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Preliminary Stormwater Site Plan

Drainage Report
Walsh Hills

Snohomish, WA

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Preliminary Stormwater Site Plan

FOR

WALSH HILLS

SNOHOMISH, WA

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SECTION 1 – PROJECT OVERVIEW

This drainage report is provided to describe the existing stormwater conditions and proposed drainage improvements associated with the *Walsh Hills* PRD and Unit Lot Subdivision project. The project site is comprised of a single property (Snohomish County tax parcel no. 280607001-03600) with a total area of approximately 19.3 acres. The project proposes to re-develop the property site into 19 detached single-family residential lots and 94 fee-simple single-family residential lots, private tracts, and public right-of-way dedication. This report is provided to identify the applicable storm drainage standards and to summarize the analysis and design provisions proposed for the project to comply with the 2012 Department of Ecology Stormwater Management Manual for Western Washington, as amended in December 2014, as specified by the Snohomish Municipal Code (SMC), section 15.16.020.

The vicinity map provided below as Figure 1 illustrates the general location of the property. The site is located at 1705 and 1711 Terrace Avenue, Snohomish WA, 98290. More generally the site is located in a portion of the NE ¼, Section 7, Township 28 North, Range 6 East, W.M. and a portion of the NW ¼, Section 7, Township 28 North, Range 6 East, W.M. in Snohomish County, Washington. (see Vicinity Map below).

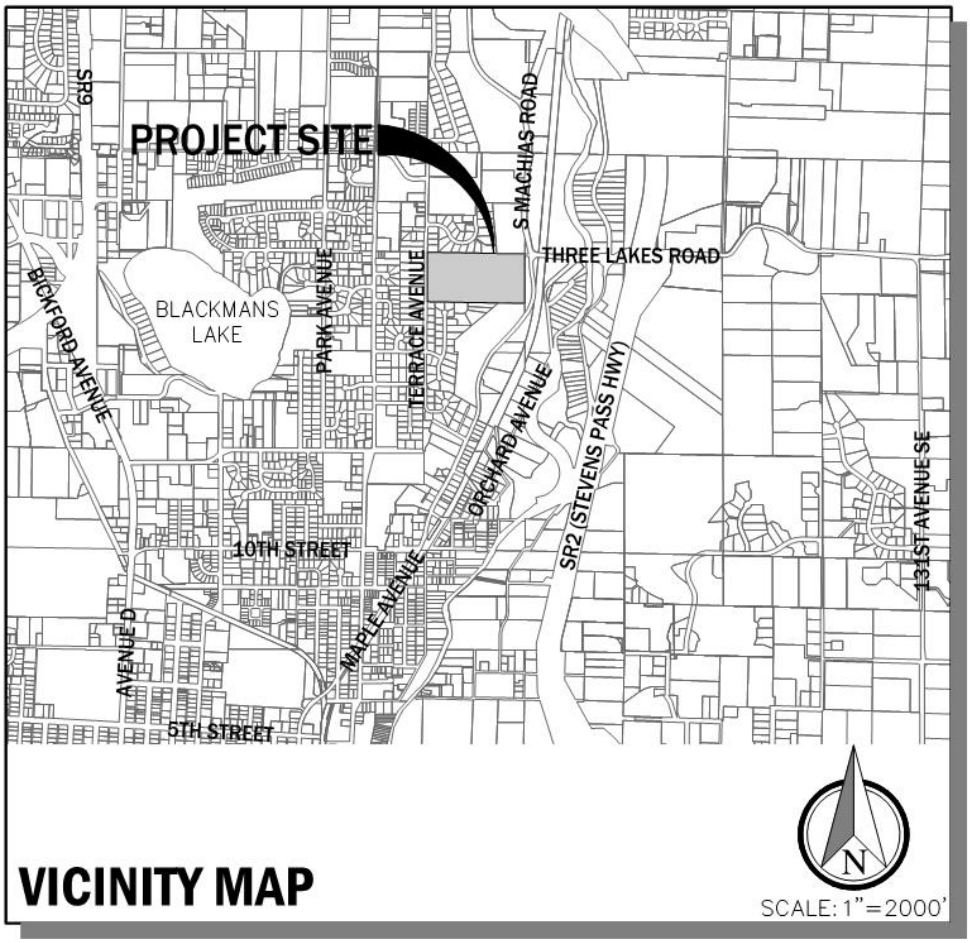

Figure 1 – Vicinity Map

The project site is currently comprised of 1 tax parcel (Snohomish County tax parcel no. 280607001-03600) totaling approximately 19.3 acres adjacent to the east side of Terrace Avenue. Steep slopes encumber the eastern portions of the site and development will be restricted to the western portion of the property. The developable area of the site slopes moderately away from a topographic high near its central region. This central area is currently occupied by a series of paved driveways and an assemblage of buildings. It contains a number of buildings supporting the Snohomish Chalet and Delta Foundation, a retirement and assisted living community. The north and east perimeters of the site are heavily forested and the western frontage has a sparse grouping of trees and open lawn areas. A number of trees of varying type, age, and health conditions exist on portions of the site.

The west 230 feet and approximately 3.5 acres of the site is zoned Single Family Residential (SF) and the remaining 15.8-acre portion east of that line is zoned Medium Density Multifamily Residential (MD). Detached single-family residences are the principal land use for the SF zone according to Snohomish Municipal Code (SMC) 14.205.020. The MD zone permits both single-family and multifamily residential uses at an allowable density of 18 dwelling units per acre per SMC 14.205.020. This stormwater report addresses the stormwater requirements for the entire parcel, which will include a separate Subdivision and PRD application for the western portion and a Unit Lot Subdivision for the eastern portion of the site. The proposed development will subdivide a 19.3-acre property to create 113 new single-family residential lots. 19 lots will be single family homes and 94 lots will be fee-simple single family homes.

The eastern portion of the site contains steep slopes and will remain undeveloped and contained in a Critical Area tract. The *Walsh Hills* project will create and/or replace a total of approximately 8.73 acres of impervious surfaces. Approximately 3.88 acres of impervious surface currently exist onsite and will be removed and or replaced with the development . The site has two basins that flow primarily as sheet and shallow concentrated flows. The east basin flows from higher elevations near the center of the project site to lower elevations in the east, flowing over steeps slopes adjacent to Machias Road. Runoff from the site then flows through a culvert that runs beneath Machias road to an existing wetland to the east. The west basin flows from the high point near the center of the project site to lower elevations to the west, and are collected by the roadside ditch along Terrace Avenue.

The developed site is required to provide Basic Water Quality treatment in addition to flow control standards in accordance with 2014 Department of Ecology Stormwater Management Manual for Western Washington (SMMWW) criteria and Snohomish County Drainage Manual for portions discharging outside of the City limits. Flow control will be provided by a detention vault for each onsite basin. The vaults will be located in the southeast and southwest portions of the developed area. The below-grade vault proposed in the southeastern portion of the site will have a control structure discharging to an existing culvert located adjacent to the west side of Machias Road. The culvert runs to the east below Machias Road and conveys stormwater to an existing wetland. It is unclear at this point if this wetland is hydraulically connected to the floodplain, in which case a flow control exemption may be applicable to the project for direct discharge. Further analysis would be required during final design to make this determination, and detention vaults are currently proposed for flow control. Basic water quality treatment will be provided by a water quality treatment vault located downstream of the detention vault. The below-grade vault proposed in the southwestern portion of the site will have a control structure discharging to the proposed storm drainage system located in the western portion of the Terrace Avenue frontage and a wetpool for water quality treatment. A small portion of Terrace Avenue near the southwest corner of the site will bypass detention, this area will be treated by a stormfilter catch basin located along the east side of Terrace Avenue and conveyed to the existing storm system.

On-site Soil Conditions

The soils of the project area are characterized generally by the Natural Resource Conservation Services (NRCS) as Tokul gravelly medial loam, 0 to 8 percent slopes and Tokul-Winston gravelly loam, 25 to 65 percent slopes.

A site-specific investigation of the existing geotechnical conditions was performed by Terra Associates, Inc. A copy of their Geotechnical Engineering Report (May 15, 2020) and the NRCS soils data is provided in Appendix A of this report for reference.

SECTION 2 – CONDITIONS AND REQUIREMENTS SUMMARY

Compliance with Project Drainage Requirements

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 Snohomish Municipal Code (SMC), section 15.16.020 and Snohomish County Drainage Manual, whichever is more stringent. The project is classified as a re-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.

Minimum Requirements

1. **Preparation of Stormwater Site Plans**: Stormwater site plans and storm drainage report herein have been prepared for the subject project. Refer to Section 7 and Appendix F of this report for the downstream analysis.

2. **Stormwater Pollution Prevention Plan (SWPPP)**: The SWPPP is summarized in Section 5. A detailed SWPPP in accordance with Department of Ecology General Construction Stormwater Permit conditions will be available on the job site prior to construction.

3. **Source Control of Pollution**: Source control Best Management Practices (BMPs) will be installed on site to the maximum extent practicable. These will include educational information in the CC&Rs for the residences regarding limiting use of phosphate fertilizers and recommendations to wash vehicles offsite at commercial car wash centers.

