #2 (applicant option).
Redevelopment outside the UGA on a parcel of 5 acres or larger	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911).
Note: This table refers to the Urban Growth Area (UGA) as designated under the Growth Management Act (GMA) (Chapter 36.70A RCW) of the State of Washington. If the Permittee is located in a county that is not subject to planning under the GMA, the city limits shall be used.	

The feasibility of the BMPs in DOE List #2 have been evaluated for the *Belmont Heights PRD* project as a new development inside the UGA. BMPs listed were considered in order for each type of surface to determine if their use/application for this project was feasible based on the following criteria:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and
2. Competing Need Criteria listed in Chapter V-5 – On-Site Stormwater Management.

Lawn and landscaped areas:

1. **Post-Construction Soil Quality and Depth in accordance with BMP T5.13**

   This BMP is feasible. All soils in lawn and landscaped areas will meet the design guidelines of BMP T5.13. This will be accomplished through one or more of the following implementation methods identified in the manual:

   a. retention of undisturbed native vegetation and soil, or
   b. amendment of existing site topsoil, or
   c. stockpiling and reuse of existing topsoil, or import of approved topsoil mix.

Roofs:

1. **Full Dispersion in accordance with BMP T5.30, or Downspout Full Infiltration Systems in accordance with BMP T5.10A**

These BMPs are not feasible. The site plan, which is in accordance with City of Monroe PRD requirements, does not retain the minimum amount of native vegetation required to apply the Full Dispersion BMP. There are also no feasible locations on site where the required vegetated flowpath length can be accommodated. The glacial till soil on site exhibits low permeability and is not a suitable receptor for infiltration or retention facilities.

2. **Bioretention facilities in accordance with BMP T7.30**

   This BMP is not feasible. The glacial till soil on site exhibits low permeability and is not a suitable receptor for infiltration or retention facilities.

3. **Downspout Dispersion Systems in accordance with BMP T5.10B**

   This BMP is not feasible. The proposed lots, designed in accordance with City of Monroe PRD requirements, are not large enough to accommodate the vegetated flow path required for dispersion.

4. **Perforated Stub-out Connections in accordance with BMP T5.10C**

   This BMP is not feasible. The glacial till soil on site exhibits low permeability and is not a suitable receptor for infiltration or retention facilities.

Other Hard Surfaces:

1. **Full Dispersion in accordance with BMP T5.30**

   This BMP is not feasible. The site plan, which is in accordance with City of Monroe PRD requirements, does not retain the minimum amount of native vegetation required to apply the Full Dispersion BMP. There are also no feasible locations on site where the required vegetated flowpath length can be accommodated.

2. **Permeable Pavement in accordance with BMP T5.156**

   This BMP is not feasible. The glacial till soil on site exhibits low permeability and is not a suitable receptor for infiltration or retention facilities.

3. **Bioretention facilities in accordance with BMP T7.30**

   This BMP is not feasible. The glacial till soil on site exhibits low permeability and is not a suitable receptor for infiltration or retention facilities.

4. **Sheet Flow Dispersion in accordance with BMP T5.12, or Concentrated Flow Dispersion in accordance with BMP T5.11**

   This BMP is not feasible. The proposed lots, designed in accordance with City of Monroe PRD requirements, are not large enough to accommodate the vegetated flowpath required for dispersion.

The Geotechnical Report prepared by Terra Associates, Inc. (see Appendix A) specifically addresses the application of on-site stormwater management BMPs. In the Infiltration section of the report, Terra concludes that, "Based on our study, it is our opinion that on-site infiltration is not a feasible alternative for management of site stormwater due to the presence of relatively-impermeable till and till-like soils at relatively shallow depths beneath the ground surface."

Developed Site Hydrology

The Standard Flow Control Requirement, part of Minimum Requirement #7, will be applied and states that, "Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow."

Developed site conditions within the study area were modeled based on the sub-basin configurations shown in Figure 5 and the land use covers summarized in Table 4.3. The residential lots were modeled based on an expected maximum 60 percent impervious coverage as allowed by Monroe Municipal Code (MNC) Bulk Requirements Chapter 18.10.140. Impervious road and sidewalk surface, both on-site and frontage, was calculated from the proposed footprint shown on the improvement plans. The remaining lot and open space area was modeled as grass. There is a small area of frontage improvements that cannot drain to the pond due to grade restrictions and is modeled as bypass area in WWHM. The upstream basin was modeled in its existing condition as there is no land cover modification proposed for this area.

The combined water quality/detention pond proposed for this project contains 8.0 feet of live storage and 4.0 feet of dead storage. The provided detention volume at the top of the flow control riser is 1.64 acre-feet, exceeding the 1.53 acre-feet required as calculated in WWHM. Flow control is provided by an 18" riser pipe with a three-orifice design used to meet the applicable standards.

Table 4.3 shows the developed land use inputs used in the WWHM model. Table 4.4 summarizes the peak design flow rates in the developed condition, both unmitigated and mitigated.

Table 4.3- Developed Drainage Sub-basins

Basin	Land Use Area (ac)				
	Forested	Grass	Pasture	Impervious	Total
Developed (To Pond)	0.00	2.18	0.00	2.72	4.90
Upstream Flow-through	0.00	0.00	2.12	0.00	2.12
Frontage Bypass	0.00	0.01	0.00	0.10	0.11
Total Area (ac)	**0.00**	**2.19**	**2.12**	**2.82**	**7.13**

Table 4.4 – Developed Peak Flows

Event	Unmitigated Pond Inflow (cfs)	Mitigated Pond Discharge (cfs)	Frontage Bypass (cfs)	Peak Flow at Point of Compliance (cfs)
2-yr	1.81	0.14	0.05	0.17
10-yr	3.26	0.25	0.09	0.28
25-yr	4.18	0.32	0.11	0.35
50-yr	4.95	0.39	0.12	0.41
100-yr	5.80	0.46	0.14	0.47

Conveyance System Analysis and Design

The project proposes to collect on-site runoff and convey it to the stormwater pond prior to release offsite. Surface runoff will be collected by roof drains, roadway and yard inlets, and a system of below grade pipes on the site. These systems convey runoff to the onsite combined water quality/detention pond for treatment and flow control.

An analysis of the capacity of the conveyance facilities for the project has been performed using a standard backwater approach. Design flows for this conveyance analysis were generated using the Rational Method for a 100-year design storm. The completed backwater analysis confirms that the proposed conveyance systems as designed contain the Rational design flows without overtopping catch basin/manhole inlets. The rational and backwater calculations are provided in Appendix C of this report, and Figure 6 displays the sub-catchment areas used for the Rational calculations.

Water Quality Treatment

Basic water quality treatment is required for surface water runoff from all new pollution generating surfaces created with development of the site per Minimum Requirement #6. Treatment will also be provided for flows from the upstream basin because its runoff will be mixed with developed site runoff. The minimum required wetpool volume calculated from WWHM (91% of total runoff volume) is 0.2462 acre-feet, or 10,724 cubic feet. Water quality treatment will be provided through the application of a wetpond in the eastern cell of the stormwater pond. There is 4.0' of dead storage in the pond which provides approximately 23,160 cubic feet of wetpond volume.

SECTION 5 – Construction Stormwater Pollution Prevention Plan

Storm Water Pollution Prevention Plan (SWPPP)

1. *Mark Clearing Limits*
   To prevent disturbance of project areas not designated for construction, a construction clearing limits fence or silt fence will be installed by the Contractor along the perimeter of the project site to protect existing native area outside of the mitigation area. These fences will be installed in accordance with the details and specifications provided in the Plans prior to any clearing and grading activities.

2. *Establish Construction Access*
   Heavy truck and equipment access during construction shall be limited to locations from 191st Ave SE. The contractor shall employ appropriate BMP measures to prevent transport of sediment offsite by motor vehicles.

3. *Control Flow Rates*
   The contractor will be responsible for installing temporary erosion control BMP's to control the release rate and water quality of surface water from active construction areas.

4. *Install Sediment Controls*
   On-site sediment retention will be controlled by a combination of silt fences, temporary interceptor trenches, and the proposed detention pond as shown on the Plans. The contractor shall inspect and provide regular maintenance of these facilities throughout the duration of construction to ensure maximum sediment control.

5. *Stabilize Soils*
   Temporary and permanent cover measures will be provided by the Contractor to protect disturbed areas. Straw mulching is typically used to provide temporary protection from erosion at exposed soil areas. Plastic covering may also be used in order to protect cut and fill slopes, and/or to encourage grass growth in newly seeded areas. Disturbed areas that remain unworked for at least 7 days will be seeded and mulched to provide permanent cover measure and to limit erosion potential.

   Water will be used by the Contractor as allowed by local agency regulations and applicable SWMM standards to prevent wind transport of exposed soils. Exposed soils will be sprayed until wet and re-sprayed as needed during dry weather periods.

6. *Protect Slopes*
   The project does not require any disturbance of soils within steep slope or erosion hazard areas. Temporary and permanent seeding to stabilize exposed soil areas is expected to be sufficient for protecting on-site slopes—whether constructed or at disturbed native areas. Plastic covering may also be used to protect cut and fill slopes if seasonal limitations warrant and/or to encourage grass growth in newly seeded areas. The contractor shall take all practical efforts including installation of temporary interceptor ditches to direct potential storm water runoff away from the top of on-site slopes.

7. *Protect Drain Inlet*
   All storm drain inlets made operable during construction or otherwise existing in the vicinity of work areas shall be protected using pre-manufactured filter fabric catch basin inserts to protect against construction storm water runoff entering the conveyance system. The Contractor will be responsible for maintenance of all temporary sediment control BMP's during construction, including removal of accumulated sediment, as well as for the ultimate removal of these controls and remaining accumulated sediment upon completion of construction.

8. *Stabilize Channels and Outlets*
   Methods of protection may include silt fence installation and maintenance, catch basin inserts, and temporary interceptor ditches. Vegetated areas shall be maintained whenever possible or practical to provide for natural filtration of construction storm water discharges.

9. *Control Pollutants*
   Special provisions shall be taken to reduce the risk of pollutant contamination from the construction access, concrete handling/wash areas, and sawcutting/surfacing activities. Vehicle maintenance shall only be performed at approved on-site areas and only after proper containment devices are in place downstream of those areas. Any flammable or otherwise hazardous liquids shall be stockpiled only at the approved construction staging area.

10. *Control Dewatering*
    Temporary dewatering efforts may be required to facilitate some elements of construction such as storm drainage and utilities installation. Any such dewatering volumes encountered will be collected and controlled using pumps and sediment traps or tanks. Discharge from these controlled onsite facilities will be dispersed to approved areas of native vegetation or otherwise treated using setting tanks or other mechanical filtration facilities prior to release to downstream systems as required to conform with General Construction Stormwater permit standards.

11. *Maintain BMPs*
    All TESC measures will be inspected and maintained on a regular basis following the maintenance requirements identified for each in the Plans and/or the project's Storm Water Pollution Prevention Plan (SWPPP). An ESC supervisor will be designated by the Contractor and the name, address and phone number of the ESC supervisor will be given to the regulatory jurisdiction prior to the start of construction.

    The ESC supervisor will inspect the site at least once a month during the dry season, weekly during the wet season, and within 24 hours of each runoff-producing storm event. An ESC maintenance report will be used as a written record of all maintenance in accordance with the project SWPPP

12. *Manage the Project*

    The Contractor will be responsible for the phasing of erosion and sediment controls during construction so that they are adequately coordinated with all construction activities. The Contractor will be responsible for maintenance of all temporary sediment control BMP's during construction, including removal of accumulated sediment, as well as for the ultimate removal of these controls and cleaning of existing permanent storm drainage facilities upon completion of construction.

13. *Protect Low Impact Development BMPs*

    The project geotechnical engineered determined that the onsite soils are not favorable for infiltrative BMPs. As such, no low impact development BMPs are proposed with this project. No special protection is required.

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FIGURES

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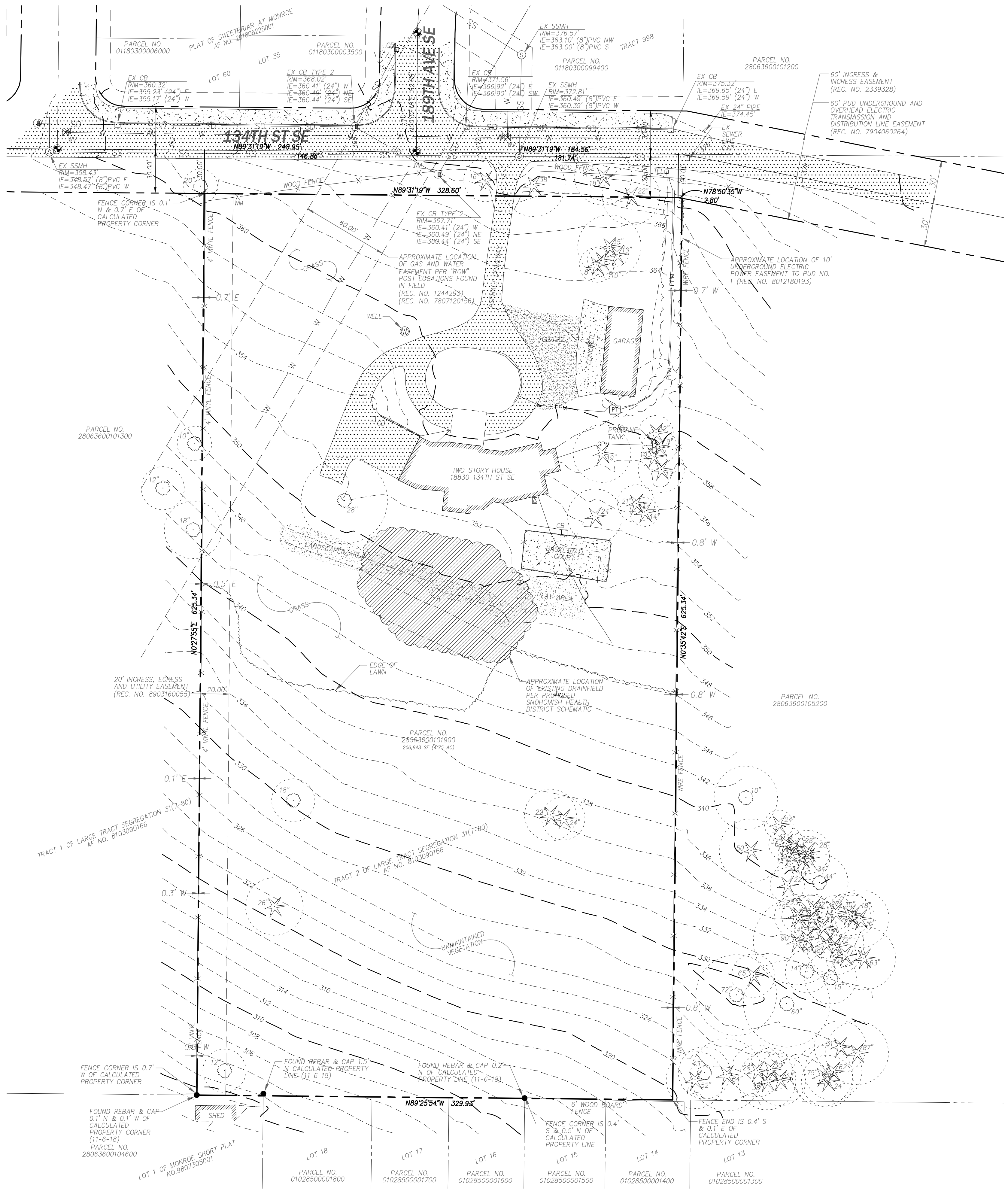

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FIGURE 2 - EXISITING SITE CONDITIONS