4. **Preservation of Natural Drainage Systems and Outfalls**: The site has two basins; one that discharges to the east with an ultimate discharge to Pilchuck River. The west basin discharges to the southwest towards Johnson Road NE and has an ultimately discharges to Pilchuck River.

5. **On-site Storm Water Management**: Storm water will be detained, treated, and released at a controlled rate by the two onsite vaults with a wetpool or water quality treatment vault located downstream. BMPs were evaluated and Post-Construction Soil Quality and Depth will be implemented.

6. **Runoff Treatment**: Basic Water Quality Treatment is required for this project. A proprietary water quality filtration facility located downstream of the detention vault will provide treatment to runoff from the east basin while a wetpool within the west vault will provide treatment for the western basin. A stormfilter catch basin will treat a small portion of the runoff from Terrace Avenue which will bypass detention. Figures 3 and 4 illustrate the developed site plan for the project.

7. **Flow Control**: Stormwater will be detained and released at a controlled rate by two onsite vaults located in the southeast and southwest portion of the developed site area. Design details of the flow control facilities are described in Section 6 of this report and is as required by current storm drainage requirements unless an exemption to show direct discharge to the floodplain can be determined with final engineering design. Figures 3 and 4 illustrate the developed site plan for the project.

8. **Wetlands Protection**: No wetland protection is proposed with or required by this project.

9. **Operation and Maintenance**: The on-site storm drainage facilities within the right-of-way are proposed to be publicly maintained. The vaults are also proposed to be publicly owned and maintained. Section 8 further describes these requirements. A site-specific operations and maintenance manual will be provided with final engineering.

SECTION 3 – EXISTING SITE CONDITIONS

The project site is currently comprised of a single tax parcel (Snohomish County tax parcel no. 280607001-03600) totaling approximately 19.3 acres adjacent to the east side of Terrace Avenue. Steep slopes encumber the eastern limits of the site and development will be restricted to the western portion of the property. The developable area of the site slopes moderately away from a topographic high near its central region. This central area is currently occupied by a series of paved driveways and an assemblage of buildings. It contains a number of buildings supporting the Snohomish Chalet and Delta Foundation, a retirement and assisted living community. The north and east perimeters of the site are heavily forested and the western frontage has a sparse grouping of trees and open lawn areas. A number of trees of varying type, age, and health conditions exist on portions of the site. The front approximately 230 feet of the site along the east frontage of Terrace Avenue is currently zoned Single Family Residential (SF). The majority and remaining portion of the site is zoned Medium Density Residential (MD).

The site is comprised of two drainage sub-basins that flow primarily as sheet and shallow concentrated flows. The east basin flows from a ridge running through the project site north to south, to lower elevations in the east, flowing down steep slopes towards Machias Road. The west basin flows from that same ridge to lower elevations in the west, towards Terrace Avenue. Steep topography in the eastern portion of the site will be contained in a Critical Area tract and will remain undeveloped with the proposed project. Appendix F of this report contains a detailed analysis/description of the offsite and downstream drainage systems.

Soils are Tokul gravelly medial loam with slopes ranging from 0 to 8 percent and Tokul-Winston gravelly loam, 25 to 65 percent slopes. Appendix A contains a copy of the site-specific geotechnical report for the project along with the applicable NRCS data.

SECTION 4 – UPSTREAM SITE CONDITIONS

The site is bordered by Terrace Avenue to the west, Machias Road to the east, and single-family residences in the north and south. Due to the existing topography it is minimal sheet flow runoff from surrounding properties could flow onsite given the existing topography. A ridge exists on the project site allowing all runoff to flow away from the site. Thus, there are no existing upstream drainage subbasins expected to contribute runoff to the site.

SECTION 5 – SWPPP

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. 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*
   Primary access to the site will be limited from the Terrace Avenue rights-of-way during construction. The contractor shall limit the amount of sediment transported by motor vehicles and track equipment onto paved roads or other offsite areas by the use of quarry spall construction entrance(s).

3. *Control Flow Rates*
   The proposed detention vault will serve stormwater runoff from the project site. This facility may be used in conjunction with other 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 fence, temporary interceptor trenches, sediment traps or ponds, and inlet protection for existing catch basins 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. In addition, existing permanent storm drainage collection and conveyance facilities may be used to direct runoff from construction work areas to the on-site vault in the southeastern portion of the site to contain or provide additional capacity for storm water runoff volumes from construction areas.

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 SCDM 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. Stormwater runoff will generally be conveyed to the existing storm drainage system on-site for conveyance to the detention and treatment facility. 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*
    Runoff from dewatering operations shall be suitably filtered using approved areas of native vegetation, setting tanks or other mechanical filtration facilities, or direct discharge to the existing on-site drainage facilities if volumes meet 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.

SECTION 6 – DEVELOPED SITE CONDITIONS

The hydrologic analysis of the runoff conditions for this project is based on drainage characteristics such as basin area, soil type, and land use (i.e., pervious vs. impervious) in accordance with the applicable standards of the 2012 Department of Ecology Stormwater Management Manual for Western Washington (SMMWW), as amended in December 2014. The 2012 Western Washington Hydrology Model (WWHM) software was used to evaluate the stormwater runoff conditions for the project site and to design the on-site flow control facilities. The following is a summary of the results of the analysis and the proposed drainage facility improvements for this project.

Existing Site Hydrology

The existing conditions of the site are shown by Figure 2. The existing drainage basins are shown in Figure 5. Historic site conditions (i.e., fully forested) were considered in the WWHM analysis of the pre-developed site to establish allowable target release rates for the developed project in accordance with SWMMWW standards for Conservation (i.e., Stream Protection Duration) Flow Control. The predeveloped land characteristics used in the WWHM model analysis are summarized in Table 6.1

Table 6.1 – Land Use Cover, Pre-Developed Site Conditions

Sub-basin Name	Description	Total Basin Area (Acres)	Land Cover (Acres)		
			Impervious	Lawn C	Forest
East	Pre-developed site	8.13	0.00	0.00	8.13
East Downstream	Pre-developed site	7.04	0.61	0.00	6.43
West	Pre-developed site	5.82	0.00	0.00	5.82
Offsite North (Flow Through)	Pre-developed site	0.93	0.45	0.48	0.00

The project site was analyzed as two onsite drainage basins to determine the pre-developed runoff conditions based on the site topography and natural ridge through the central region of the site. An offsite basin, adjacent to the northwest property boundary, was also included due to offsite runoff being collected by the west vault in the developed condition. This offsite basin was modelled as existing conditions in both pre-developed and developed scenarios as it will remain undisturbed during construction.

Runoff from the east basin travels primarily as sheet and shallow concentrated flow from the center of the project site towards Machias Road. An existing culvert conveys runoff from the east basin below Machias Road easterly to a wetland which acts as the point of compliance for this basin. This wetland is located on a portion of a vacant property also owned by applicant for this project, although this parcel is not a part of the subdivision. Water collected on this parcel is temporarily impounded on this parcel by an old railroad embankment which now serves as the Centennial Trail and by Three Lakes Road. There was no outlet pipe observed on the property and ponded water is believed to move laterally through the porous fill of the Centennial Trail embankment or subsurface to a lower, vacant parcel east of the trail.

Stormwater runoff from the west basin flows primarily west from the same central ridge of the site to a shallow ditch along Terrace Avenue. These existing conditions were evaluated with the WWHM software and a report showing input and results is provided in Appendix B.

Developed Site Hydrology

The site is planned to be improved with paved public roads, storm drainage systems, and public and private utility infrastructure in support of 113 individual single-family residential lots. Primary and emergency access to the site will be provided by Terrace Avenue. Maximum lot coverages of 55% and 60% were assumed for all lots located within the Single-Family Residential (SF) and Medium Density Residential (MDR) zones respectively. Flow control for the east basin will be provided by a vault located in the southeast portion of the site, with a discharge to an existing culvert on the west side of Machias Road which leads to an existing wetland on the east side of Machias Road.

Flow control for the west basin will be provided by a vault located in the southwest portion of the site which will discharge to the proposed storm system in Terrace Avenue. This proposed public storm system continues southerly along Terrace Avenue and discharges to an existing culvert on the east side of Terrace Avenue approximately 450 feet downstream of the project site. A small portion of Terrace Avenue near the southwest corner of the site will bypass detention, this area has been designated as the southwest bypass basin.

Figure 6 shows the developed site sub-basin. The developed land use conditions displayed in Table 6.2 were used as the developed site conditions for the WWHM model.

Table 6.2 – Land Use Cover, Developed Conditions

Sub-basin Name	Description	Total Area (Acres)	Land Cover (Acres)		
			Impervious	Forest	Lawn
East Basin	Developed site	10.35	6.24	0.38	3.73
East Downstream	Developed Site	7.04	0.61	0.00	6.43
West Basin	Developed site	3.41	2.20	0.00	1.21
Southwest Bypass	Developed Site	0.18	0.14	0.00	0.04
Offsite North (Flow Through)	Developed site	0.93	0.45	0.48	0.00

The results of the developed site runoff analysis and hydrologic model are summarized in Table 6.4 and 6.5 below, and the detailed WWHM report is provided in Appendix B.