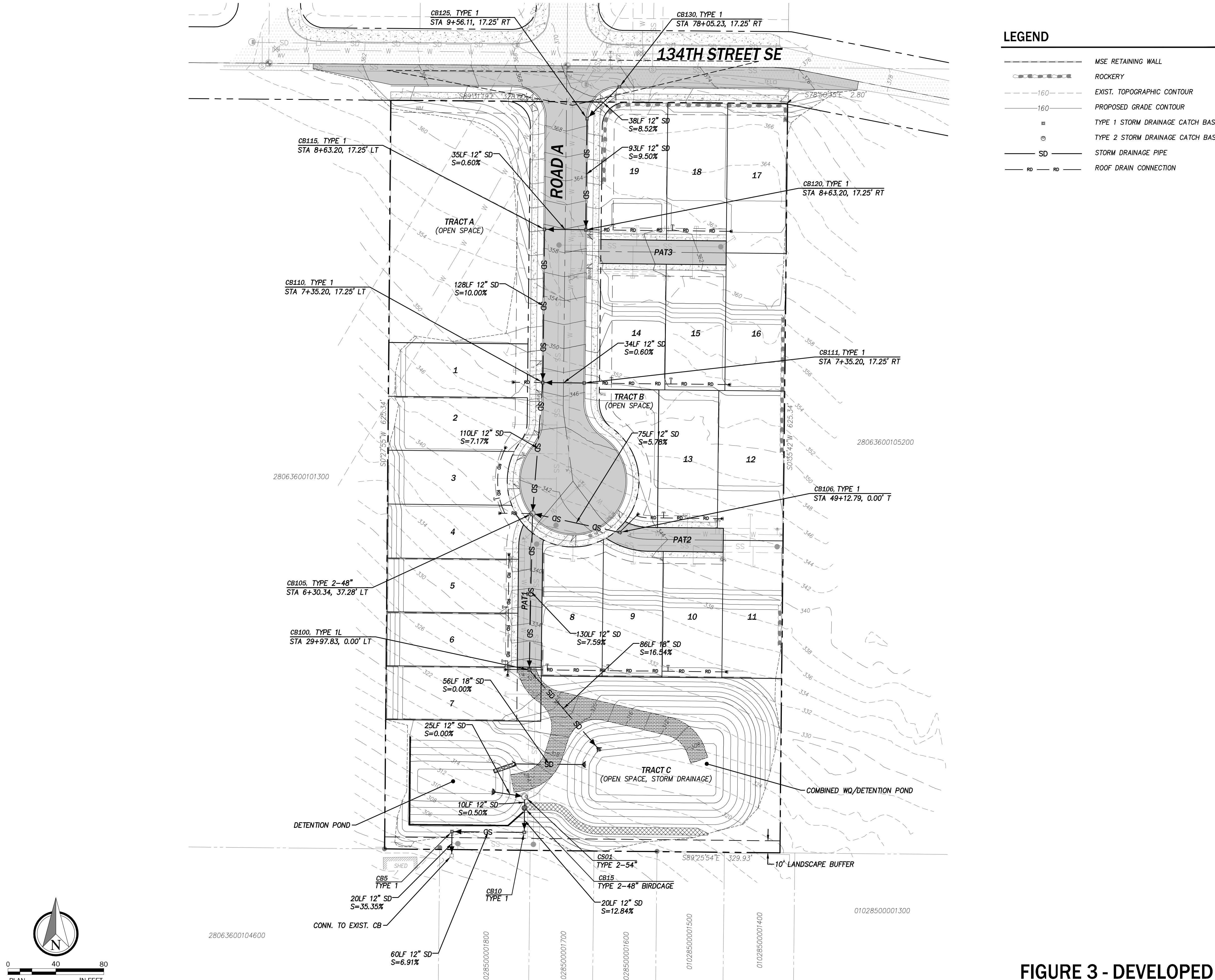

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FIGURE 3 - DEVELOPED SITE CONDITIONS

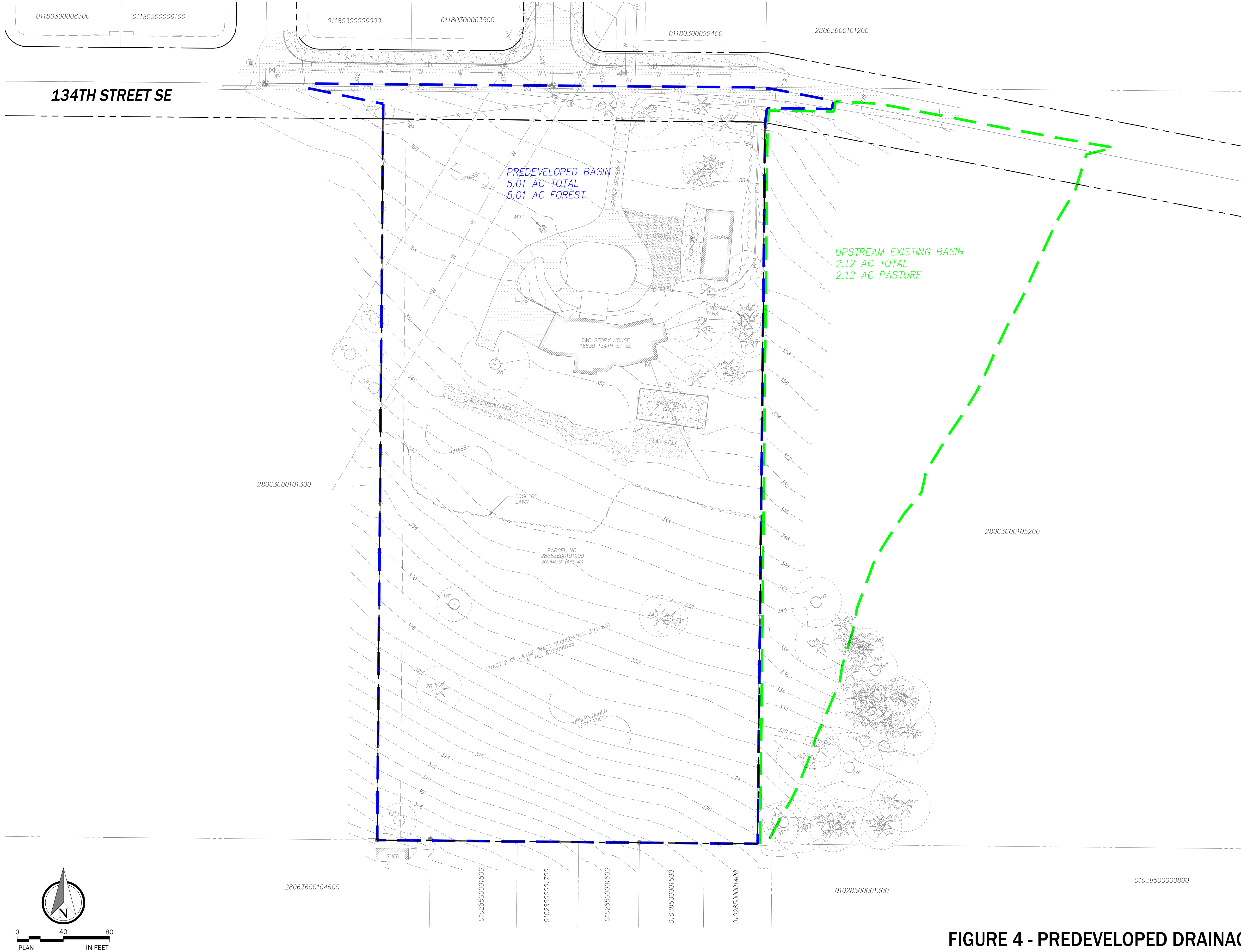

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FIGURE 4 - PREDEVELOPED DRAINAGE BASINS

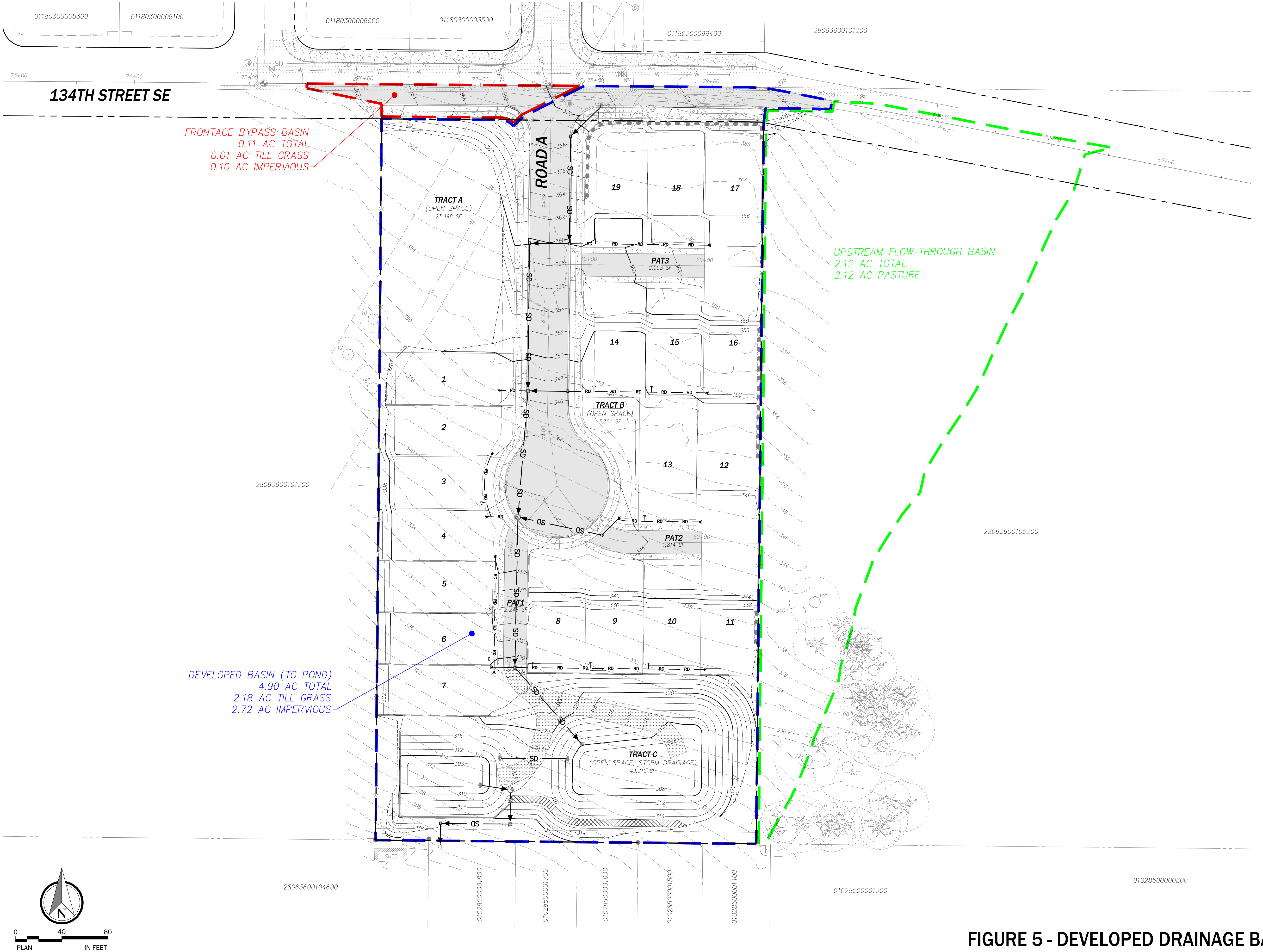

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FIGURE 5 - DEVELOPED DRAINAGE BASINS