Flow Control

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. The hydrologic analysis of the runoff conditions for the project site is based on drainage area characteristics such as basin area, soil type, and land use (i.e., pervious, impervious). WWHM software was used to evaluate the storm water hydrology/runoff conditions for the detention vault.

The onsite storm drainage vaults have been designed to provide flow control for both the east and west basins of the site. Discharge from the facilities is released at a controlled rate in accordance with SWMMWW standards. A two-orifice flow control riser is proposed for the outlet control structure for the west basin vault to achieve conformance with the release to downstream system in Terrace Avenue. A two-orifice flow control riser is proposed for the outlet control structure for the east basin vault to achieve conformance with the release to downstream system off site. The sizes of the orifices on the risers have been designed to control the release durations to match the historic, pre-developed site conditions from 50% of the 2-year event up to the 50-year event. Tables 6.4, 6.5, 6.6a and 6.6b summarizes the WWHM results for the flow control analysis for the project. The full WWHM results are provided in the report in Appendix B.

Table 6.4 – Predeveloped Peak Design Flows

Basin ID	Land-Use Condition	Peak Flows at Point of Compliance (cfs)		
		2-year	10-year	50-year
East Basin	Pre-Developed	0.87	1.76	2.90
West Basin	Pre-Developed	0.45	0.87	1.37

Table 6.5 – Developed Peak Design Flows

Vault	Land-Use Condition	Peak Flows at Point of Compliance (cfs)		
		2-year	10-year	50-year
East Basin	Developed	0.74	1.42	2.31
West Basin	Developed	0.28	0.45	0.64

Table 6.6a –Walsh Hills East Vault Detention Volumes

Vault Live Storage Surface Area	13,104 SF
Live Storage Depth (incl. freeboard)	13.0’
Detention Volume	163,800 CF
Riser Height	12.5’
‘Riser Diam.	18”
Orifice 1 Diam. @ 0.00’	1.90”
Orifice 2 Diam. @ 6.75’	2.25”

Table 6.6b –Walsh Hills West Vault Detention Volumes

Vault Live Storage Surface Area	4,080 SF
Live Storage Depth (incl. freeboard)	7.2’
Detention Volume	27,336 CF
Riser Height	6.7’
Riser Diam.	18”
Orifice 1 Diam. @ 0.00’	2.175”
Orifice 2 Diam. @ 3.10’	2.20”

Water Quality

The SWMMWW requires all proposed projects that create greater than 5,000 sf of pollution-generating impervious surfaces (PGIS) provide water quality facilities to treat runoff of these surfaces. The project is a single-family residential project with detached homes located within both Single Family and Medium Density Residential (MD) zones. This moderate density residential project requires Basic Water Quality treatment. Basic water quality standards will be met via an appropriately sized water quality media treatment vault for the east basin and a wetpool located within the detention vault for the west basin. A small portion of Terrace Avenue near the southwest corner of the site will bypass detention, this area will be treated by a stormfilter catch basin located along the east side of Terrace Avenue and conveyed to the existing storm system. Additional details for these facilities will be provided with final engineering.

Conveyance Facilities

The project proposes to collect on-site runoff from the east basin and convey it to the stormwater detention vault located in the southeast portion of the site. Controlled discharges will be conveyed via an 18-inch HDPE tightline down the steep slope area and released to an existing culvert on the west side of Machias Road.

Runoff from the west basin will be collected and conveyed to a combined detention and water quality vault located in southwest portion of the site. The controlled storm water discharge from this vault will then be conveyed to the south within a proposed conveyance system which will discharge to an existing drainage ditch along the east side of Terrace Avenue approximately 450 feet downstream of the site. 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 vaults for flow control and water quality treatment as needed.

The pavement widening and improved pedestrian (i.e., sidewalk) facilities required along the Terrace Avenue frontage will eliminate existing driveway culverts and drainage diches. These drainage facilities will be replaced by continuous concrete vertical curb and gutter, catch basin inlets, and below grade pipes. These new facilities will collect and convey runoff south to the west storm drainage vault. Rational and backwater calculations will be provided with final engineering.

OnSite Stormwater Management

Per Section I-2.5.5 of the 2014 SWMWW, projects triggering Minimum Requirements #1-9 are required to meet the Low Impact Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth; or List #2. Per List #2, the applicable BMPs have been evaluated below in Table 6.8:

Table 6.8 – BMP Analysis

Surface	BMP	Description	Feasible?	Analysis
Lawn	T5.13	Post-Construction Soil Quality and Depth	Yes	BMPT5.13 will be implemented for both basins of the project site.
Roof	T5.30	Full dispersion	No	Dispersion infeasible due to steep slopes and insufficient flowpaths available onsite
Roof	T5.10A	Downspout Full Infiltration Systems	No	Infiltration infeasible due to glacial till soils with low permeability
Roof	T7.30	Bioretention	No	Bioretention infeasible due to insufficient available space

Roof	T5.10B	Downspout Dispersion Systems	No	Dispersion infeasible due to steep slopes and insufficient flowpaths available onsite
Roof	T5.10C	Perforated stub out connections	No	Infiltration infeasible due to glacial till soils with low permeability
Other Hard Surfaces	T5.30	Full dispersion	No	Dispersion infeasible due to steep slopes and insufficient flowpaths available onsite
Other Hard Surfaces	T5.15	Permeable Pavement	No	Permeable pavement infeasible due to glacial till soils with low permeability.
Other Hard Surfaces	T7.30	Bioretention	No	Bioretention infeasible due to insufficient available space
Other Hard Surfaces	T5.12	Sheet flow dispersion	No	Dispersion infeasible due to steep slopes and insufficient flowpaths available onsite

Individual lot BMPs will be further evaluated with Building Permit once final building products are determined.

SECTION 7 – DOWNSTREAM ANALYSIS

An investigation of the current storm drainage conditions downstream of the site was performed to evaluate potential runoff contributions to the onsite storm water systems as well as to identify any downstream constraints. Appendix F contains the complete Offsite Drainage Analysis report detailing that analysis and findings.

SECTION 8 – OPERATIONS AND MAINTENANCE MANUAL

The on-site storm drainage facilities that are the subject of this report and that are being proposed with the project will be publicly maintained. These drainage systems include catch basins, storm conveyance pipes, treatment facilities, and detention vaults located on the east and west side of the site. These drainage systems have been designed in accordance with the applicable provisions of the SWMMWW, a site-specific Operations and Maintenance Manual addressing the maintenance of these facilities will be included with final engineering.

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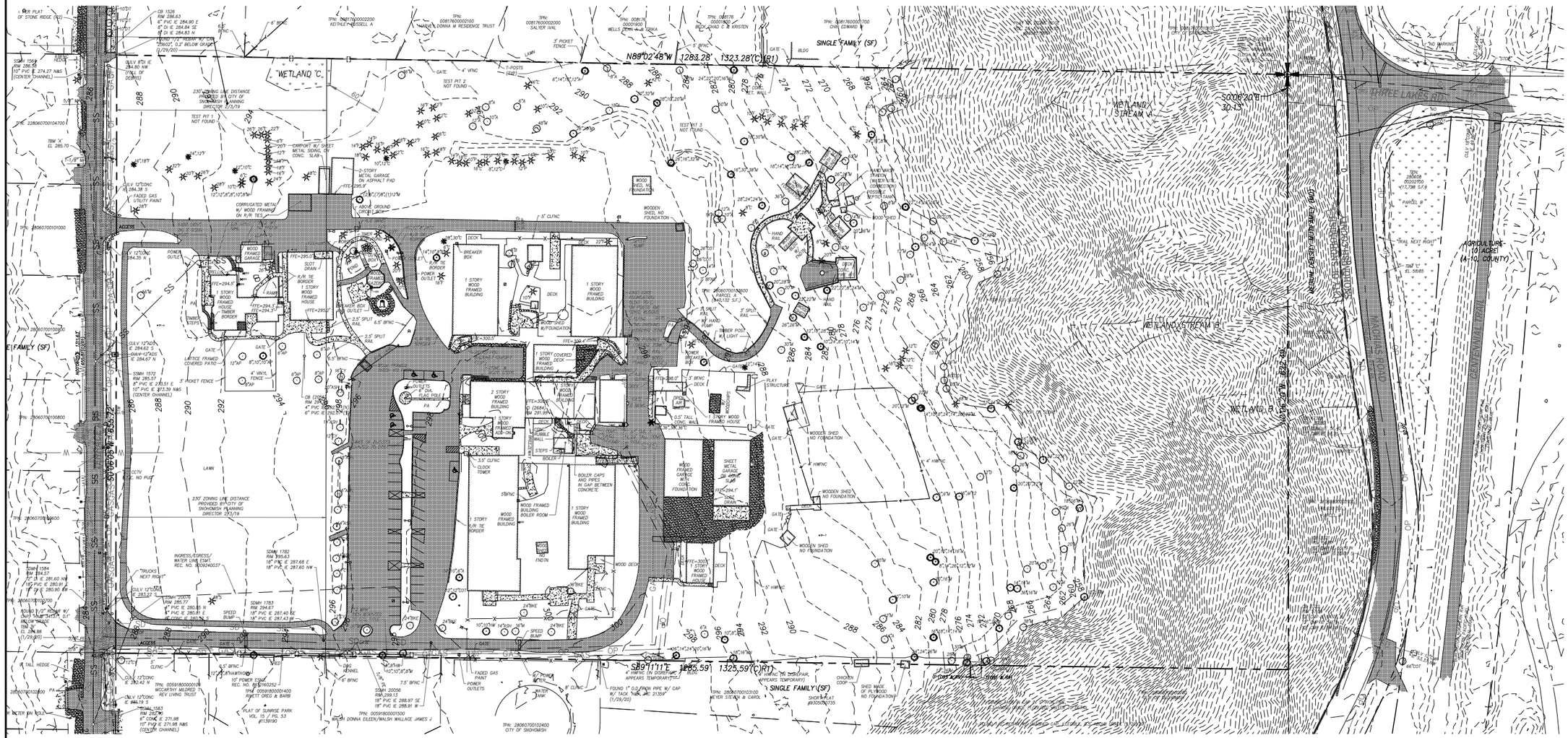
FIGURES



SURVEY DATA

EXISTING BOUNDARY, TOPOGRAPHIC, AND PLANIMETRIC INFORMATION SHOWN ON THIS PLAN AND OTHERS IN THIS SET WERE USED AS A BASIS FOR DESIGN AND REPRESENT FIELD SURVEY DATA AND MAPPING PREPARED BY AXIS SURVEY & MAPPING, AS PROVIDED BY THE PROJECT OWNER, AND DOES NOT REPRESENT WORK BY CPH CONSULTANTS. THE FOLLOWING SURVEY DATA WAS PROVIDED WITH THE TOPOGRAPHIC MAP BY AXIS SURVEY AND MAPPING:

LEGAL DESCRIPTION

PARCEL A

BEGINNING AT THE NORTHEAST CORNER OF SECTION 7, TOWNSHIP 28 NORTH, RANGE 6 EAST W.M., KING COUNTY, WASHINGTON.

THENCE WEST ALONG THE NORTH LINE OF SECTION 7 TO THE NORTHWEST CORNER OF THE NORTHWEST QUARTER OF THE NORTHEAST QUARTER OF THE NORTHEAST QUARTER OF SAID SECTION 7;

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THENCE EAST TO THE SOUTHEAST CORNER OF THE NORTHEAST QUARTER OF THE NORTHEAST QUARTER OF THE NORTHEAST QUARTER, SAID POINT BEING ON THE WEST LINE OF SECTION 8, TOWNSHIP 28 NORTH, RANGE 6 EAST, W.M.;

THENCE SOUTH ALONG THE WEST LINE OF SECTION 8 TO A POINT IN THE CENTERLINE OF THE COUNTY ROAD, SAID POINT BEING 824.7 FEET SOUTH OF THE NORTHWEST CORNER OF SECTION 8;

THENCE NORTHERLY ALONG THE CENTERLINE OF THE COUNTY ROAD TO THE NORTH LINE OF SECTION 8;

THENCE WEST ALONG THE NORTH LINE OF SAID SECTION 8 TO THE TRUE POINT OF BEGINNING;

EXCEPT ANY PORTION WITHIN COUNTY ROADS.

SITUATE IN THE COUNTY OF SNOHOMISH, STATE OF WASHINGTON.

VERTICAL DATUM

NAVD '88 PER WGS SURVEY CONTROL POINT DESIGNATION SS04.

HORIZONTAL DATUM

NAD '83/'11

BASIS OF BEARING

ORIGINATING BENCHMARK: WGS SURVEY CONTROL POINT SS04

FOUND 4"x4" CONCRETE POST WITH LEAD PLUG LEANING EASTERLY, ELEV.: 149.87.

TEMPORARY BENCHMARKS:

TBM 'A' SET MAG NAIL AND AXIS CONTROL WASHER ON WEST SIDE OF TERRACE AVE ±113.6' SOUTHWESTERLY OF NORTHWEST BOUNDARY CORNER; ELEV.: 285.70.

TBM 'B' TOP OF FOUND REBAR AND CAP AT SOUTHWEST BOUNDARY CORNER, ELEV. 284.88.

TBM 'C' SET REBAR AND RED CONTROL CAP ON EASTERLY SIDE OF MACHIAS RD ±241.7' SOUTHEASTERLY OF THE SECTION CORNER, ELEV. 58.35.

NOTES

THE INFORMATION DEPICTED ON THIS MAP REPRESENTS THE RESULTS OF A SURVEY MADE ON JANUARY 30, 2020 AND CAN ONLY BE CONSIDERED AS INDICATING THE GENERAL CONDITIONS EXISTING AT THAT TIME.

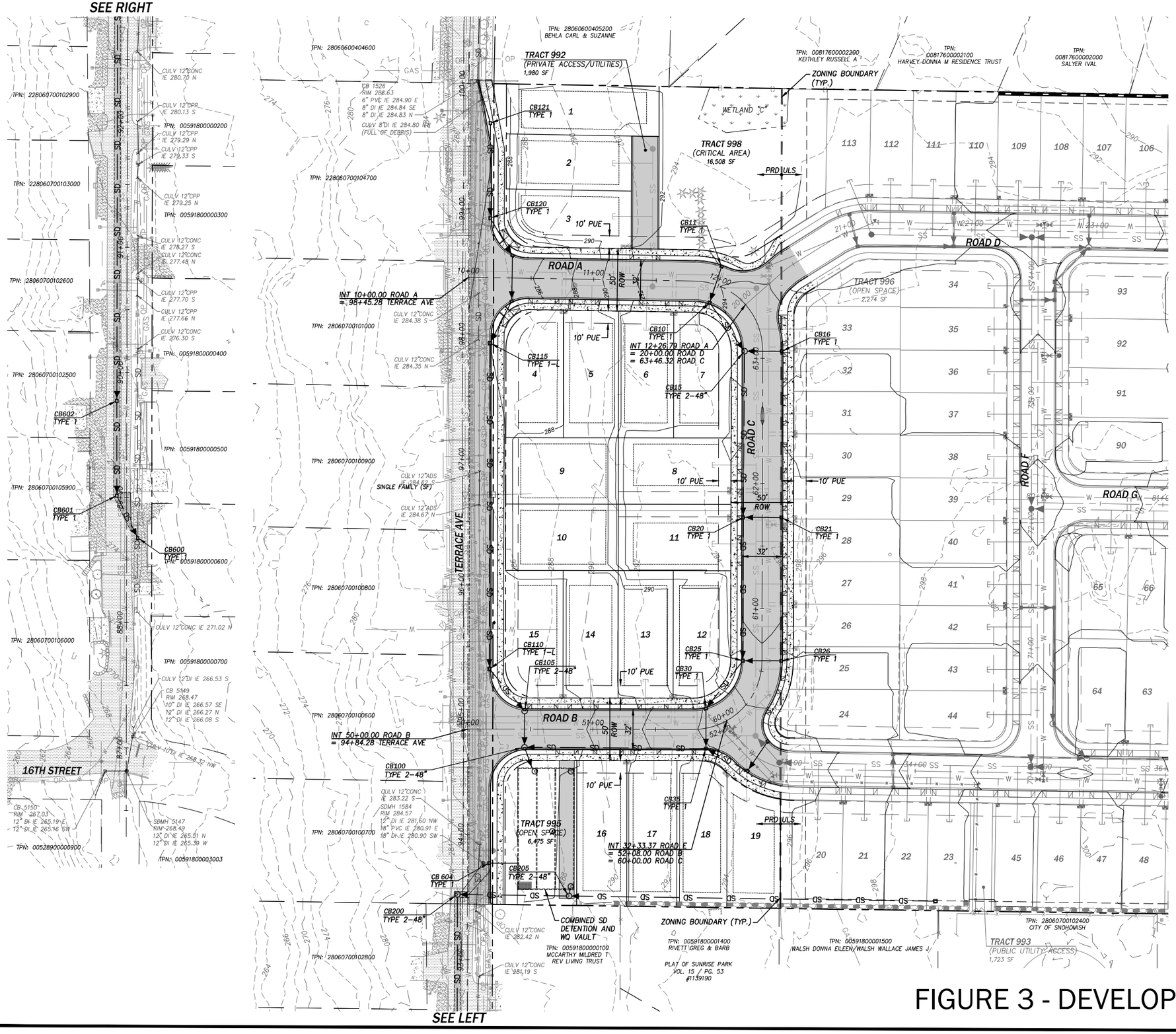
THIS SURVEY MEETS UNITED STATES NATIONAL MAP ACCURACY STANDARDS FOR VERTICAL ACCURACY OF ONE HALF THE CONTOUR INTERVAL.