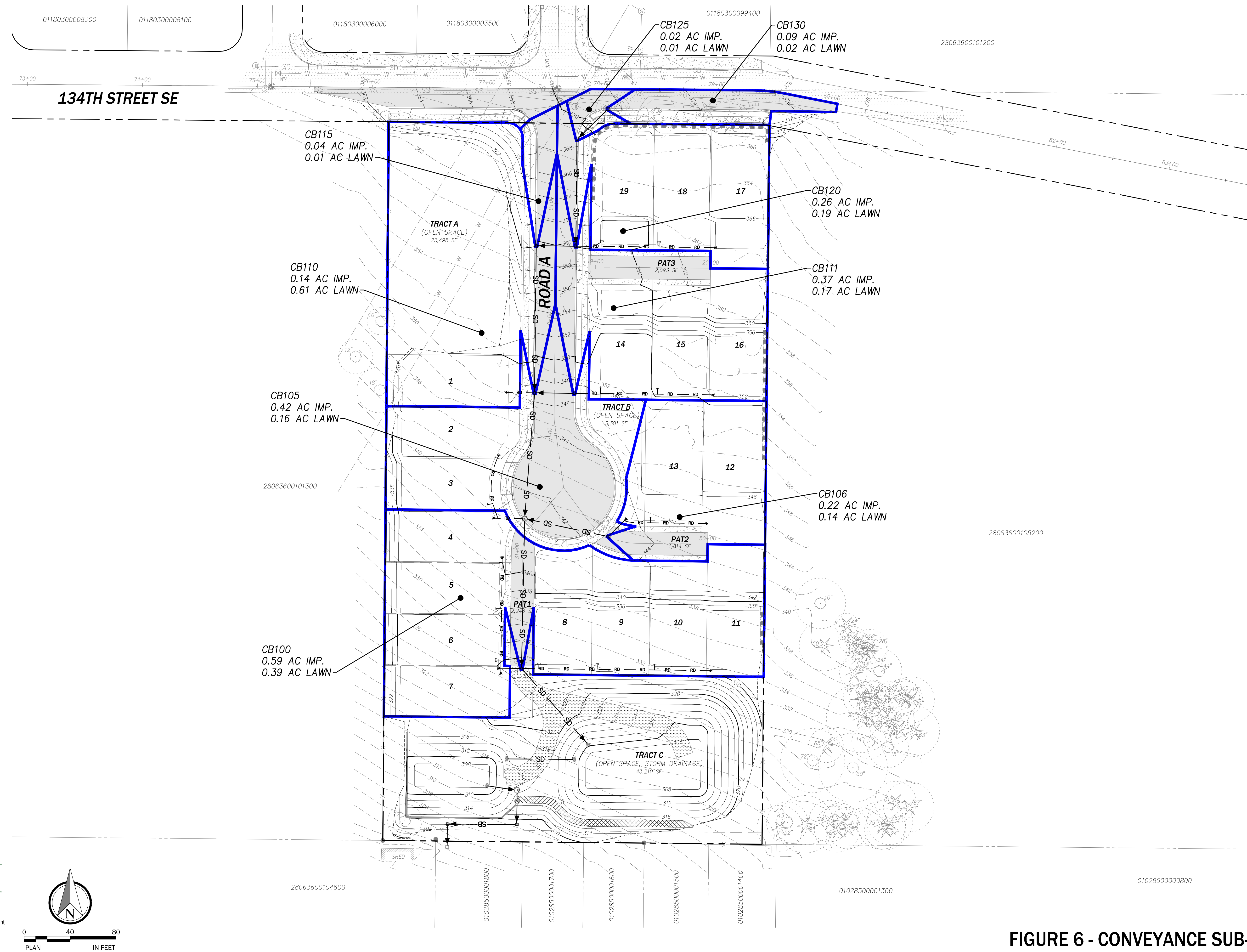

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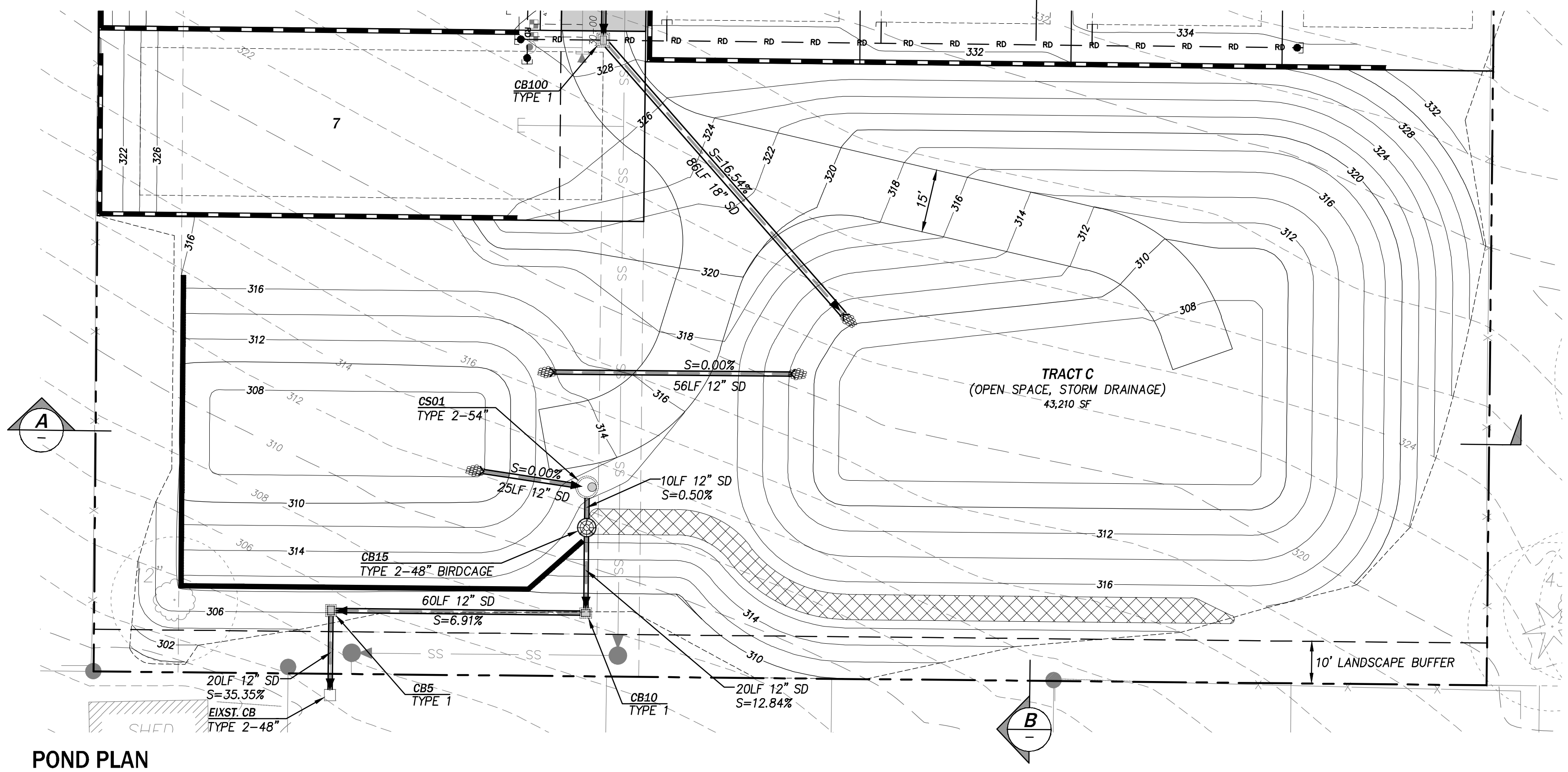
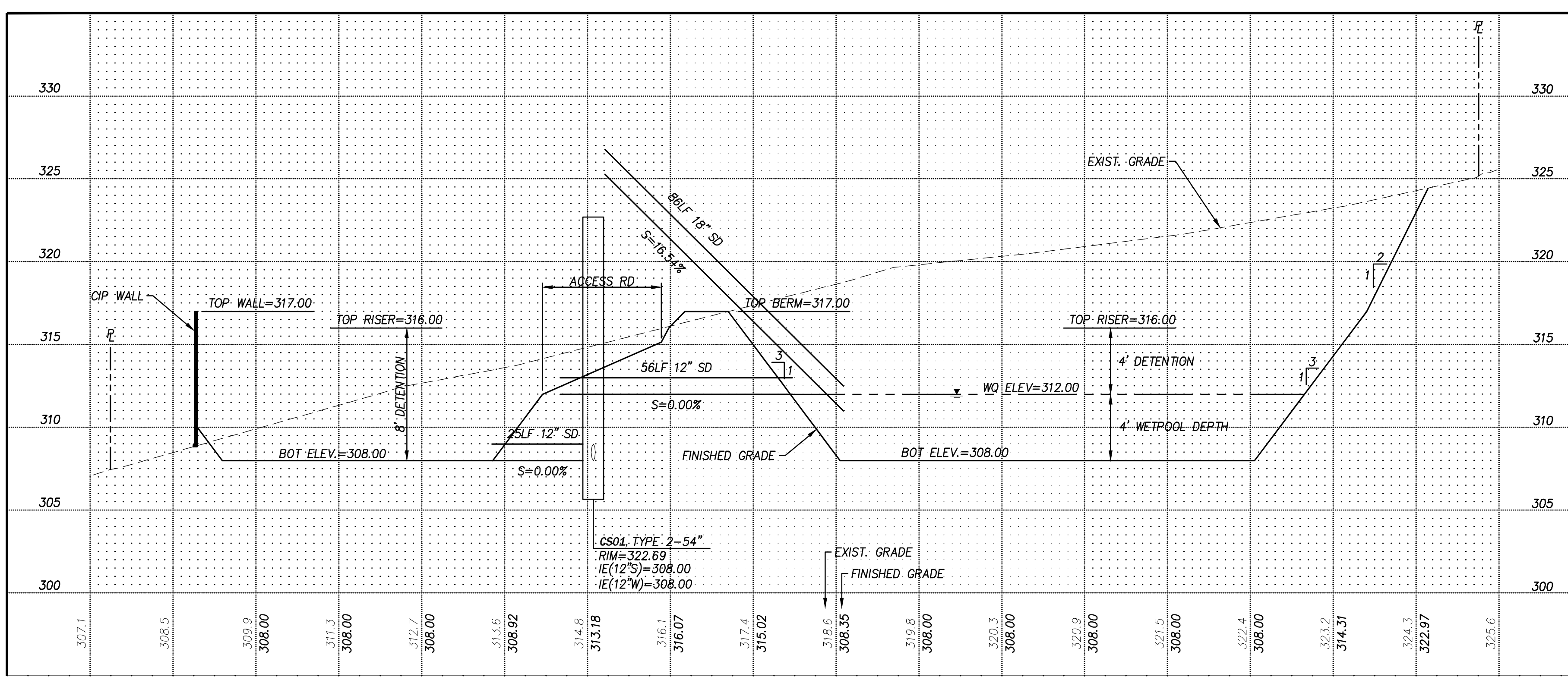
FIGURE 6 - CONVEYANCE SUB-BASINS

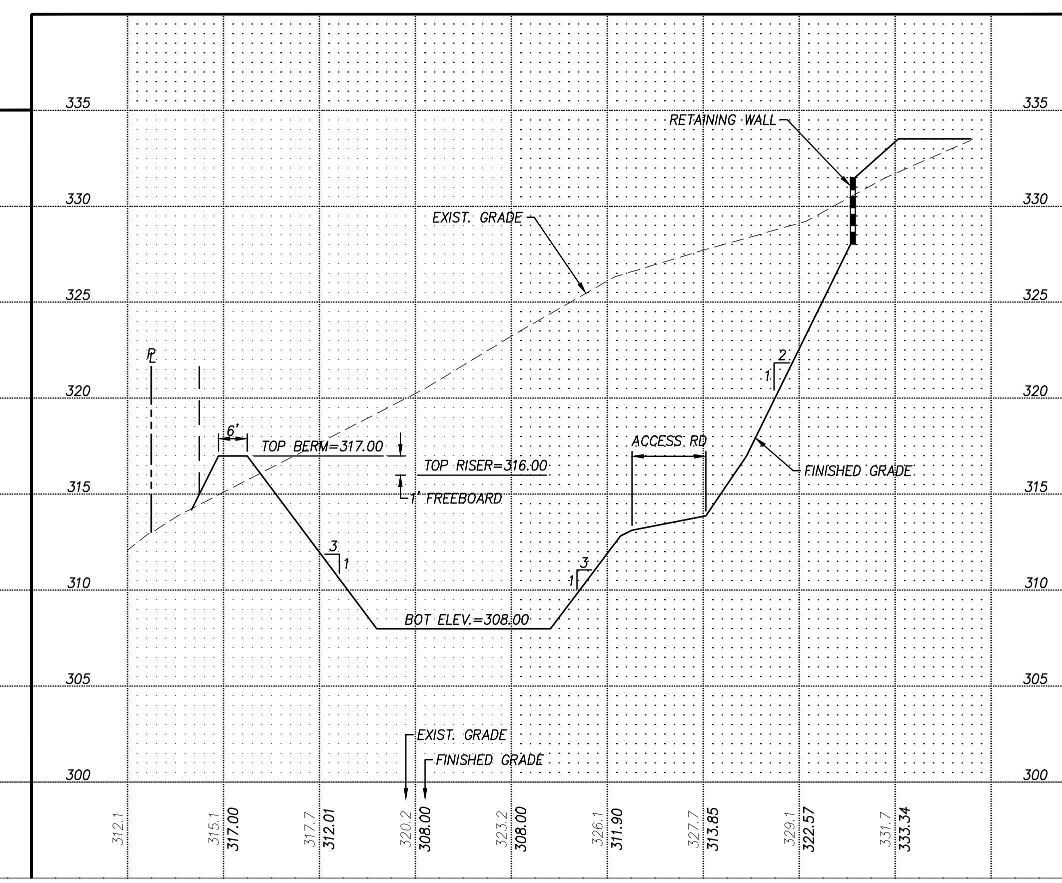


POND PLAN

SCALE: AS NOTED



SECTION A



SECTION B

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VERT. 0 5 10 IN FEET

HORIZ. 0 20 40 IN FEET

FIGURE 7 - STORMWATER POND DETAILS

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APPENDIX A

NRCS SOILS REPORT AND GEOTECHNICAL REPORT

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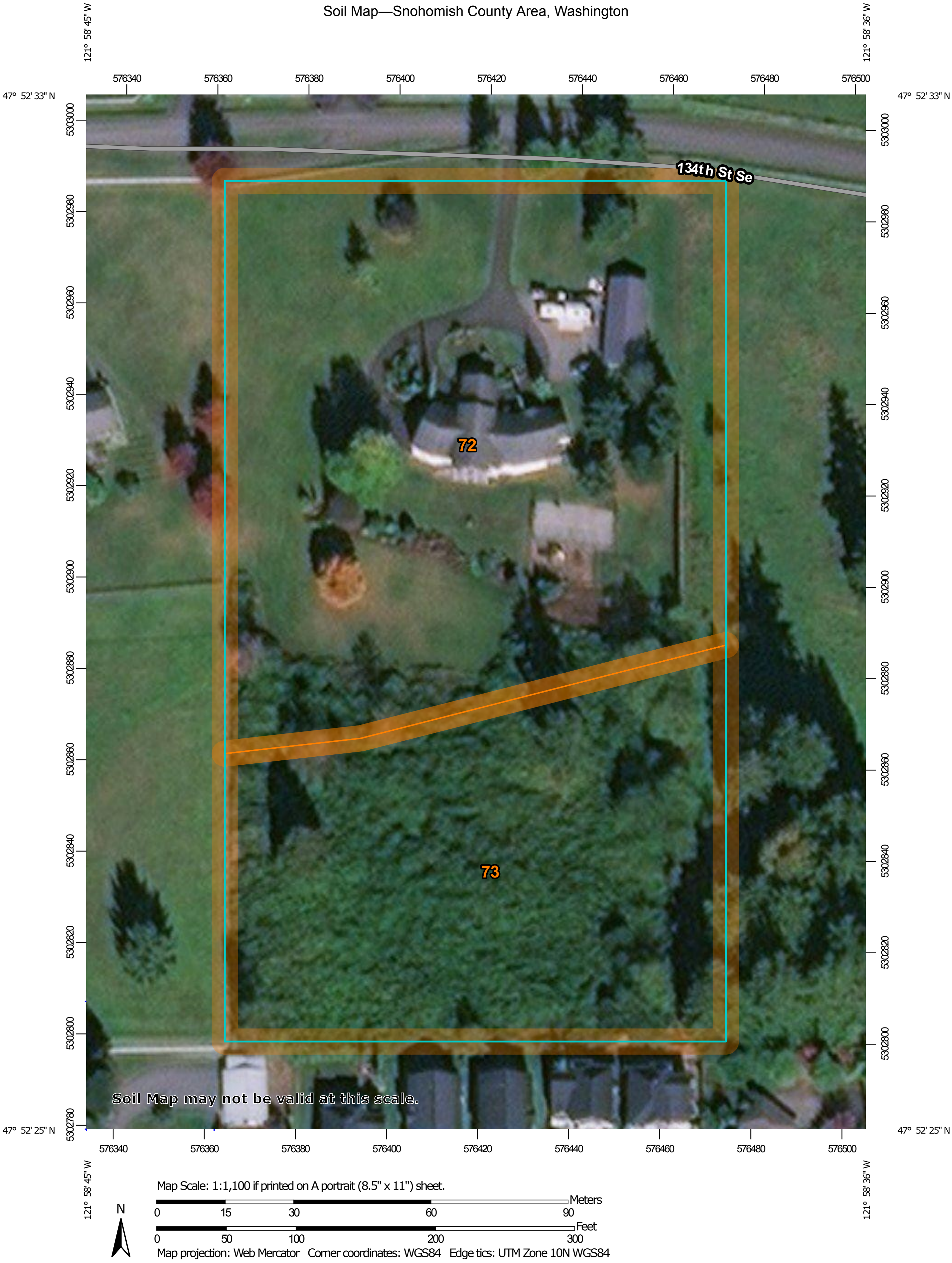
Land Use Consulting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Soil Map may not be valid at this scale.
Map Scale: 1:1,100 if printed on A portrait (8.5" x 11") sheet.
Meters
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Feet
0 50 100 200 300
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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

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

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

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

Soil Survey Area: Snohomish County Area, Washington
Survey Area Data: Version 20, Sep 10, 2018

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

Date(s) aerial images were photographed: Mar 29, 2016—Oct 10, 2016

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
72	Tokul gravelly medial loam, 0 to 8 percent slopes	3.1	61.1%
73	Tokul gravelly medial loam, 8 to 15 percent slopes	2.0	38.9%
Totals for Area of Interest		**5.1**	**100.0%**

GEOTECHNICAL REPORT

Barajas Property
18830 – 134th Street SE
Monroe, Washington

Project No. T-8064

Terra Associates, Inc.

Prepared for:

D.R. Horton
Kirkland, Washington

December 4, 2018

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

December 4, 2018
Project No. T-8064

Ms. Katie Stecks
D.R. Horton
11241 Slater Avenue NE, Suite 200
Kirkland, Washington 98033

Subject: Geotechnical Report
Barajas Property
18830 – 134th Street SE
Monroe, Washington

Dear Ms. Stecks:

As requested, we conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design and construction.

The soils observed in our subsurface explorations are glacial deposits comprised predominantly of medium dense to dense silty sand with gravel interpreted to be weathered till overlying unweathered till deposits consisting of dense to very dense, moderately- to strongly-cemented silty sand with gravel and occasional cobbles. We observed light to moderate seepage of perched groundwater in eight of the nine test pits.

In our opinion, there are no geotechnical conditions that would preclude development of the site, as currently planned. The residences can be supported on conventional spread footings bearing on competent native soils on structural fill placed on the competent native soils. Floor slabs and pavements can be similarly supported.

Detailed recommendations addressing these issues and other geotechnical design considerations are presented in the attached report. We trust the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

John C. Sadler, L.E.G., L.H.G.
Project Manager/Senior Engineering Geologist

12-4-18

Carolyn S. Decker, P.E.
Project Engineer

CAROLYN S. DECKER STATE OF WASHINGTON 47016 REGISTERED PROFESSIONAL ENGINEER

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Geotechnical Report
Barajas Property
18830 – 134th Street SE
Monroe, Washington

1.0 PROJECT DESCRIPTION

The proposed project is a residential subdivision. An unreferenced, undated site plan provided to us indicates the development will consist of 22 single-family lots with associated infrastructure and access improvements. The site will be accessed off of 134th Street SE by a new roadway that terminates at a cul-de-sac in the south-central portion of the site. Stormwater runoff collected from the development will be conveyed to a detention facility in the southwestern portion of the site. The plan does not indicate the type of detention facility that will be used. Site grading and building plans are currently not available. Based on the sloping surface gradients, we expect that moderate cuts and fills will be required to establish building pad and roadway elevations.

We expect that the residences will be two- to three-story wood-frame structures with the main floor levels constructed at grade or framed over a crawl space. We anticipate that foundation loads would be relatively light, in the range of 2 to 3 kips per foot for bearing walls and 25 to 50 kips for isolated columns.

The recommendations contained in the following sections of this report are based on these design features. We should review design drawings and specifications as they are developed to verify that our recommendations are valid for the proposed construction, and to amend or modify our report, as necessary.

2.0 SCOPE OF WORK

We explored subsurface conditions at the site in nine test pits excavated to depths about four to eight feet below ground surface using a track-mounted excavator. Using the results of our subsurface exploration and laboratory testing, analyses were undertaken to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions
- Geologic hazards per the City of Monroe Municipal Code
- Seismic design parameters per the 2015 International Building Code (IBC)
- Site preparation and grading
- Excavations
- Foundations

- Slab-on-grade floors
- Stormwater facilities
- Infiltration feasibility
- Drainage
- Utilities
- Pavements

It should be noted that recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment is beyond Terra Associates' purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The site is an approximately 4.76-acre parcel located south of and adjacent to 134th Street SE, approximately 670 feet to 1,000 feet west of the intersection with 191st Avenue SE in Monroe, Washington. The site location is shown on Figure 1.

A single-family residence and a detached garage occupy the north-central and northeastern portions of the site, respectively. Existing surface gradients generally slope down to the south at gentle to moderate inclinations. Vegetation in the northern portion of the site consists primarily of grass lawn and landscape trees and shrubs. The southern portion of the site is vegetated primarily with thick brush and scattered mature coniferous and deciduous trees.

We observed a localized wet area in the east-central portion of the site. The wet area is located immediately downgradient from a corrugated plastic pipe emerging from a pad of cobble-size rocks that appears to be a surface discharge point for one or more drains installed at the site.

3.2 Soils

The soils observed in our subsurface explorations are glacial deposits comprised predominantly of medium dense to dense silty sand with gravel interpreted to be weathered till overlying unweathered till deposits consisting of dense to very dense, moderately- to strongly-cemented silty sand with gravel and occasional cobbles. Eight of the nine test pits terminated in dense to very dense till encountered below depths of about 2.5 to 6 feet. Test Pit TP-1 terminated in a dense, weakly to moderately cemented, outwash-like sand with silt and gravel unit that is interpreted to be an ice-contact deposit. We were unable to determine the vertical extent of the sand with silt and gravel unit due to localized groundwater seepage and caving.

We observed about 1 to 3 feet of loose to medium dense silt to sandy silt containing trace to scattered amounts of gravel in Test Pits TP-6 and TP-7. The silt unit overlies till and till-like soils at both locations and is also interpreted to be an ice contact deposit.

The *Surficial geologic map of the Skykomish and Snoqualmie Rivers area, Snohomish and King Counties, Washington*, by D.B. Booth, 1990, shows the site mapped as Vashon till (Qvt). The dense to very dense silty sand with gravel observed in the test pits is consistent with this geologic unit.

Detailed descriptions of the subsurface conditions we observed in our site explorations are presented on the Test Pit Logs in Appendix A. The approximate test pit locations are shown on Figure 2.

3.3 Groundwater

We observed light to moderate groundwater seepage in 8 of the 9 test pits that was generally perched above the till between depths of about 2 and 2.5 feet. Exceptions to this include moderate groundwater seepage observed between about 3 and 4 feet in Test Pit TP-1 that appeared to be perched above the dense outwash-like sand with silt and gravel, and in Test Pit TP-9 where groundwater is perched on dense till-like soil about 0.3 feet below ground surface.

The occurrence of shallow perched groundwater is typical for sites underlain by relatively impermeable till and till-like soils. We expect that perched groundwater levels and flow rates at the site will fluctuate seasonally, with highest levels typically developing during the wet winter months (October through May).

3.4 Geologic Hazards

We evaluated site conditions for the presence of geologic hazards as designated by Chapter 20.05.120 (Geologically hazardous areas) of the City of Monroe Municipal Code (MMC). Geologically hazardous areas are defined by the MMC as areas susceptible to erosion, sliding, earthquake, or other geological events and include erosion hazard areas, landslide hazard areas, seismic hazard areas, and other geological events including tsunami, mass wasting, debris flows, rock falls, and differential settlement.

3.4.1 Erosion Hazard Areas

Section 20.05.120.B.1 of the MMC defines erosion hazard areas as "...at least those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having "severe" or "very severe" rill and inter-rill erosion hazard."

The Natural Resources Conservation Service (NRCS) has mapped the site soils as *Tokul gravelly medial loam, 0 to 8 percent slopes* and *Tokul gravelly medial loam, 8 to 15 percent slopes*. The erosion hazard of both soil types is described by the NRCS as slight, which does not meet the definition of an erosion hazard area given above.

We did not observe any indications of significant active erosion at the site; however, the site soils will be susceptible to erosion when exposed during development. In our opinion, the erosion potential of the site soils would be adequately mitigated with proper implementation and maintenance of Best Management Practices (BMPs) for erosion prevention and sedimentation control in the planned development area. BMPs for erosion prevention and sedimentation control will need to be in place prior to and during site development, and should be maintained until permanent site stabilization measures are in place. All BMPs for erosion prevention and sedimentation control should conform to City of Monroe requirements.

3.4.2 Landslide Hazard Areas

Section 20.05.120.B.2 of the MCC defines landslide hazard areas as "...areas potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. Examples of these may include, but are not limited to, the following:

a. Areas of historic failure, such as:
   i. Those areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" limitation for building site development.
   ii. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Department of Natural Resources.

b. Areas with all three of the following characteristics:
   i. Slopes steeper than 15 percent.
   ii. Hillsides intersecting geologic contacts with a relatively permeable sediment overlaying a relatively impermeable sediment or bedrock.
   iii. Springs or groundwater seepage.

c. Areas that have shown movement during the Holocene epoch (from ten thousand years ago to the present) or that are underlain or covered by mass wastage debris of that epoch.

d. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and faults) in subsurface materials.

e. Slopes having a gradient steeper than 80 percent subject to rock fall during seismic shaking.

f. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action.

g. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding.

h. Any area with a slope of forty percent or steeper and with a vertical relief of ten or more feet except areas composed of consolidated rock. A slope delineated by establishing its toe and top and measured by averaging the inclination over at least ten feet of vertical relief."

We did not observe conditions meeting the above criteria at the site. In our opinion, the site conditions are not susceptible to landsliding and no landslide hazard exists.

3.4.3 Seismic Hazard Areas

Section 20.05.120.B.3 of the MCC defines defines seismic hazard areas as areas that are "...subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface failure."

The closest known Class A fault (existence of Quaternary fault of tectonic origin demonstrated by geologic evidence) to the project site is the southern Whidbey Island fault zone (SWIFZ). The SWIFZ is described as a northwest-trending (average strike N51°W), 5- to 7-kilometer wide fault zone that extends more than 65 kilometers from the Strait of Juan de Fuca southeast to Mukilteo on the eastern side of Possession Sound.

The subject site is located about 7.5 miles northeast of the north fault strand mapped by the USGS. We did not observe any indications of faulting or surface rupture at the project site and are unaware of any reported documentation of surface rupture due to past movement along the SWIFZ in the project area. Considering this, it is our opinion that the potential for ground rupture at the project site during a severe seismic event is negligible.

Based on the soil and groundwater conditions we observed in our subsurface explorations, it is our opinion that there is no risk for damage resulting from seismically induced slope failure, settlement, soil liquefaction, or lateral spreading. In our opinion, unusual seismic hazard areas do not exist at the site and design in accordance with local building codes for determining seismic forces would adequately mitigate impacts associated with ground shaking.

3.4.4 Other Geologically Hazardous Areas

In our opinion, the site is not susceptible to potential hazards resulting from geologically hazardous events described in Section 20.05.120.B.4 of the MCC that include tsunami, mass wasting, debris flows, rock falls, and differential settlement.

3.5 Seismic Design Parameters

Based on the site soil conditions and our knowledge of the area geology, per the 2015 International Building Code (IBC), site class "C" should be used in structural design. Based on this site class, in accordance with the IBC, the following parameters should be used in computing seismic forces:

Seismic Design Parameters (2015 IBC)

Spectral response acceleration (Short Period), S_{Ms}	1.185 g
Spectral response acceleration (1 – Second Period), S_{M1}	0.606 g
Five percent damped .2 second period, S_{Ds}	0.790 g
Five percent damped 1.0 second period, S_{D1}	0.404 g

The above values were determined for Latitude 47.874734°N and Longitude -121.977252°W using the USGS Ground Motion Parameter Calculator web site accessed November 29, 2018 at the web site http://earthquake.usgs.gov/designmaps/us/application.php.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, there are no geotechnical conditions that would preclude the planned development. The residences can be supported on conventional spread footings bearing on competent native soils underlying organic topsoil, or on structural fill placed on the competent native soils. Floor slabs and pavements can be similarly supported.

The site soils contain a sufficient amount of fines (silt- and clay-sized particles) such that they will be difficult to compact as structural fill when too wet or too dry. Accordingly, the ability to use the soils from site excavations as structural fill will depend on their moisture content and the prevailing weather conditions at the time of construction, and the ability of the contractor to properly moisture condition the soil. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill.

Undisturbed bearing surfaces composed of the native silt observed in Test Pits TP-6 and TP-7, or structural fill derived from the native silt, would typically provide suitable support for conventional spread footing foundations, floor slabs, and pavements; however, the soils will be easily disturbed by normal construction activity, particularly when wet. If disturbed, the soil will not be suitable for support, and the affected material would need to be removed with the foundations lowered to obtain support on an undisturbed soil subgrade. Alternatively, the soils can be removed, and grade restored with structural fill.

Based on our observations, it appears that a moderate perched groundwater condition exists beneath the site that may persist throughout much of the year. Considering this, it would be prudent for the contractor to anticipate the need for some initial construction drainage and soil moisture conditioning efforts to facilitate site grading.

Detailed recommendations regarding these issues and other geotechnical design considerations are provided in the following sections of this report. These recommendations should be incorporated into the final design drawings and construction specifications. Terra Associates, Inc. should review proposed building and grading plans for the project when available to verify that our geotechnical recommendations have been properly interpreted and incorporated into the project design, and to provide additional or alternate recommendations, if needed.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation, organic surface soils, and other deleterious materials should be stripped and removed from the site. We expect surface stripping depths of about four to eight inches will generally be required to remove the organic surficial soils in the planned development areas; however, about two feet of dark brown organic silty sand was observed in Test Pit TP-7. Stripped vegetation debris should be removed from the site. Organic soils will not be suitable for use as structural fill, but may be used for limited depths in nonstructural areas or for landscaping purposes.

In the developed portions of the site, demolition of existing structures should include removal of existing foundations and abandonment of underground septic systems and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil.

Once clearing and grubbing operations are complete, cut and fill operations to establish desired building grades can be initiated. A representative of Terra Associates, Inc. should examine all bearing surfaces to verify that conditions encountered are as anticipated and are suitable for placement of structural fill or direct support of building and pavement elements. Our representative may request proofrolling exposed surfaces with a heavy rubber-tired vehicle to determine if any isolated soft and yielding areas are present. If unstable yielding areas are observed, they should be cut to firm bearing soil and filled to grade with structural fill. If the depth of excavation to remove unstable soils is excessive, use of geotextile fabric such as Mirafi 500X or equivalent in conjunction with structural fill can be considered in order to limit the depth of removal. In general, our experience has shown that a minimum of 18 inches of clean, granular structural fill over the geotextile fabric should establish a stable bearing surface.

We anticipate that most of the site soils will be suitable for use as structural fill provided they are properly moisture conditioned when placed. As discussed, the ability to use the native soils, particularly the observed silt soils, as structural fill will depend on the soil's moisture content when excavated, the prevailing weather conditions during site grading, and the ability of the contractor to properly moisture condition the soil. During the normally dry summer months, it may be possible to dry soils that are wet of optimum by aeration. As an alternative, stabilizing the moisture in the native soil with cement or lime can be considered. If soil amendment products are used, additional Temporary Erosion and Sedimentation Control (TESC) BMPs will need to be implemented to mitigate potential impacts to stormwater runoff associated with possible elevated pH levels. Moisture conditioning of soils that are dry of optimum would require the addition of water to the soils and thoroughly blending the material prior to compaction.

If grading activities are planned during the wet winter months, or if they extend into fall and winter, the owner should be prepared to import wet weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

*Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials planned to be imported to the site for use as structural fill.

Structural fill should consist of properly moisture conditioned material that is placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-698 (Standard Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In our opinion, reducing the lift thickness to a maximum of six inches and using a sheep's-foot roller to compact the fill will improve the ability to achieve adequate compaction of the fine grained soils.

4.3 Slopes and Embankments

All permanent cut and fill slopes should be graded with a finished inclination of no greater than 2:1 (Horizontal:Vertical). Upon completion of grading, the slope face should be appropriately vegetated or provided with other physical means to guard against erosion. Final grades at the top of the slope must promote surface drainage away from the slope crest. Water must not be allowed to flow uncontrolled over the slope face. If surface runoff must be directed towards the top of a slope, it may be necessary to route collected water to an appropriate point of discharge beyond the toe in a closed system.

Embankment fills placed on slopes exceeding a grade of 20 percent must be keyed and benched into competent native soils. A generalized slope fill detail is shown on Figure 3. At a minimum, we recommend constructing a toe drain in the key trench for the fill embankment. The locations and extent of such toe drains will be best determined in the field at the time of construction. All fill placed for embankment construction should meet the structural fill requirements provided in Section 4.2 of this report.

4.4 Excavations

All excavations at the site associated with confined spaces, such as lower building level retaining walls, must be completed in accordance with local, state, and federal requirements. Based on the Washington State Safety and Health Administration (WSHA) regulations the medium dense to dense native soils would typically be classified as Type C soils. Very dense, cemented till and till-like soils would be classified as Type A soil.

Accordingly, for temporary excavations of more than 4 feet and less than 20 feet in depth, the side slopes in Type C soils should be laid back at a slope inclination of 1.5:1 (Horizontal:Vertical) or flatter. Side slopes in Type A soils can be laid back at a slope inclination of 0.75:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition, with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot vertical portion will need to be laid back at a minimum slope inclination of 1:1. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a four-foot vertical cut with an equivalent horizontal bench to the cut slope toe is required. If there is insufficient room to complete the excavations in this manner, or if excavations greater than 20 feet deep are planned, you may need to use temporary shoring to support the excavations.

Based on our field observations, seepage of perched groundwater should be anticipated within site excavations completed during the wet winter and spring months. In our opinion, the volume of water and rate of flow into site excavations should be relatively minor and would not be expected to impact the stability of the excavations when completed as described above. Conventional sump pumping procedures along with a system of collection trenches, if necessary, should be capable of maintaining a relatively dry excavation for construction purposes in these soils.

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

4.5 Foundations

The residential structures may be supported on conventional spread footing foundations bearing on competent native materials or on structural fill placed on a competent native material subgrade. Foundation subgrades should be prepared as recommended in Section 4.2 of this report. Perimeter foundations exposed to the weather should bear at a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab.

We recommend designing foundations bearing on competent soils for a net allowable bearing capacity of 2,500 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used in design. With the anticipated loads and this bearing stress applied, building settlements should be less than one-half inch total and one-fourth inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressure acting on the sides of the footings may also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 350 pounds per cubic foot (pcf). We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent native soil or the excavations are backfilled with structural fill, as described in Section 4.2 of this report. The recommended passive and friction values include a safety factor of 1.5.

4.6 Slab-on-Grade Floors

Slab-on-grade floors may be supported on a subgrade prepared as recommended in Section 4.2 of this report. Immediately below the floor slab, we recommend placing a four-inch thick capillary break layer composed of clean, coarse sand or fine gravel that has less than three percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction, and aid in uniform curing of the concrete slab. It should be noted that if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will be ineffective in assisting uniform curing of the slab and can actually serve as a water supply for moisture seeping through the slab and affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained.