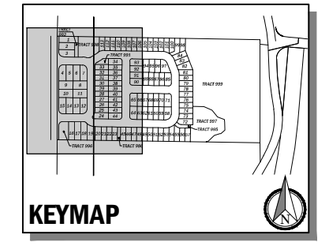
N

0 60 120

PLAN IN FEET

FIGURE 2 - EXISTING SITE CONDITIONS



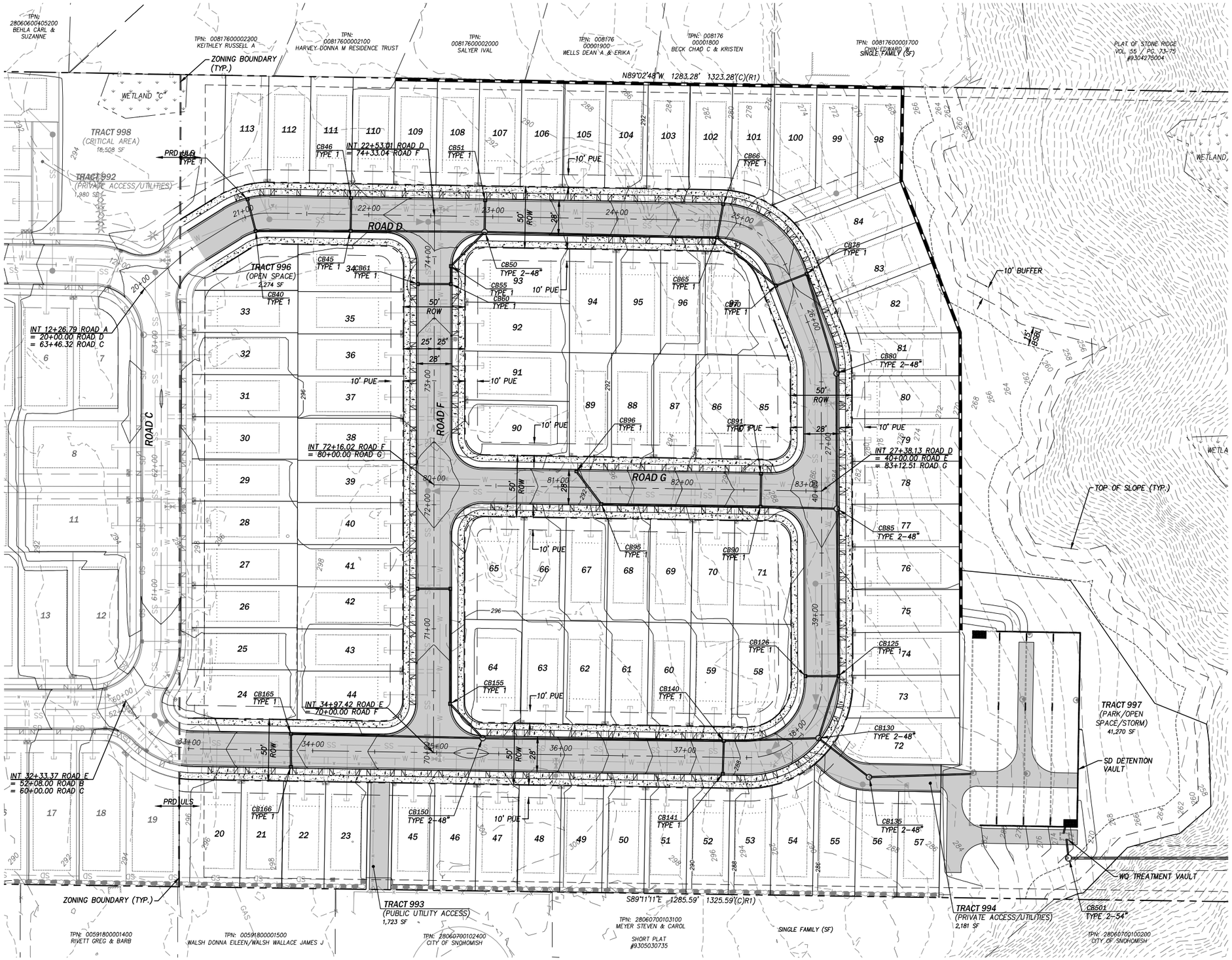


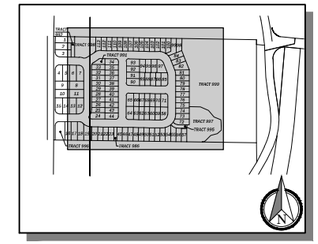
LEGEND

- MSE RETAINING WALL
- ROCKERY
- 160 — EXIST. TOPOGRAPHIC CONTOUR
- 160 — PROPOSED GRADE CONTOUR
- TYPE 1 STORM DRAINAGE CATCH BASIN
- TYPE 2 STORM DRAINAGE CATCH BASIN
- SD — STORM DRAINAGE PIPE
- RD — RD — ROOF DRAIN CONNECTION

0 40 80
PLAN IN FEET

FIGURE 3 - DEVELOPED SITE CONDITIONS (PRD)





KEYMAP

LEGEND

- MSE RETAINING WALL
- ROCKERY
- 160 EXIST. TOPOGRAPHIC CONTOUR
- 160 PROPOSED GRADE CONTOUR
- TYPE 1 STORM DRAINAGE CATCH BASIN
- TYPE 2 STORM DRAINAGE CATCH BASIN
- YARD DRAIN
- SD STORM DRAINAGE PIPE
- RD RD ROOF DRAIN CONNECTION

0 40 80
PLAN IN FEET

FIGURE 4 - DEVELOPED SITE CONDITIONS (ULS)

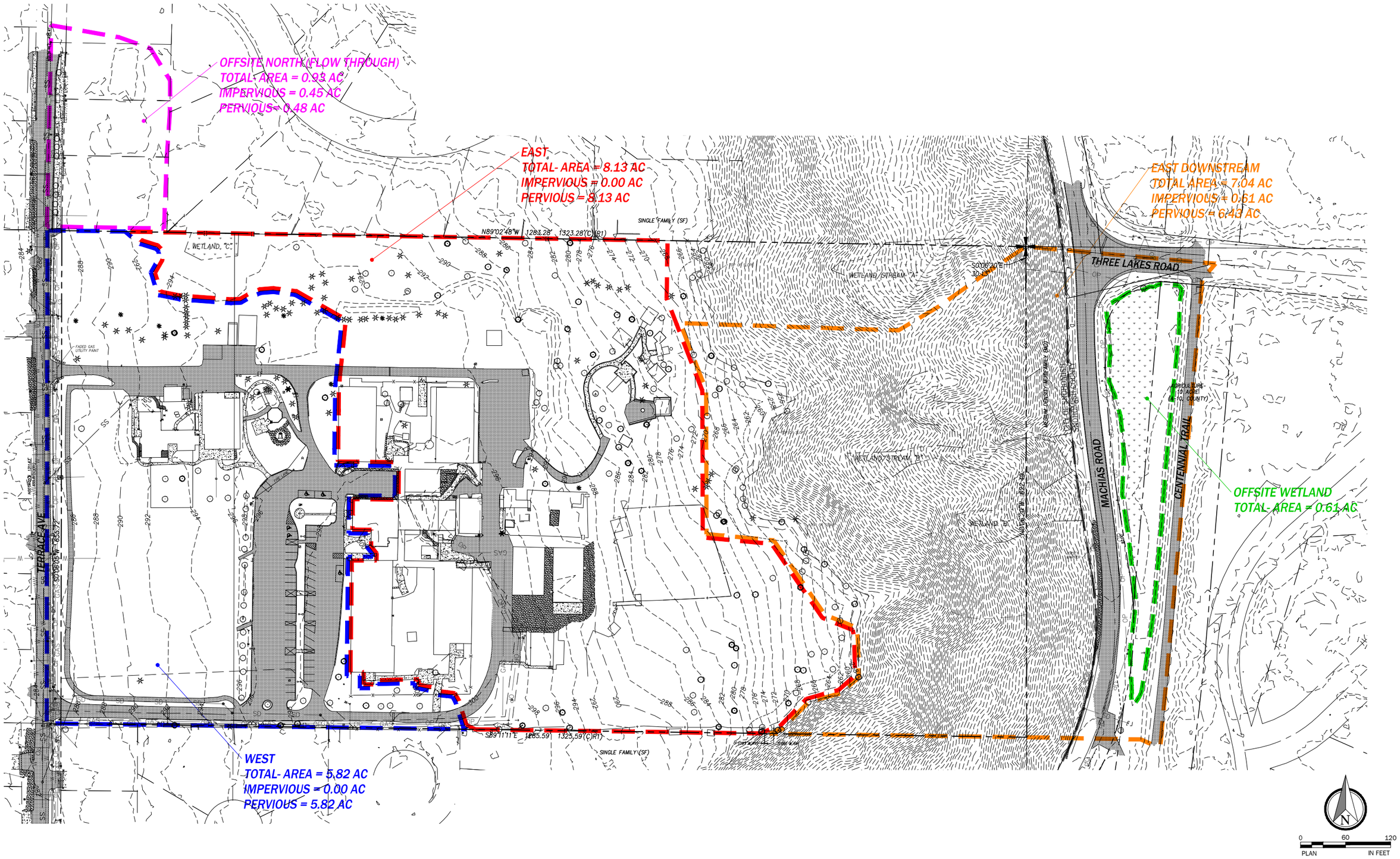


FIGURE 5 - EXISTING DRAINAGE SUB-BASINS

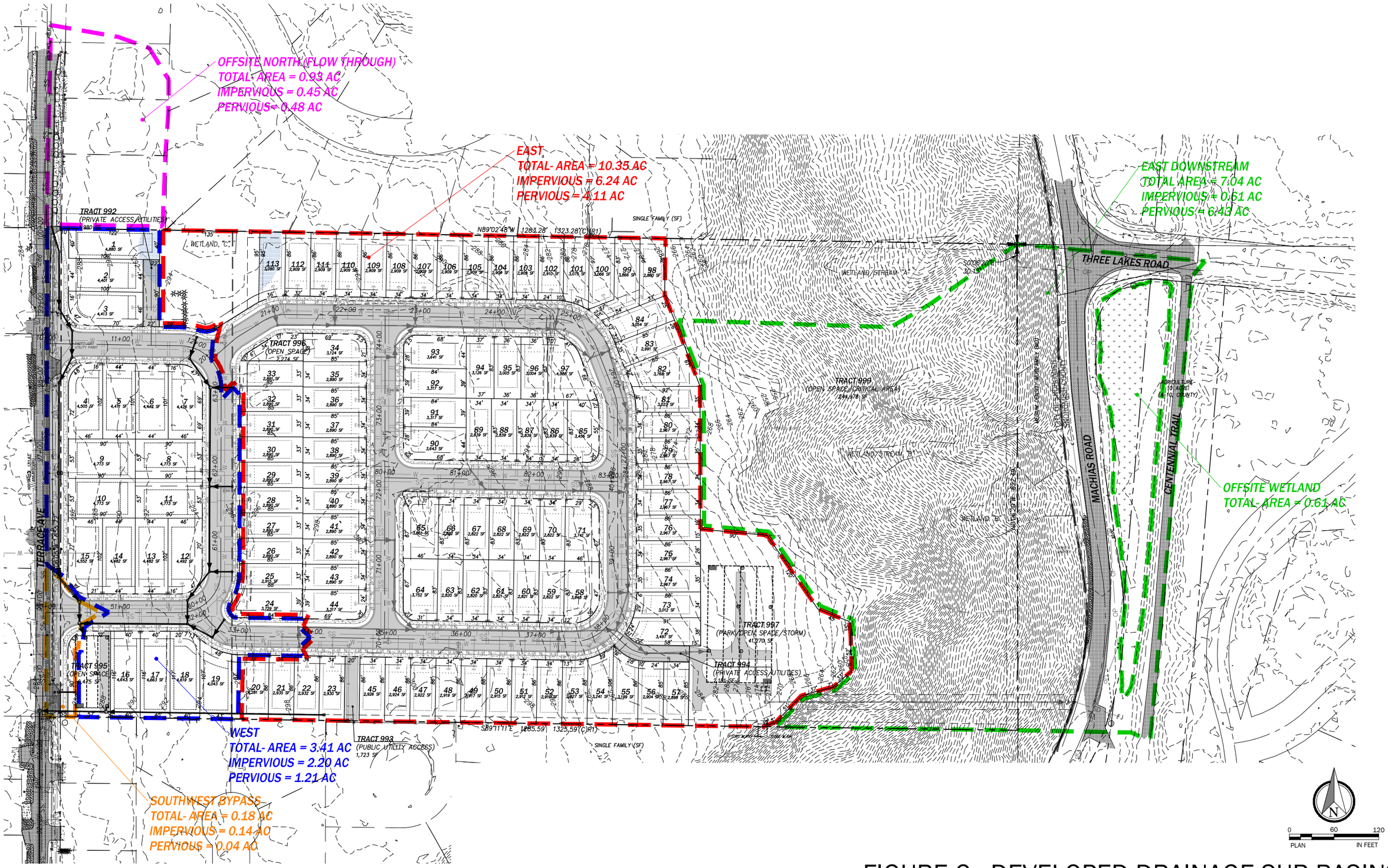
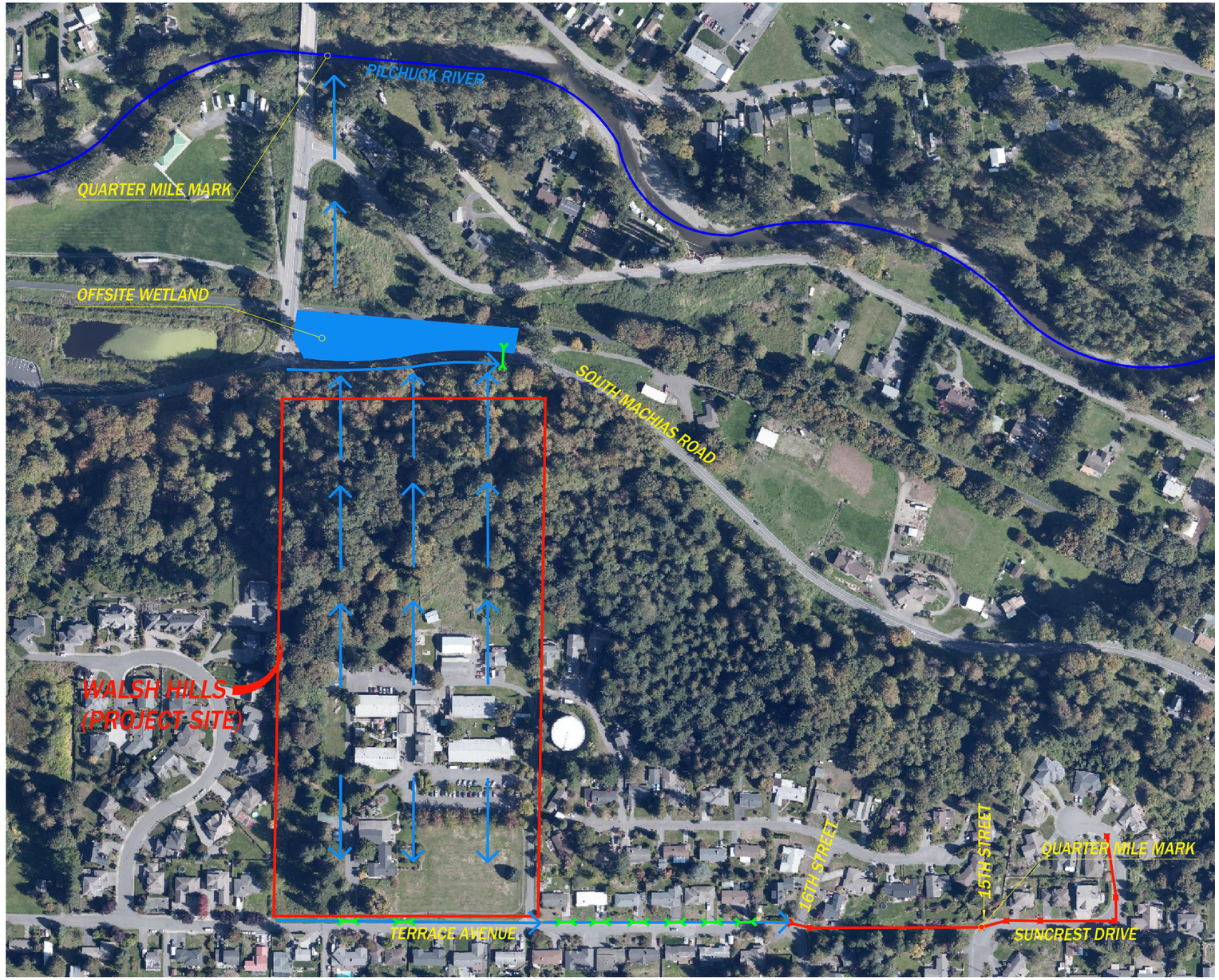


FIGURE 6 - DEVELOPED DRAINAGE SUB-BASINS

SE 1/4, NE 1/4, SEC. 17, TWP. 25 N, R. 5 E., W.M.

WALSH HILLS

CITY OF SNOHOMISH SNOHOMISH COUNTY, WASHINGTON



CP|H
CONSULTANTS
Site Planning • Civil Engineering
Land Use Consulting • Project Management
11431 Willows Rd. NE, Suite 120
Redmond, WA 98052
Phone: (425) 285-2390 | FAX: (425) 285-2389
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N