4.7 Lateral Earth Pressures for Below-Grade Walls

The magnitude of earth pressures developing on below-grade walls will depend on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill, as described in Section 4.2 of this report. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 4.

With wall backfill placed and compacted as recommended, and drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 4.5 of this report.

Gravity block or mechanically stabilized earth (MSE) walls can also be used to accommodate vertical breaks in grade that may be required to achieve desired site elevations. We can design or provide soil design parameters for a design build approach for these alternative wall systems, if requested.

4.8 Infiltration Feasibility

Based on our study, it is our opinion that on-site infiltration is not a feasible alternative for management of site stormwater due to the presence of relatively-impermeable till and till-like soils at relatively shallow depths beneath the ground surface.

There may be opportunities to infiltrate limited amounts of site stormwater in the medium dense soils observed in the upper 2 to 2.5 feet of several of the test pits using Low Impact Development (LID) natural drainage practices (NDPs). The feasibility of using NDPs at the site should be based on field conditions observed at the time of site grading.

4.9 Stormwater Facilities

We understand that site stormwater will be routed to a detention vault or detention pond located in the southwestern portion of the planned development area. Conceptual design information is currently not available. Terra Associates, Inc. should review site development plans when available to verify that our recommendations are appropriate for the vault or pond design, and to provide additional or alternate recommendations, if necessary.

Detention Vault

If on-site detention will be provided by a buried vault, we expect that very dense, cemented till would be exposed throughout the bottom of the vault excavation. Vault foundations supported by these native soils may be designed for an allowable bearing capacity of 6,000 psf provided that the foundation subgrade is at least 8 feet below finished grade adjacent to the vault. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 4.5.

The magnitude of earth pressures developing on the vault walls will depend in part on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill, as recommended in the Section 4.2 of this report. Lateral earth pressures recommended in Section 4.7 can be used in designing the below-grade vault walls. If it is not possible to discharge collected water at the footing elevation, we recommend setting the invert elevation of the wall drainpipe equivalent to the outfall invert and connecting the drain to the outfall pipe for discharge. For any portion of the wall that falls below the invert elevation of the wall drain, an earth pressure equivalent to a fluid weighing 85 pcf should be used. For evaluating walls under seismic loading, an additional uniform earth pressure equivalent to 8H psf, where H is the height of the below-grade wall in feet, can be used. These values assume a horizontal backfill condition. Where applicable, a uniform horizontal traffic surcharge value of 75 psf should be included in design of vault walls.

The vault may be subject to uplift pressures if drainage is not provided the full depth of the structure. The weight of the structure and the weight of the backfill soil above its foundation will provide resistance to uplift. A soil unit weight of 125 pcf can be used for the vault backfill provided the backfill is placed and compacted as structural fill as recommended above.

Detention Pond

We anticipate that pond construction would consist primarily of cuts into native soil. If fill berms will be constructed, the berm locations should be stripped of topsoil, duff, existing fill soils, and soils containing organic material prior to the placement of fill. The fill berms should be constructed by placing structural fill in layers no more than 12 inches thick, compacting each layer to a minimum of 95 percent relative compaction, as determined by ASTM Test Designation D-1557 (Modified Proctor). Material used to construct pond berms should consist predominately of granular soils with a maximum size of 3 inches and a minimum of 20 percent fines. The results of laboratory testing indicate that soils meeting this gradational requirement exist on-site. Terra Associates, Inc. should examine and test all on-site or imported materials proposed for use as berm fill prior to their use.

Because of exposure to fluctuating stored water levels, soils exposed on the interior pond slopes may be subject to some risk of periodic shallow instability or sloughing. Establishing interior slopes at a gradient of 3:1 (Horizontal:Vertical) will significantly reduce or eliminate this potential. Exterior berm slopes and interior slopes above the maximum water surface should be graded to a finished inclination no steeper than 2:1 (Horizontal:Vertical). Finished slope faces should be thoroughly compacted and vegetated to guard against erosion.

We expect that perched groundwater seepage will be intercepted by the detention pond excavation, particularly during the wet winter months. However, based on our field observations, we anticipate that the volume of groundwater that might find its way into the pond as seepage would likely be small with respect to the design volume capacity of the pond.

4.10 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the building areas. We recommend providing a positive drainage gradient away from building perimeters. If a positive gradient cannot be provided, provisions for collection and disposal of surface water adjacent to the structure should be provided.

Surface water from developed areas must not be allowed to flow in an uncontrolled and concentrated manner over the crests of site slopes and embankments. Surface water should be directed away from the slope crests to a point of collection and controlled discharge. If site grades do not allow for directing surface water away from the slopes, then the water should be collected and tightlined to an approved point of controlled discharge.

Subsurface

We recommend installing a continuous drain along the outside lower edge of the perimeter building foundations. The drains can consist of four-inch diameter perforated PVC pipe that is enveloped in washed ½- to ¾-inch gravel-sized drainage aggregate that extends six inches above and to the sides of the pipe. The pipe can be laid to grade at an invert elevation equivalent to the bottom of footing grade.

The foundation drains and roof downspouts should be tightlined separately to an approved point of controlled discharge. All drains should be provided with cleanouts at easily accessible locations. These cleanouts should be serviced at least once each year.

4.11 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or local jurisdictional requirements. At minimum, trench backfill should be placed and compacted as structural fill as described in Section 4.2 of this report. As noted, the native soils are moisture sensitive and will require careful control of moisture to facilitate proper compaction. If utility construction takes place during the winter or if it is not feasible to properly moisture condition the excavated soil at the time of construction, it may be necessary to import suitable wet weather fill for utility trench backfilling.

4.12 Pavements

Pavements should be constructed on subgrades prepared as recommended in Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. Proofrolling the subgrade with heavy construction equipment should be completed to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. For traffic consisting mainly of light passenger vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of hot mix asphalt (HMA) over four inches of crushed rock base (CRB)
- 3 ½ inches full depth HMA over prepared subgrade

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for ½-inch class HMA and CRB.

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final designs and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical services during construction in order to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Barajas Property project in Monroe, Washington. This report is for the exclusive use of D.R. Horton and their authorized representatives. No other warranty, expressed or implied, is made.

The analyses and recommendations presented in this report are based on data obtained from the subsurface explorations completed at the site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report, prior to proceeding with construction.

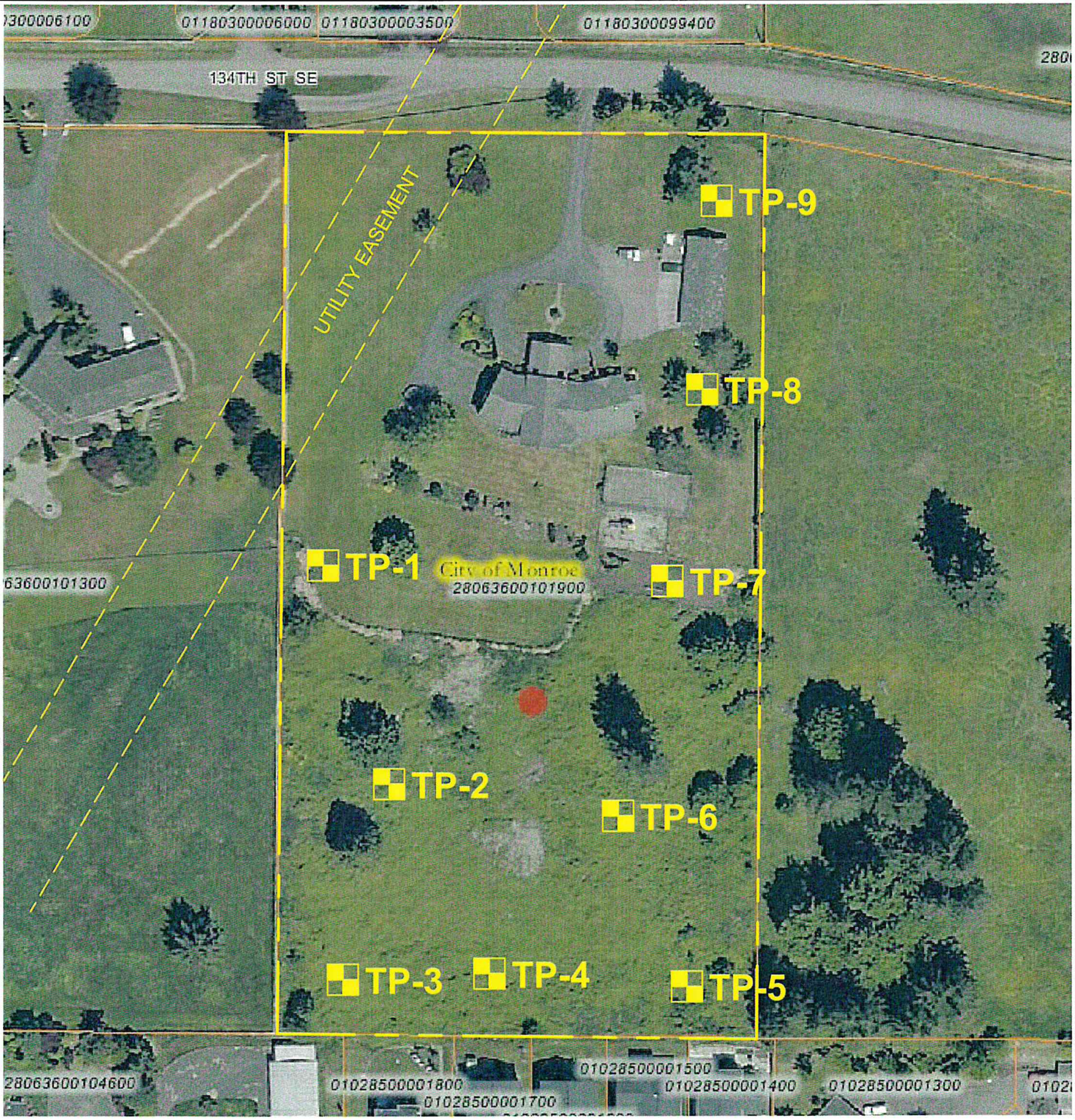
REFERENCE: WSDOT GEOPORTAL (2018)

NOT TO SCALE

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

VICINITY MAP
BARAJAS PROPERTY
MONROE, WASHINGTON

Proj. No.T-8064	Date DEC 2018	Figure 1



REFERENCE:

SCOPI

NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

LEGEND:

APPROXIMATE TEST PIT LOCATION

0 100 200

APPROXIMATE SCALE IN FEET

N

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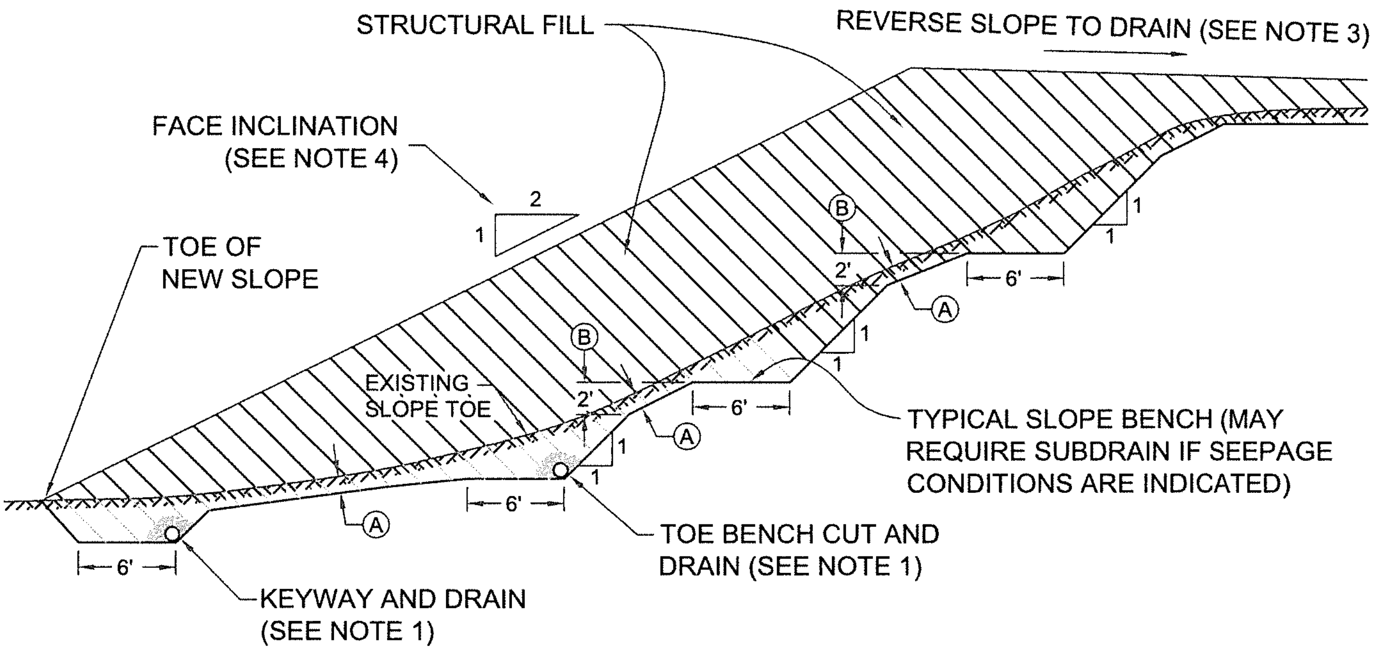
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
BARAJAS PROPERTY
MONROE, WASHINGTON

Proj. No.T-8064	Date DEC 2018	Figure 2



NOT TO SCALE

NOTES:

1) DRAINS SHALL CONSIST OF 6" DIAMETER PERFORATED PVC PIPE ENVELOPED IN 1 cu. ft. OF WASHED 3/4" MINUS DRAINAGE GRAVEL.

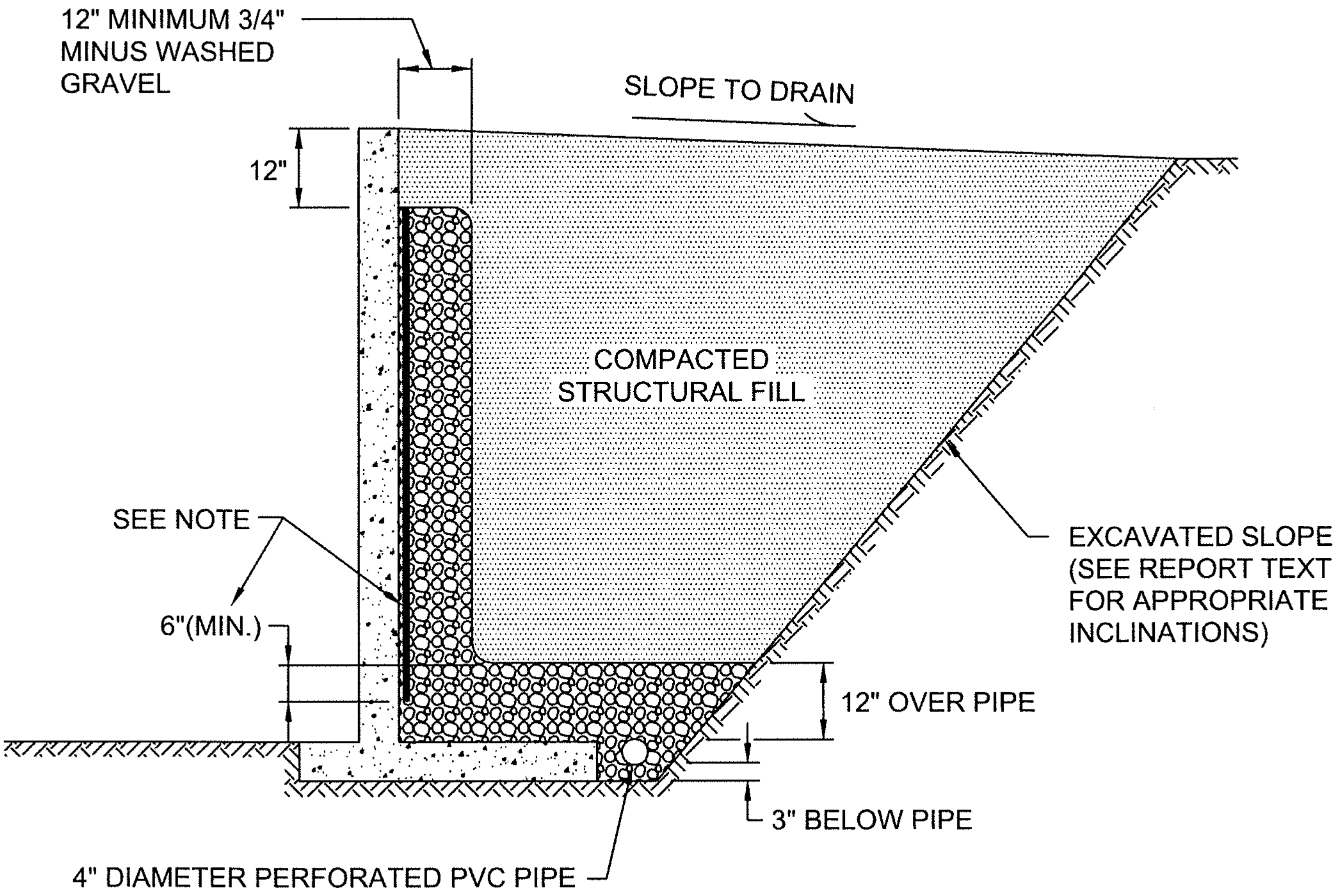
2) (A) – TOPSOIL REMOVAL THICKNESS BETWEEN KEYWAY AND BENCHES.

(B) – VERTICAL ELEVATION DIFFERENCE BETWEEN TOP OF LOWER BENCH BACKCUT AND UPPER BENCH ELEVATION.

3) RECOMMENDED PRIOR TO ESTABLISHMENT OF PERMANENT EROSION CONTROL MEASURES AND SITE DRAINAGE.

4) PERMANENT FACE INCLINATION TO BE ESTABLISHED AT 2:1 (H:V) OR AS RECOMMENDED BY THE GEOTECHNICAL ENGINEER

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	GENERALIZED SLOPE FILL DETAIL BARAJAS PROPERTY MONROE, WASHINGTON		
	Proj. No.T-8064	Date DEC 2018	Figure 3



NOT TO SCALE

NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF 6 INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	TYPICAL WALL DRAINAGE DETAIL BARAJAS PROPERTY MONROE, WASHINGTON		
	Proj. No.T-8064	Date DEC 2018	Figure 4

APPENDIX A

FIELD EXPLORATION AND LABORATORY TESTING

Barajas Property
Monroe, Washington

We explored subsurface conditions at the site in 9 test pits excavated to depths about 4.5 to 6.5 feet below ground surface using a track-mounted excavator. The test pit locations are shown on Figure 2. The test pit locations were approximately determined in the field by sighting and pacing relative to existing surface features. The Test Pit Logs are presented as Figures A-2 through A-10.

An engineering geologist from our office conducted the field reconnaissance and subsurface exploration, classified the observed soils, maintained a log of each test pit, obtained representative soil samples, and performed a visual reconnaissance of the site. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits were placed in sealed containers and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Pit Logs. Grain size analyses were performed on six soil samples. The test results are shown on Figures A-11 and A-12.

MAJOR DIVISIONS				LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
			Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
				GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
		SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
				SP	Poorly-graded sands, sands with gravel, little or no fines.
			Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
				SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS	More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity. (Lean clay)
				OL	Organic silts and organic clays of low plasticity.
		SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
				CH	Inorganic clays of high plasticity. (Fat clay)
				OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS				PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

Density	Standard Penetration Resistance in Blows/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

Consistancy	Standard Penetration Resistance in Blows/Foot
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

Symbol	Definition
I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
II	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

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UNIFIED SOIL CLASSIFICATION SYSTEM
BARAJAS PROPERTY
MONROE, WASHINGTON

Proj. No.T-8064	Date DEC 2018	Figure A-1

LOG OF TEST PIT NO. TP-1

FIGURE A-2

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Lawn **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 3 to 4 Feet **DEPTH TO CAVING:** 2 to 4 Feet

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
0–3.5	1 (at ~2.5)	(6 inches SOD and TOPSOIL) Red-brown silty SAND to sandy SILT, fine grained, trace of fine gravel, moist to wet, scattered cobbles. (SM/ML)	Medium Dense	49.1
3 (groundwater ▼)				
3.5–6		Gray-brown SAND with silt and gravel, fine to medium sand, fine to coarse gravel, moist to wet, weakly to moderately cemented, scattered cobbles. (SP-SM)	Dense	
6	2	Test pit terminated at 8 feet. Moderate groundwater seepage between about 3 and 4 feet. Minor caving between about 2 and 4 feet.		11.8
7, 8, 9, 10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-2

FIGURE A-3

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 2 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–2.5	1 (at 2)	(6 inches DUFF and TOPSOIL) Red-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist to wet, scattered cobbles. (SM)	Medium Dense	43.5
2.5–3.5		Gray-brown silty SAND, moist to wet, mottled. (SM)	Medium Dense to Dense	
3.5–5.5	2 (at 4.5) 3 (at 5.5)	Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, moderately to strongly cemented. (SM) (Till)	Dense to Very Dense	12.3 11.8
5.5–10		Test pit terminated at 5.5 feet. Light groundwater seepage at about 2 feet on north side of test pit.		

Groundwater symbol (▼) shown at 2 ft.

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-3

FIGURE A-4

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(6 inches DUFF and TOPSOIL)		
		Red-brown silty SAND, fine grained, trace of fine gravel, moist to wet, scattered cobbles. (SM)		
1			Medium Dense	
2				
		Gray-brown silty SAND, moist to wet, mottled. (SM)		
3			Medium Dense to Dense	
		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, moderately to strongly cemented, trace of cobbles. (SM) (Till)		
4				
5	1		Very Dense	6.9
6				
		Test pit terminated at 6 feet. Light groundwater seepage at about 2 feet.		
7				
8				
9				
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Environmental Earth Sciences

LOG OF TEST PIT NO. TP-4

FIGURE A-5

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6 inches DUFF and TOPSOIL)		
0.5–2.5		Red-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist to wet, scattered cobbles. (SM)	Medium Dense	
2.5–3.5		Gray-brown silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, mottled, moderately cemented, scattered cobbles. (SM) (Till-like)	Dense to Very Dense	
3.5–6		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)	Very Dense	
6		Test pit terminated at 6 feet. No groundwater seepage.		

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-5

FIGURE A-6

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 2 to 2.5 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 – 1.2		(6 inches DUFF and TOPSOIL) Dark brown organic silty SAND, fine to medium sand, trace of fine gravel, moist to wet, scattered cobbles. (OL/SM)	Loose to Medium Dense	
1.2 – 2.5 (groundwater ▼ at 2)		Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, mottled. (SM)	Medium Dense	
2.5 – 3.2		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, mottled, moderately cemented. (SM) (Till-like)	Dense to Very Dense	
3.2 – 6	1 (at 5)	Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)	Very Dense	7.9
6 – 10		Test pit terminated at 6 feet. Light groundwater seepage between about 2 and 2.5 feet.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Environmental Earth Sciences

LOG OF TEST PIT NO. TP-6

FIGURE A-7

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 2 to 2.5 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–2.5 (groundwater ▼ at 2)	1 (at 2)	(8 inches DUFF and TOPSOIL) Brown SILT with sand and gravel to sandy SILT with gravel, fine sand, fine to coarse gravel, moist to wet. (ML)	Loose to Medium Dense	46.5
2.5–3.5		Gray-brown SILT with sand to sandy SILT, fine sand, trace of fine to coarse gravel, moist, trace of cobbles, trace of 1.5-foot diameter boulders. (ML)	Medium Dense	
3.5–6		Gray-brown silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, numerous cobbles, scattered boulders to 3 feet in diameter. (SM)	Dense	
6–6.5		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)	Very Dense	
6.5–10		Boring terminated at 6.5 feet. Light to moderate groundwater seepage between 2 and 2.5 feet.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-7

FIGURE A-8

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 2 To 2.5 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 – 2		Dark brown organic silty SAND, moist to wet. (OL/SM)	Medium Dense	
2 – 3 (▼ 2)	1	Brown sandy SILT, fine grained, wet. (ML)		52.2
3 – 4		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, mottled, moderately cemented, numerous cobbles. (SM) (Till-like)	Dense	
4 – 5	2	Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)	Very Dense	12.2
5		Test pit terminated at 5 feet. Light groundwater seepage between about 2 and 2.5 feet.		

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-8

FIGURE A-9

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 2 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(4 inches SOD and TOPSOIL) Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist to wet. (SM)	Medium Dense	
2		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, scattered mottling, scattered cobbles. (SM)	Dense to Very Dense	
3.5		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)	Very Dense	
	1	Test pit terminated at 4 feet. Light groundwater seepage at about 2 feet.		12.7
5				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-9

FIGURE A-10

PROJECT NAME: Barajas Property **PROJ. NO:** T-8064 **LOGGED BY:** JCS

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Lawn **APPROX. ELEV:** N/A

DATE LOGGED: November 2, 2018 **DEPTH TO GROUNDWATER:** 0.3 Feet **DEPTH TO CAVING:** N/A

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(4 inches SOD and TOPSOIL)		
▼		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, mottled, moderately cemented, numerous cobbles. (SM) (Till-like)		
1	1		Dense	11.0
2				
		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, strongly cemented, scattered cobbles. (SM) (Till)		
3			Very Dense	
4				
		Test pit terminated at 4.5 feet. Light groundwater seepage at 0.3 feet on north side of test pit.		
5				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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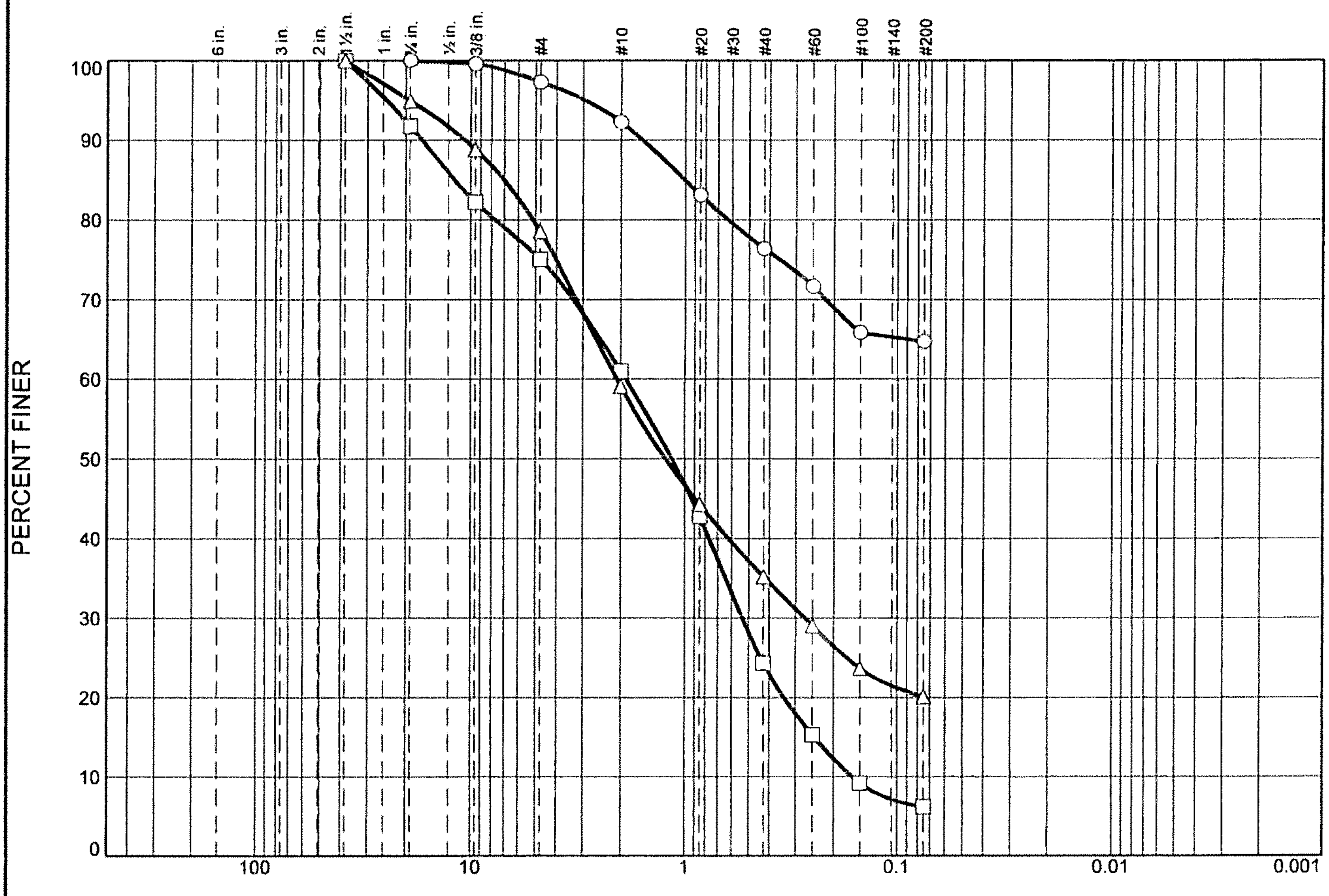
Geology and
Environmental Earth Sciences

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.7	5.1	15.8	11.7	64.7	
□	0.0	8.3	16.7	14.0	36.7	18.1	6.2	
△	0.0	5.1	16.4	19.4	23.9	15.1	20.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.0083							
□			11.8597	1.8953	1.1483	0.5349	0.2447	0.1634	0.92	11.60
△			7.0146	2.0853	1.2313	0.2725				

Material Description	USCS	AASHTO
○ sandy SILT	ML	
□ SAND with silt and gravel	SP-SM	
△ silty SAND with gravel	SM	

Project No. T-8064 **Client:** D.R. Horton

Project: Barajas Property

○ **Location:** TP-1 **Depth:** 2.5'

□ **Location:** TP-1 **Depth:** 6'

△ **Location:** TP-3 **Depth:** 5'

Remarks:

○ Tested November 13, 2018

□ Tested November 13, 2018

△ Tested November 13, 2018

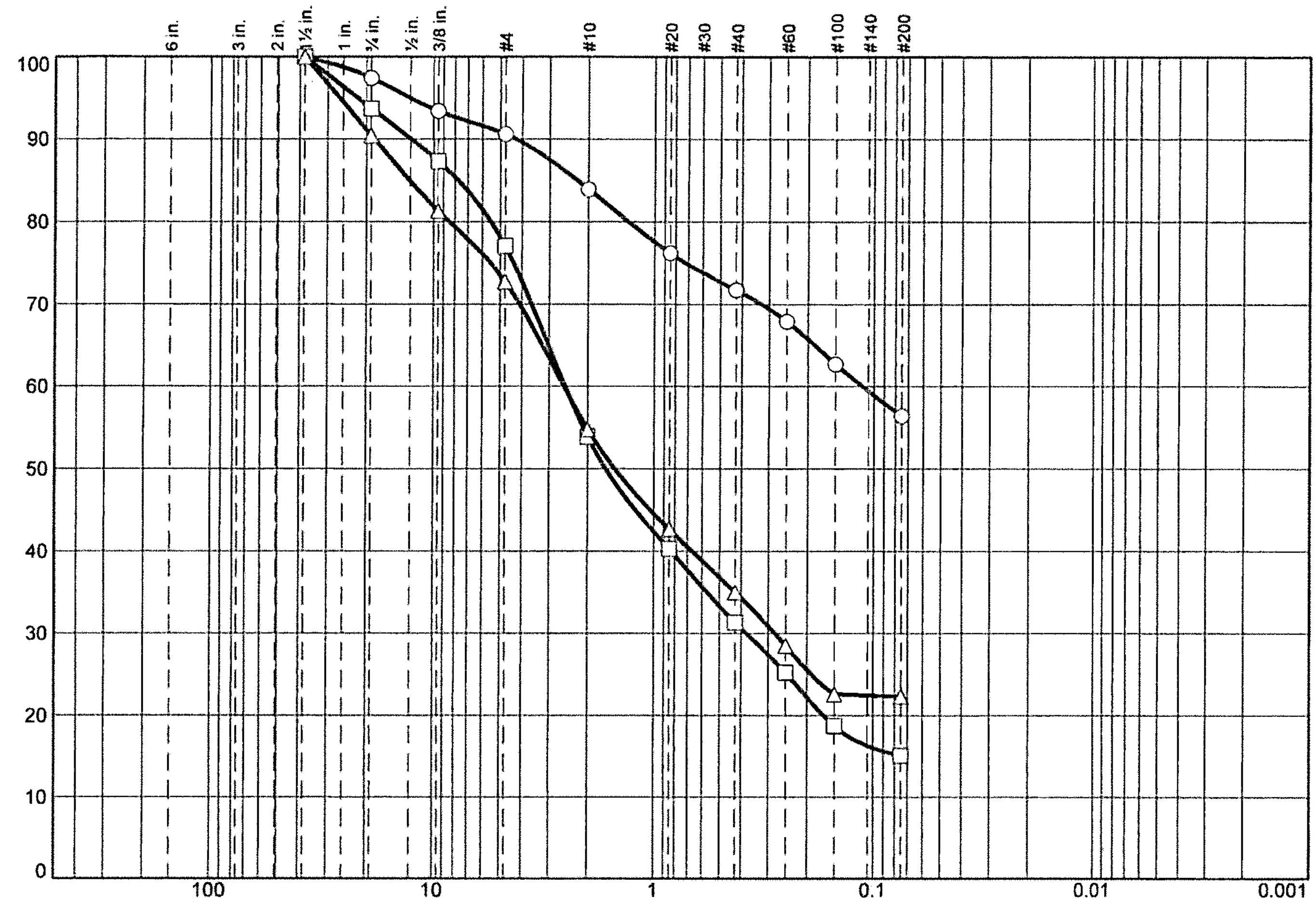
Terra Associates, Inc.