0 150 300
PLAN IN FEET

FIGURE 7 - DOWNSTREAM MAP

C|P|H
CONSULTANTS

APPENDIX A

NRCS SOILS REPORT AND GEOTECHNICAL REPORT

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

United States Department of Agriculture

Natural Resources Conservation Service

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

Custom Soil Resource Report for Snohomish County Area, Washington

May 14, 2020

Preface

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

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

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

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

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

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

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Soil Map (Walsh Hills).....6
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Map Unit Descriptions (Walsh Hills)..... 8
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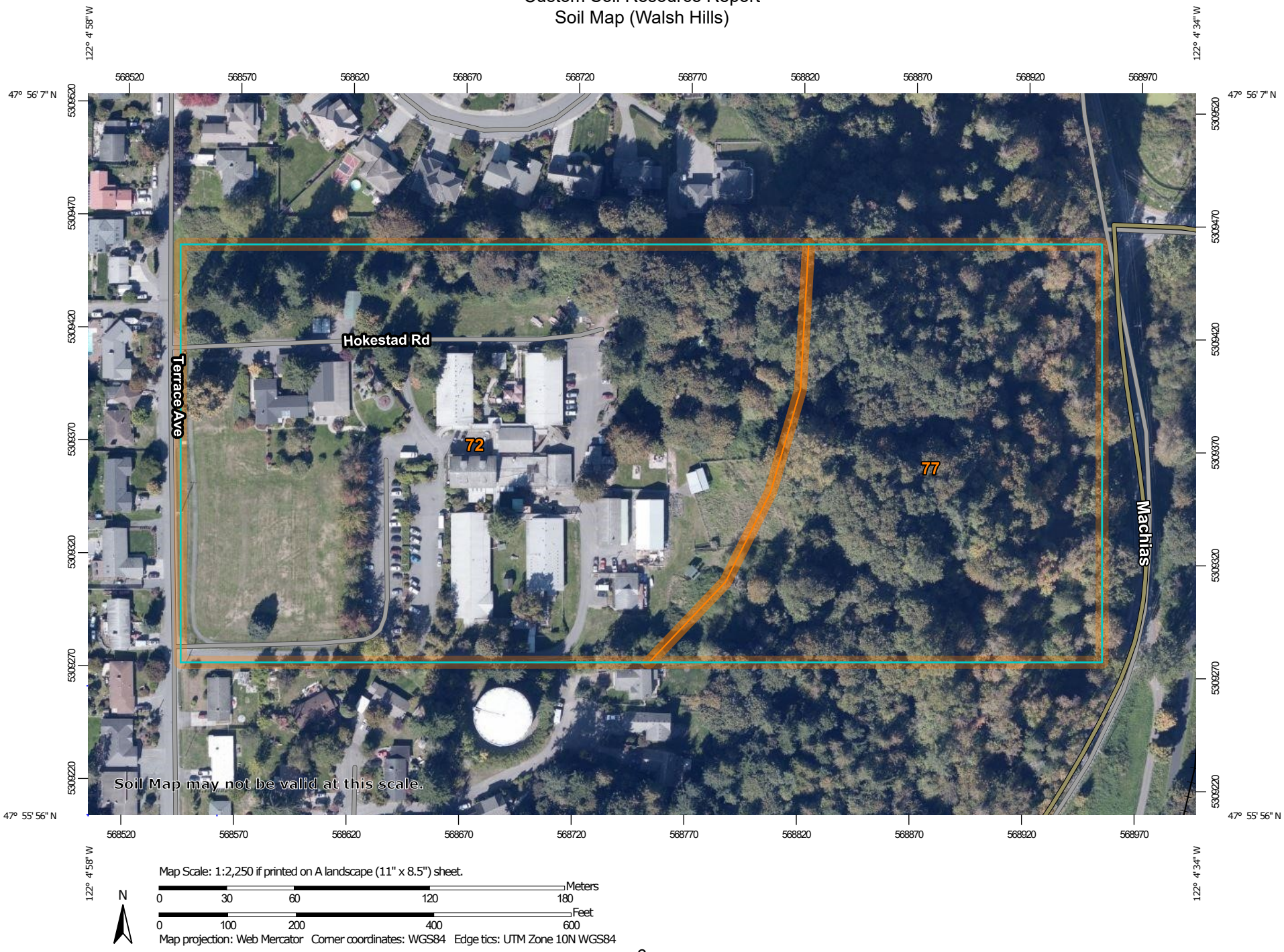
72—Tokul gravelly medial loam, 0 to 8 percent slopes..... 10
77—Tokul-Winston gravelly loams, 25 to 65 percent slopes..... 11

Soil Map

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

Custom Soil Resource Report
Soil Map (Walsh Hills)



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 21, Sep 16, 2019

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

Date(s) aerial images were photographed: Sep 26, 2018—Oct 16, 2018

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

Map Unit Descriptions (Walsh Hills)

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

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

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

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

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

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

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas

shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

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

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

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

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

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

Snohomish County Area, Washington

72—Tokul gravelly medial loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t61k
Elevation: 160 to 1,150 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Tokul and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tokul

Setting

Landform: Till plains, hillslopes
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Volcanic ash mixed with loess over glacial till

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
Oa - 1 to 2 inches: highly decomposed plant material
A - 2 to 6 inches: gravelly medial loam
Bs1 - 6 to 9 inches: gravelly medial loam
Bs2 - 9 to 17 inches: gravelly medial loam
Bs3 - 17 to 24 inches: gravelly medial loam
BC - 24 to 33 inches: gravelly medial fine sandy loam
2Bsm - 33 to 62 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 39 inches to cemented horizon; 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: B
Forage suitability group: Limited Depth Soils (G002XN302WA), Limited Depth Soils (G002XF303WA)

Hydric soil rating: No

Minor Components

Pastik

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Barneston

Percent of map unit: 5 percent
Landform: Kames, eskers, moraines
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest, interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Norma

Percent of map unit: 3 percent
Landform: Depressions, drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

Mckenna

Percent of map unit: 2 percent
Landform: Depressions, drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

77—Tokul-Winston gravelly loams, 25 to 65 percent slopes

Map Unit Setting

National map unit symbol: 2j08
Elevation: 150 to 1,900 feet
Mean annual precipitation: 40 to 80 inches
Mean annual air temperature: 46 to 50 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Tokul and similar soils: 60 percent
Winston and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tokul

Setting

Landform: Till plains, escarpments
Parent material: Volcanic ash over basal till

Typical profile

H1 - 0 to 4 inches: gravelly medial loam
H2 - 4 to 22 inches: gravelly medial loam
H3 - 22 to 31 inches: gravelly medial fine sandy loam
H4 - 31 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 25 to 65 percent
Depth to restrictive feature: 20 to 40 inches to densic material
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Winston

Setting

Landform: Escarpments
Parent material: Volcanic ash and glacial outwash

Typical profile

H1 - 0 to 3 inches: gravelly ashy loam
H2 - 3 to 25 inches: gravelly fine sandy loam
H3 - 25 to 60 inches: extremely gravelly coarse sand

Properties and qualities

Slope: 25 to 65 percent
Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Hydric soil rating: No

GEOTECHNICAL REPORT

Terrace Avenue Development
1711 Terrace Avenue
Snohomish, Washington

Project No. T-8204

Terra Associates, Inc.

Prepared for:

D.R. Horton
Kirkland, Washington

May 15, 2020

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

May 15, 2020
Project No. T-8204

Ms. Raelyn Hulquist
D.R. Horton
11241 Slater Avenue NE, Suite 200
Kirkland, Washington 98033

Subject: Geotechnical Report
Terrace Avenue Development
1711 Terrace Avenue
Snohomish, Washington

Dear Ms. Hulquist:

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 site soils generally consist of approximately six to eight inches of organic topsoil overlying medium dense to very dense silty sand with varying amounts of gravel (weathered and unweathered glacial till). The test borings showed the glacial till soils to the termination of the test borings. We did not observe groundwater seepage in the test pits although light to moderate groundwater seepage was observed in the test borings.

In our opinion, the native and existing inorganic fill soils on the site will be suitable for support of the proposed construction, provided the recommendations presented in this report are incorporated into project design and construction.

We trust the information presented in this report is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Michael Xenos, E.I.T.
Staff Engineer

CAROLYN S. DECKER
STATE OF WASHINGTON
47019
REGISTERED
PROFESSIONAL ENGINEER

5-15-2020

Carolyn S. Decker, P.E.
Project Engineer

12220 113th Avenue NE, Ste. 130, Kirkland, Washington 98034
Phone (425) 821-7777 • Fax (425) 821-4334

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Field Exploration and Laboratory Testing ..... Appendix A
Slide Output ..... Appendix B

Geotechnical Report
Terrace Avenue Development
1711 Terrace Avenue
Snohomish, Washington

1.0 PROJECT DESCRIPTION

The project consists of redeveloping the site with 19 single-family residences in the western portion of the site and 94 townhome units in the central portion of the site along with two stormwater detention vaults, associated utilities, landscaping, and access. The eastern steep slope would remain undeveloped. Based on the grading plan prepared by CPH Consultants, dated May 12, 2020 grading to achieve building lot and roadway elevations will consist of cuts and fills from 1 to 20 feet. Part of the grading consists of constructing a maximum 18-foot retaining wall near the top of the steep slope. Other vertical grade transitions will be supported with retaining walls as well.

Site stormwater will be collected and direct to one of two stormwater detention vaults located in the southeast and southwest corners of the site. The discharge pipe for the southeast vault will extend to the east down the steep slope and connect to the existing stormwater system.

We expect that the single-family residences and townhome units will be two- to three-story, wood-frame buildings with the main floors framed over a crawlspace with an attached garage constructed at grade. The structural loading carried by building foundations for the single-family residences and townhome buildings are expected to be relatively light, in the range of 2 to 6 kips per foot for bearing walls and 30 to 60 kips for isolated columns.

The recommendations contained in the following sections of this report are based on our understanding of the above design features. We should review design drawings as they become available to verify that our recommendations have been properly interpreted and incorporated into project design and to amend or supplement our recommendations, if required.