Kirkland, WA

Figure A-11

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	2.6	6.8	6.7	12.2	15.3	56.4	
□	0.0	6.3	16.7	23.1	22.6	16.2	15.1	
△	0.0	9.6	17.7	17.9	19.8	12.7	22.3	

╳	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			2.2520	0.1133						
□			7.7327	2.5352	1.6581	0.3795				
△			12.8367	2.5702	1.5085	0.2806				

Material Description	USCS	AASHTO
○ sandy SILT	ML	
□ silty SAND with gravel	SM	
△ silty SAND with gravel	SM	

Project No. T-8064 **Client:** D.R. Horton

Project: Barajas Property

○ **Location:** TP-6 **Depth:** 2'

□ **Location:** TP-7 **Depth:** 5'

△ **Location:** TP-9 **Depth:** 1'

Remarks:

○ Tested November 13, 2018

□ Tested November 13, 2018

△ Tested November 13, 2018

Terra Associates, Inc.

Kirkland, WA

Figure A-12

Tested By: FQ

CP|H
CONSULTANTS

Appendix B

WWMH Input Parameters and Results

Site Planning
Civil Engineering
Project Management
Land Use Consulting

	Impervious	
Basin	SF	Acre
Roads	21,386	0.49
Sidewalk	4,923	0.11
Lots	63,022	1.45
Driveway Drops	840	0.02
PATs	6,153	0.14
Tract C Access Road	3,705	0.09
Pond Surface	17,997	0.41
Bypass	4,740	0.11

Property Area	206,848	4.75
Frontage Area	11,361	0.26
Total Site Area	218,209	5.01
Total Impervious	122,766	2.82
Total Pervious	95,443	2.19

Upstream Basin	SF	Acre
Pasture	92375	2.12
Total	92375	2.12

Frontage Bypass Basin	4740	0.11
Imperviois	4207	0.10
Pervious	533	0.01

Area to Pond	305,844	7.02
Impervious	118,559	2.72
Pervious	187,285	4.30

Lot #	Area (SF)	Imp. (SF)	Pervious (SF)
1	5,227	3,136	2,091
2	5,127	3,076	2,051
3	4,562	2,737	1,825
4	4,937	2,962	1,975
5	4,936	2,962	1,974
6	4,931	2,959	1,972
7	5,827	3,496	2,331
8	5,578	3,347	2,231
9	5,393	3,236	2,157
10	5,250	3,150	2,100
11	5,750	3,450	2,300
12	6,825	4,095	2,730
13	5,750	3,450	2,300
14	5,740	3,444	2,296
15	5,250	3,150	2,100
16	5,750	3,450	2,300
17	6,259	3,755	2,504
18	5,754	3,452	2,302
19	6,191	3,715	2,476
Total	105,037	63,022	42,015

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	190128_Pond SSD
Site Name:	Belmont Heights PRD
Site Address:	
City:	Monroe, WA
Report Date:	1/29/2019
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.20
Version Date:	2016/02/25
Version:	4.2.12

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

Predeveloped

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	5.01
Pervious Total	5.01
Impervious Land Use	acre
Impervious Total	0
Basin Total	5.01

Element Flows To:

Surface	Interflow	Groundwater

Upstream

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Flat	2.12
Pervious Total	2.12
Impervious Land Use	acre
Impervious Total	0
Basin Total	2.12

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Developed to Pond

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	2.18
Pervious Total	2.18
Impervious Land Use	acre
ROADS FLAT	2.72
Impervious Total	2.72
Basin Total	4.9

Element Flows To:

Surface	Interflow	Groundwater
Detention Pond	Detention Pond	

Upstream Flow-through

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Flat	2.12
Pervious Total	2.12
Impervious Land Use	acre
Impervious Total	0
Basin Total	2.12

Element Flows To:

Surface	Interflow	Groundwater
Detention Pond	Detention Pond	

Frontage Bypass

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.01
Pervious Total	0.01
Impervious Land Use	acre
ROADS FLAT	0.1
Impervious Total	0.1
Basin Total	0.11

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

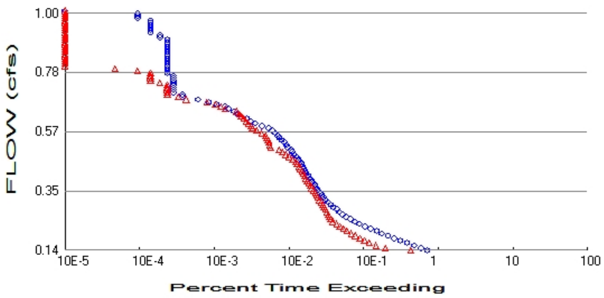
Detention Pond

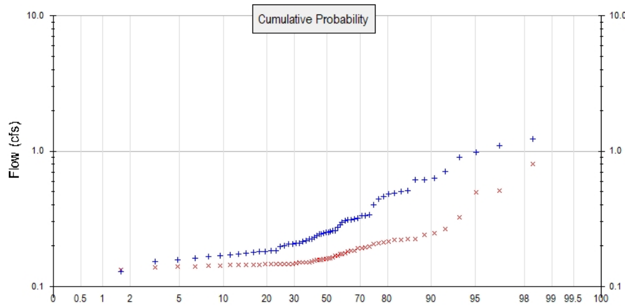
Depth: 9 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	Area (ac.)	Volume (ac-ft.)	Outlet Struct	NotUsed	NotUsed	NotUsed	NotUsed
0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000
2.000	0.056	0.086	0.081	0.000	0.000	0.000	0.000
4.000	0.263	0.224	0.114	0.000	0.000	0.000	0.000
6.000	0.351	0.839	0.140	0.000	0.000	0.000	0.000
8.000	0.449	1.639	0.675	0.000	0.000	0.000	0.000
9.000	0.501	2.114	7.908	0.000	0.000	0.000	0.000

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 7.13
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.31
Total Impervious Area: 2.82

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.272234
5 year	0.445841
10 year	0.589641
25 year	0.807918
50 year	0.999549
100 year	1.2182

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.172625
5 year	0.23403
10 year	0.281799
25 year	0.350854
50 year	0.409056
100 year	0.473449

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.336	0.140
1950	0.319	0.172
1951	0.245	0.149
1952	0.210	0.150
1953	0.170	0.147
1954	0.978	0.185
1955	0.339	0.170
1956	0.284	0.239
1957	0.402	0.204
1958	0.502	0.221

1959	0.258	0.157
1960	0.255	0.160
1961	1.222	0.266
1962	0.257	0.162
1963	0.489	0.181
1964	0.311	0.144
1965	0.214	0.144
1966	0.129	0.133
1967	0.252	0.211
1968	0.310	0.174
1969	1.091	0.214
1970	0.179	0.141
1971	0.316	0.163
1972	0.205	0.195
1973	0.205	0.150
1974	0.508	0.184
1975	0.223	0.152
1976	0.199	0.159
1977	0.157	0.147
1978	0.181	0.146
1979	0.634	0.192
1980	0.272	0.146
1981	0.183	0.145
1982	0.253	0.163
1983	0.459	0.155
1984	0.246	0.225
1985	0.307	0.198
1986	0.704	0.494
1987	0.331	0.325
1988	0.169	0.146
1989	0.218	0.141
1990	0.230	0.156
1991	0.236	0.152
1992	0.182	0.150
1993	0.167	0.138
1994	0.172	0.157
1995	0.243	0.220
1996	0.444	0.209
1997	0.906	0.800
1998	0.153	0.169
1999	0.196	0.142
2000	0.162	0.223
2001	0.063	0.133
2002	0.226	0.144
2003	0.176	0.146
2004	0.297	0.246
2005	0.209	0.146
2006	0.611	0.192
2007	0.483	0.175
2008	0.610	0.510
2009	0.183	0.144

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	1.2219	0.8003
2	1.0908	0.5103
3	0.9784	0.4943

4	0.9056	0.3246
5	0.7040	0.2658
6	0.6336	0.2457
7	0.6108	0.2392
8	0.6098	0.2255
9	0.5082	0.2226
10	0.5017	0.2213
11	0.4887	0.2202
12	0.4833	0.2143
13	0.4587	0.2112
14	0.4442	0.2085
15	0.4021	0.2044
16	0.3390	0.1984
17	0.3355	0.1949
18	0.3309	0.1921
19	0.3189	0.1916
20	0.3156	0.1850
21	0.3112	0.1844
22	0.3098	0.1813
23	0.3074	0.1752
24	0.2975	0.1745
25	0.2838	0.1724
26	0.2720	0.1697
27	0.2583	0.1686
28	0.2574	0.1629
29	0.2545	0.1626
30	0.2525	0.1621
31	0.2523	0.1604
32	0.2461	0.1594
33	0.2453	0.1573
34	0.2426	0.1567
35	0.2362	0.1562
36	0.2298	0.1553
37	0.2255	0.1518
38	0.2232	0.1516
39	0.2181	0.1502
40	0.2145	0.1499
41	0.2099	0.1496
42	0.2088	0.1486
43	0.2051	0.1474
44	0.2050	0.1474
45	0.1986	0.1464
46	0.1961	0.1463
47	0.1829	0.1462
48	0.1826	0.1458
49	0.1819	0.1456
50	0.1805	0.1445
51	0.1787	0.1445
52	0.1761	0.1444
53	0.1724	0.1441
54	0.1702	0.1440
55	0.1688	0.1422
56	0.1667	0.1414
57	0.1625	0.1409
58	0.1574	0.1404
59	0.1529	0.1376
60	0.1290	0.1335
61	0.0631	0.1334

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1361	15169	9133	60	Pass
0.1448	12637	4173	33	Pass
0.1536	10117	3129	30	Pass
0.1623	8177	2556	31	Pass
0.1710	6637	2177	32	Pass
0.1797	5523	1896	34	Pass
0.1884	4534	1653	36	Pass
0.1972	3743	1458	38	Pass
0.2059	3198	1279	39	Pass
0.2146	2669	1144	42	Pass
0.2233	2244	1019	45	Pass
0.2321	1856	933	50	Pass
0.2408	1619	827	51	Pass
0.2495	1406	773	54	Pass
0.2582	1239	743	59	Pass
0.2669	1120	715	63	Pass
0.2757	1012	687	67	Pass
0.2844	929	661	71	Pass
0.2931	831	634	76	Pass
0.3018	776	607	78	Pass
0.3105	709	581	81	Pass
0.3193	655	542	82	Pass
0.3280	621	519	83	Pass
0.3367	588	501	85	Pass
0.3454	558	482	86	Pass
0.3542	524	455	86	Pass
0.3629	501	432	86	Pass
0.3716	480	415	86	Pass
0.3803	450	395	87	Pass
0.3890	430	375	87	Pass
0.3978	409	362	88	Pass
0.4065	388	347	89	Pass
0.4152	364	333	91	Pass
0.4239	350	321	91	Pass
0.4326	340	306	90	Pass
0.4414	328	291	88	Pass
0.4501	315	277	87	Pass
0.4588	297	262	88	Pass
0.4675	284	236	83	Pass
0.4763	271	213	78	Pass
0.4850	252	192	76	Pass
0.4937	238	173	72	Pass
0.5024	227	156	68	Pass
0.5111	206	122	59	Pass
0.5199	198	118	59	Pass
0.5286	186	115	61	Pass
0.5373	170	112	65	Pass
0.5460	158	107	67	Pass
0.5548	151	104	68	Pass
0.5635	142	92	64	Pass
0.5722	126	79	62	Pass
0.5809	113	69	61	Pass
0.5896	92	66	71	Pass

0.5984	76	61	80	Pass
0.6071	65	57	87	Pass
0.6158	58	53	91	Pass
0.6245	48	49	102	Pass
0.6332	44	46	104	Pass
0.6420	39	42	107	Pass
0.6507	33	30	90	Pass
0.6594	30	26	86	Pass
0.6681	23	22	95	Pass
0.6769	18	17	94	Pass
0.6856	13	9	69	Pass
0.6943	8	7	87	Pass
0.7030	8	5	62	Pass
0.7117	6	5	83	Pass
0.7205	6	5	83	Pass
0.7292	6	5	83	Pass
0.7379	6	5	83	Pass
0.7466	6	4	66	Pass
0.7553	6	3	50	Pass
0.7641	6	3	50	Pass
0.7728	6	3	50	Pass
0.7815	5	3	60	Pass
0.7902	5	2	40	Pass
0.7990	5	1	20	Pass
0.8077	5	0	0	Pass
0.8164	5	0	0	Pass
0.8251	5	0	0	Pass
0.8338	5	0	0	Pass
0.8426	5	0	0	Pass
0.8513	5	0	0	Pass
0.8600	5	0	0	Pass
0.8687	5	0	0	Pass
0.8774	5	0	0	Pass
0.8862	5	0	0	Pass
0.8949	5	0	0	Pass
0.9036	5	0	0	Pass
0.9123	4	0	0	Pass
0.9211	4	0	0	Pass
0.9298	3	0	0	Pass
0.9385	3	0	0	Pass
0.9472	3	0	0	Pass
0.9559	3	0	0	Pass
0.9647	3	0	0	Pass
0.9734	3	0	0	Pass
0.9821	2	0	0	Pass
0.9908	2	0	0	Pass
0.9995	2	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.2462 acre-feet
On-line facility target flow:	0.1254 cfs.
Adjusted for 15 min:	0.1254 cfs.
Off-line facility target flow:	0.0897 cfs.
Adjusted for 15 min:	0.0897 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
Detention Pond POC	☐	838.96			☐	0.00			
Total Volume Infiltrated		838.96	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

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

Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   190128_Pond SSD.wdm
MESSU      25   Mit190128_Pond SSD.MES
           27   Mit190128_Pond SSD.L61
           28   Mit190128_Pond SSD.L62
           30   POC190128_Pond SSD1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      16
      IMPLND       1
      PERLND      13
      RCHRES       1
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Detention Pond              MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                             in  out          ***
   16      C, Lawn, Flat          1    1    1    1   27    0
   13      C, Pasture, Flat       1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   16         0    0    1    0    0    0    0    0    0    0    0    0
   13         0    0    1    0    0    0    0    0    0    0    0    0
```

```
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   16         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   13         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   16         0    0    0    0    0    0    0    0    0    0    0
   13         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   16              0       4.5      0.03       400      0.05       0.5     0.996
   13              0       4.5      0.06       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   16              0         0         2         2         0         0         0
   13              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   16            0.1      0.25      0.25         6       0.5      0.25
   13           0.15       0.4       0.3         6       0.5       0.4
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   16              0         0         0         0       2.5         1         0
   13              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                       in  out          ***
    1      ROADS/FLAT             1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    1         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    1         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
```

```
    1         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    1            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    1             0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    1             0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Developed to Pond***
PERLND  16                        2.18     RCHRES   1      2
PERLND  16                        2.18     RCHRES   1      3
IMPLND   1                        2.72     RCHRES   1      5
Upstream Flow-through***
PERLND  13                        2.12     RCHRES   1      2
PERLND  13                        2.12     RCHRES   1      3
Frontage Bypass***
PERLND  16                        0.01     COPY   501     12
PERLND  16                        0.01     COPY   601     12
PERLND  16                        0.01     COPY   501     13
PERLND  16                        0.01     COPY   601     13
IMPLND   1                         0.1     COPY   501     15
IMPLND   1                         0.1     COPY   601     15

******Routing******
PERLND  16                        2.18     COPY     1     12
IMPLND   1                        2.72     COPY     1     15
PERLND  16                        2.18     COPY     1     13
PERLND  13                        2.12     COPY     1     12
PERLND  13                        2.12     COPY     1     13
RCHRES   1                           1     COPY   501     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                            ***
    1     Detention Pond          1    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***
```

```
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                       ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1              1      0.01       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                          ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1            0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
    6    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.030000  0.000000  0.000000
  2.000000  0.056000  0.086000  0.080688
  4.000000  0.263000  0.224000  0.114110
  6.000000  0.351000  0.839000  0.139756
  8.000000  0.449000  1.639000  0.674672
  9.000000  0.501000  2.114000  7.908392
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.2            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.2            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   1 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
END EXT TARGETS
```

```
MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16

END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

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APPENDIX C

CONVEYANCE CALCULATIONS

APPENDIX C - CPH Rational Calculations

Project Name: Belmont Heights PRD
CPH Project No.: 0035-18-027

	10 yr	25 yr	100yr
a_R	2.44	2.66	2.61
b_R	0.64	0.65	0.63
P_R	2.8	3.2	3.8

(NOAA Atlas - Isopluvial Maps: Figures 27,28,30)

Description: Rational calculation spreadsheet for backwater analysis

Basin / Subbasin	Total Area		C1	A1 (acres)	C2	A2 (acres)	Cc	Flowpath Slope (ft/ft)	k_R (KCSWDM Table 3.2.1.C)	Velocity (fps)	Length of Flowpath (feet)	Travel Time (minutes)	Travel Time Used (minutes)	i_R	I_R	A_t (acres)	Q Basin (cfs)	Q_t Total (cfs)	Length of Pipe (feet)	Diameter of Pipe (inches)	Slope of Pipe (ft/ft)	Manning's Value "n"	Velocity Full (fps)	Q_f Full (cfs)	Q_f/Q_t	Q Ratio	To CB
	SF	AC																									
CB100	42875	0.98	0.90	0.59	0.25	0.39	0.64	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.98	1.96	7.35	**CPH Backwater Spreadsheet**								
CB105	25287	0.58	0.90	0.42	0.25	0.16	0.72	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.58	1.30	5.40	**CPH Backwater Spreadsheet**								
CB110	32738	0.75	0.90	0.14	0.25	0.61	0.37	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.75	0.87	3.37	**CPH Backwater Spreadsheet**								
CB115	2354	0.05	0.90	0.04	0.25	0.01	0.73	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.05	0.12	1.33	**CPH Backwater Spreadsheet**								
CB120	19811	0.45	0.90	0.26	0.25	0.19	0.62	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.45	0.88	1.21	**CPH Backwater Spreadsheet**								
CB125	1484	0.03	0.90	0.02	0.25	0.01	0.63	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.03	0.07	0.33	**CPH Backwater Spreadsheet**								
CB130	4657	0.11	0.90	0.09	0.25	0.02	0.80	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.11	0.27	0.27	**CPH Backwater Spreadsheet**								
CB106	15896	0.36	0.90	0.22	0.25	0.14	0.64	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.36	0.73	0.73	**CPH Backwater Spreadsheet**								
CB111	23324	0.54	0.90	0.37	0.25	0.17	0.70	0.02	17.00	2.08	50.00	0.40	6.30	0.82	3.11	0.54	1.16	1.16	**CPH Backwater Spreadsheet**								

PROJECT: Belmont Heights PRD
DATE: 1/30/2019
CPH PROJECT No. 0035-18-027

DESCRIPTION: Storm drain conveyance system for Belmont Heights PRD: Backwater Spreadsheet.

		1	2	3	4	5	6		7	8	9	10			11	12		13	14	15				16	17		18			19	20		
PIPE SEGMENT		Design Flow Q	Length	Pipe Size	Manning's n	Downstream Invert Elevation	Upstream Inlet Elevation	Pipe Slope	Barrel Area	Barrel Velocity	Barrel Velocity Head	TW Elevation	Barrel Perimeter	Friction Slope	Friction Loss	Entrance HGL Elevation	Entrance Loss Coefficient	Entrance Head Loss	Exit Head Loss	Outlet Control Elevation	d_c/D	Critical Depth	Critical Velocity	Inlet Control Elevation	Approach Velocity Head	K_b	Bend Head Loss	Q_3/Q_1	K_j	Junction Head Loss	Head Water	Rim Elevation	Overflow?
D/S CB	**U/S CB**	(cfs)	(ft)	(in)		(ft)	(ft)	(ft/ft)	(sq. ft)	(fps)	(ft)	(ft)	(ft)	S_f	(ft)	(ft)	k_e	(ft)	(ft)	(ft)		(ft)	(fps)	(ft)	(ft)		(ft)	(%)		(ft)	(ft)	(ft)	
Pond	CB100	7.35	86.3	18	0.012	311.00	325.28	0.165	1.77	4.16	0.27	316.00	4.71	0.00	0.36	326.78	0.50	0.13	0.27	327.18	0.57	0.86	5.25	326.27	0.77	0.00	0.000	0%	0.00	0.00	326.42	328.78	Contained
CB100	CB105	5.40	130.5	12	0.012	325.78	335.69	0.076	0.79	6.88	0.77	326.42	3.14	0.02	2.53	336.69	0.50	0.38	0.77	337.84	0.57	0.57	4.28	338.81	0.33	0.00	0.000	0%	0.00	0.00	338.47	340.69	Contained
CB105	CB110	3.37	109.8	12	0.012	335.69	343.56	0.072	0.79	4.29	0.30	338.47	3.14	0.01	0.83	344.56	0.50	0.15	0.30	345.01	0.57	0.57	4.28	345.08	0.04	0.00	0.000	0%	0.00	0.00	345.04	346.79	Contained
CB110	CB115	1.33	128	12	0.012	343.56	356.36	0.100	0.79	1.69	0.04	345.04	3.14	0.00	0.15	357.36	0.50	0.02	0.04	357.43	0.57	0.57	4.28	357.24	0.04	0.00	0.000	0%	0.00	0.00	357.39	359.57	Contained
CB115	CB120	1.21	34.5	12	0.012	356.36	356.57	0.006	0.79	1.54	0.04	357.39	3.14	0.00	0.03	357.57	0.50	0.02	0.04	357.63	0.57	0.57	4.28	357.49	0.00	0.00	0.000	0%	0.00	0.00	357.62	359.57	Contained
CB120	CB125	0.33	92.9	12	0.012	356.57	365.40	0.095	0.79	0.42	0.00	357.62	3.14	0.00	0.01	366.40	0.50	0.00	0.00	366.40	0.57	0.57	4.28	366.22	0.00	0.00	0.000	0%	0.00	0.00	366.40	368.40	Contained
CB125	CB130	0.27	37.8	12	0.012	365.40	368.62	0.085	0.79	0.34	0.00	366.40	3.14	0.00	0.00	369.62	0.50	0.00	0.00	369.62	0.57	0.57	4.28	369.44	0.00	0.00	0.000	0%	0.00	0.00	369.62	371.62	Contained
CB105	CB106	0.73	74.6	12	0.012	335.69	340.00	0.058	0.79	0.93	0.01	338.47	3.14	0.00	0.03	341.00	0.50	0.01	0.01	341.02	0.57	0.57	4.28	340.86	0.00	0.00	0.000	0%	0.00	0.00	341.02	343.14	Contained
CB110	CB111	1.16	34.5	12	0.012	343.56	343.77	0.006	0.79	1.48	0.03	345.04	3.14	0.00	0.03	345.07	0.50	0.02	0.03	345.12	0.57	0.57	4.28	344.68	0.00	0.00	0.000	0%	0.00	0.00	345.12	346.77	Contained

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APPENDIX D

DOWNSTREAM ANALYSIS

Downstream Analysis Drainage System Table

Symbol	Drainage Component Type, Name, and Size	Drainage Component Description	Slope	Distance from site discharge	Existing Problems	Potential Problems	Observations of field inspector, resource reviewer, or resident
see map	Type: sheet flow, swale, stream, channel, pipe, pond; Size: diameter, surface area	drainage basin, vegetation, cover, depth, type of sensitive area, volume	%	¼ ml = 1,320 ft.	constrictions, under capacity, ponding, overtopping, flooding, habitat or organism destruction, scouring, bank sloughing, sedimentation, incision, other erosion		tributary area, likelihood of problem, overflow pathways, potential impacts
1	Sheet Flow	Runoff flows southwesterly across site	~10%	0'	None observed		See photos #1, #2, #5, #6
2	Interceptor Trench with perforated pipe	Sheet flow enters gravel interceptor trench along north property boundary of Toivo Ridge development and flows west to an existing catch basin	~6%	5'	None observed		See downstream map
3	Catch basins and conveyance pipes	Runoff flows through a series of catch basins and underground pipes	~12%	5' - 955'	None observed		See downstream map
4	Detention Pond	Runoff discharges into Trombley Hill detention pond	0%	955' – 1200'	None observed		See photo #9
5	Control Structure and conveyance pipes	Runoff discharges from pond and ultimately outfalls to a wetland southwest of pond	~4%	1200' – 1320'	None observed		See downstream map

1/31/2019

LEGEND

PROPERTY BOUNDARY
SHEET FLOW
UNDERGROUND CONVEYANCE SYSTEM
GRAVEL INTERCEPTOR TRENCH

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N

0 100 200
PLAN IN FEET

DOWNSTREAM MAP

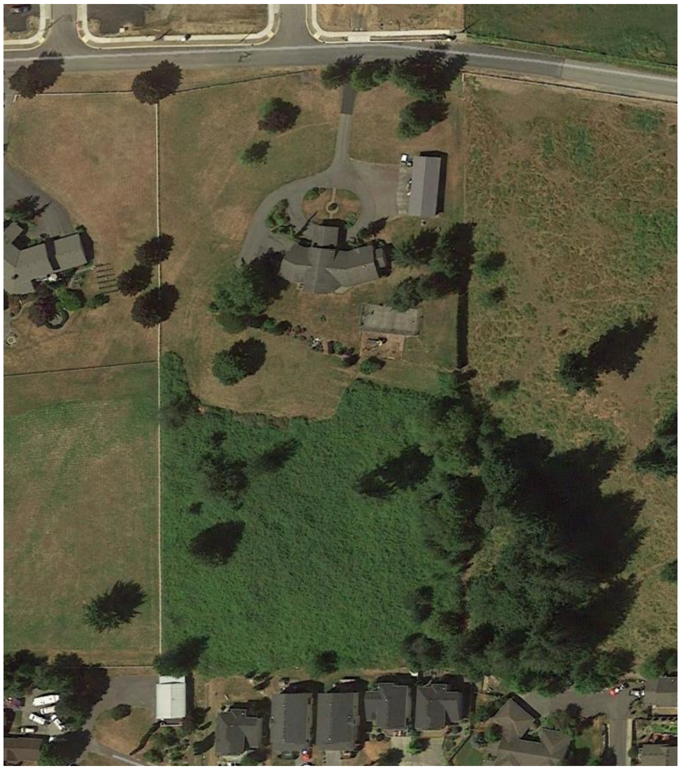

Photo #1: Aerial imagery of project site.

Photo #2: Looking south at project site from 134th St SE at approximately midpoint of northern property boundary.

Photo #3: Looking west at 134th St SE along northern property boundary of project site.

Photo #4: Looking east at 134th St SE along northern property boundary of project site.

Photo #5: Looking south along eastern property boundary of project site.

Photo #6: Looking south along western property boundary of project site.

Photo #7: Looking north towards southern property boundary of project site. Buried stormwater pipes between existing house and fence convey flows to Trombley Hill detention pond.

Photo #8: Looking south from same location as photo #7. Buried stormwater pipes between existing house and fence convey flows to Trombley Hill detention pond.

Photo #9: Looking west at Trombley Hill detention pond.

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APPENDIX E

OPERATIONS AND MAINTENANCE MANUAL

V-4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table V-4.5.2(1) Maintenance Standards - Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants	Any evidence of oil,	No contaminants or pol-

Table V-4.5.2(1) Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	and Pollution	gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	lutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees

Table V-4.5.2(1) Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
		If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure (s); e.g.,rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (if Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Ponds Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation If settlement is apparent, measure berm to determine amount of settlement	Dike is built back to the design elevation.

Table V-4.5.2(1) Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
		Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms over 4 feet in height	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with	Piping eliminated. Erosion potential resolved.

Table V-4.5.2(1) Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
		potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	
Emergency Overflow/Spillway	Emergency Overflow/Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

Table V-4.5.2(2) Maintenance Standards - 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	Sediment is removed

Table V-4.5.2(3) Maintenance Standards - Closed Detention Systems (Tanks/Vaults) (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	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 (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See "Catch Basins" (No. 5)	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(4) Maintenance Standards - Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall. Structure is not in upright position (allow up to 10% from plumb). Connections to outlet pipe	Structure securely attached to wall and outlet pipe. Structure in correct position. Connections to outlet pipe are water tight; structure repaired or replaced and works as

Table V-4.5.2(4) Maintenance Standards - Control Structure/Flow Restrictor (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		are not watertight and show signs of rust.	designed.
		Any holes - other than designed holes - in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).
Catch Basin	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(5) Maintenance Standards - 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%. 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. Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height. Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No Trash or debris located immediately in front of catch basin or on grate opening. No trash or debris in the catch basin. Inlet and outlet pipes free of trash or debris. 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 is sit-

Table V-4.5.2(5) Maintenance Standards - Catch Basins (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
		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	ting 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. 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.	Basin replaced or repaired to design standards. 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. Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
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	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into	Mechanism opens with

Table V-4.5.2(5) Maintenance Standards - Catch Basins (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Working	frame have less than 1/2 inch of thread.	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.

Table V-4.5.2(6) Maintenance Standards - 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 are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4

Table V-4.5.2(6) Maintenance Standards - Debris Barriers (e.g., Trash Racks) (continued)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
			inch.
	Bars.	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

Table V-4.5.2(7) Maintenance Standards - Energy Dissipaters

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.

Table V-4.5.2(7) Maintenance Standards - Energy Dissipaters (continued)

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(8) Maintenance Standards - Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet

Table V-4.5.2(10) Maintenance Standards - Filter Strips (continued)

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
		ation starts to take over.	
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

Table V-4.5.2(11) Maintenance Standards - Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per	Trash and debris removed from pond.

Table V-4.5.2(11) Maintenance Standards - Wetponds (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		1000-SF of pond area.	
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of

Table V-4.5.2(11) Maintenance Standards - Wetponds (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
			berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Table V-4.5.2(12) Maintenance Standards - Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to	Maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks

Table V-4.5.2(17) Maintenance Standards - Coalescing Plate Oil/Water Separators (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	inlet/outlet pipe.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

Table V-4.5.2(18) Maintenance Standards - Catch Basin 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 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.