2.0 SCOPE OF WORK

On August 29, 2019, we observed the soil and groundwater conditions in 8 test pits excavated with a track-mounted mini-excavator to depths of approximately three to ten feet below existing surface grades. On September 17, 2019 and September 18, 2019, we supplemented this data by drilling 2 borings to depths of 100 feet below existing surface grades. Using the results of our field study 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 Snohomish Municipal Code.
- Seismic Design Parameters per the current International Building Code (IBC).
- Site preparation and grading.
- Relative slope stability.
- Excavations

- Foundations
- Floor slabs.
- 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 are 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 19-acre parcel located at 1711 Terrace Avenue in Snohomish, Washington. The approximate site location is shown on Figure 1.

The majority of the site is currently developed with a single-family residential structure, an office building, eight warehouse buildings, and associated access and landscaping. The eastern portion of the site is undeveloped and covered with a moderate forest and associated understory. Site topography is generally flat with a slight slope from west to east that transitions to a steep slope in the eastern, undeveloped portion of the site. The relatively flat portion of the site has an overall relief of approximately 30 feet. The eastern steep slopes have an overall relief of approximately 210 feet.

3.2 Soils

In general, the soil conditions observed consist of approximately six to eight inches of organic topsoil overlying medium dense to very dense silty sand with varying amounts of gravel (weathered and unweathered glacial till) to the termination of the test pits. The exception to this general condition was observed in Test Pit TP-3 where we observed approximately nine feet of medium dense till-like and organic fills overlying the unweathered glacial till deposits.

The test borings showed the glacial till soils are present to the termination of the test borings. We observed an approximately 4- to 8-foot thick layer of hard silt with sandy interbeds at approximately 45 to 55 feet below current site grades.

The *Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington* by J.P. Minard (1985) maps the site as Till (Qvt). The native soils observed in the test pits and test borings are generally consistent with this mapped geology.

The preceding is intended to be a general review of the soil conditions encountered. For more detailed descriptions, please refer to the Test Pit and Test Boring Logs in Appendix A.

3.3 Groundwater

No groundwater seepage was observed in the test pits. We observed light to moderate groundwater seepage in Test Boring B-1 at depths of 23 feet and 50 feet, and in Test Boring B-2 at depths of 6 and 56 feet. The shallow seepage at Test Boring B-2 was observed at the contact between the upper weathered till and underlying unweathered till. Additionally, we did observe mottled soils, which is typically an indication that shallow, perched, groundwater seepage develops during the wet winter months. We expect that perched groundwater levels and flow rates at the site will fluctuate seasonally with the highest levels occurring during and shortly following the winter months (November through May).

The deeper points of seepage observed in the test borings were observed within coarsely-grained zones at the interface between the unweathered till and hard silts as well as atop silt interbeds. This groundwater seepage would not be significantly affected by seasonal weather variations and will be present during the drier summer and fall months.

3.4 Geologic Hazards

We evaluated site conditions for the presence of geologic hazards including erosion hazard areas, landslide hazard areas, and seismic hazard areas in accordance with the City of Snohomish Municipal Code, specifically Section 14.275.

3.4.1 Erosion Hazard Areas

Section 14.275.010.B.1 of the City of Snohomish Municipal Code (SMC) defines erosion hazard areas as "areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a moderate-to-severe, severe, or very severe rill and inter-rill (sheet wash) erosion hazard."

The soils observed in the western and central portions of the site are classified as Tokul gravelly medial loam, zero to eight percent slopes by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). Over these portions of the site with the existing slope gradients, these soils will have a slight potential for erosion when exposed. The soils observed in the eastern, steep slope portion of the site are classified as Tokul-Winston gravelly loams, 25 to 65 percent slopes by the NRCS. Over this portion of the site with the existing slope gradients, these soils will have a severe potential for erosion when exposed and; therefore, meet the above criteria for an erosion hazard area per the SMC.

However, as only the western and central portions of the site are to be developed, it is our opinion that provided the eastern portion of the site remains in its current condition, the site is not an erosion hazard area per the SMC.

Regardless, erosion protection measures as required by the City of Snohomish will need to be in place prior to the start of construction activities.

3.4.2 Landslide Hazard Areas

Section 14.275.010.B.2 of the SMC defines landslide hazard areas as "areas subject to landslides based on geology, soils, topography, and hydrology, including:

> a. Areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a severe limitation for building site development.
>
> b. Areas mapped by the Washington Department of Ecology (Coastal Zone Atlas) or the Washington State Department of Natural Resources (slope stability mapping) as unstable (U or class 3), unstable old slides (UOS or class 4), or unstable recent slides (URS or class 5).
>
> c. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Washington State Department of Natural Resources.
>
> d. Areas where the following coincide: slopes steeper than fifteen percent, relatively permeable sediment overlying a relatively impermeable sediment or bedrock, and ground water seepage.
>
> e. Areas that have shown movement in the past ten thousand years or that are underlain or covered by mass wastage debris of that time frame.
>
> f. Slopes that are parallel or sub-parallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials.
>
> g. Slopes steeper than eighty percent subject to rock fall during seismic shaking.
>
> h. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action.
>
> i. Areas at risk from snow avalanches.
>
> j. Canyons or active alluvial fans subject to debris flows or catastrophic flooding.
>
> k. Slopes of 40 percent or steeper with a vertical relief of 10 or more feet except areas composed of consolidated rock."

Existing site topography in the western and central portions of the site consists of a slight slope with little to no risk of mass movement due to geologic, topography, or hydrologic factors. The steep slope located in the eastern portion of the site has an overall relief of approximately 210 feet with grades of up to 85 percent, meeting condition 'k' listed above. Therefore, the eastern portion of the site would be considered a landslide hazard area per the SMC. As such, the code-required setbacks and buffers will need to be included in the drawings. Section 4.3 below details our analysis of the slope's stability and includes a determination of the appropriate setbacks and buffers.

3.4.3 Seismic Hazard Areas

Section 14.275.010.B.3 of the SMC defines seismic hazard areas as "areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface faulting. One indicator of potential earthquake damage is a record of past earthquake damage. Settlement and soil liquefaction occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow groundwater table."

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations. Liquefaction mainly affects geologically recent deposits of fine-grained sands underlying the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction; thus, eliminating the soil's strength.

Based on the soil and groundwater conditions observed, it is our opinion that the risk of liquefaction-related impacts to the proposed structures would be negligible. It is also our opinion that there is little to no risk for severe damage resulting from seismically induced settlement. Therefore, in our opinion, the site does not contain seismic hazard areas as defined by the SMC.

3.5 Seismic Design Parameters

Based on the site soil conditions and our knowledge of the area geology, per the current International Building Code (IBC), Site Class C should be used in structural design.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

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

The native and existing fill soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use these soils from site excavations as structural fill will depend on their moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill.

Any development in the vicinity of Test Pit TP-3 should take into account the presence of the organic fill material below the till-like fills. Any organic fill material would not present a suitable bearing surface due to the potential for settlement following the decay of organic material over time. As site grading progresses, it may be necessary to improve the upper ground conditions by excavation and re-compaction where organic soils are encountered to achieve a suitable bearing surface. The need for overexcavation and replacement should be determined by observations in the field during 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.

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 six to eight inches will be required to remove the organic surficial soils. 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. 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.

As noted above, the existing organic fill material observed in Test Pit TP-3 would not be suitable for support of building elements. The need for and lateral extent of over excavation and replacement should be determined in the field during grading.

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.

The native soils observed at the site contain a sufficient amount of fines (silt and clay size particles) that will make them difficult to compact as structural fill if they are too wet or too dry. Accordingly, the ability to use these soils from site excavations as structural fill will depend on their moisture content and the prevailing weather conditions when site grading activities take place. Soils that are too wet to properly compact could be dried by aeration during dry weather conditions or mixed with an additive such as cement or lime to stabilize the soil and facilitate compaction. If an additive is used, additional Best Management Practices (BMPs) for its use will need to be incorporated into the Temporary Erosion and Sedimentation Control (TESC) plan for the project. Soils that are dry of optimum should be moisture conditioned by controlled addition of water and blending prior to material placement.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and 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 imported to the site for use as structural fill.

Structural fill should be 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-1557 (Modified 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 nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Relative slope stability

Part of our investigation was to determine the appropriate buffers and setbacks for the proposed development from the eastern steep slope. In order to determine the buffers and setbacks, we have completed three slope stability analyses. The analyses were performed at locations designated as Cross Sections A-A', B-B', and C-C' using the computer program Slide 2018. The approximate cross section location is shown on Figure 2.

Our analysis considered both static and pseudostatic (seismic) conditions. A horizontal acceleration of 0.15g was used in the pseudostatic analysis to simulate slope performance under earthquake loading. This value is based on the maximum considered earthquake (MCE) peak ground acceleration (PGA) adjusted for pseudostatic analysis following procedures outlined in Section 6.2.2 of the FHWA-NHI-11-032 Seismic Design – Geotechnical Features Manual.

Based on our field exploration, laboratory testing, and previous experience with similar soil types, we chose the following parameters for our analysis:

Table 1 – Slope Stability Analysis Soil Parameters

Soil Type	Unit Weight (pcf)	Friction Angle (Degrees)	Cohesion (psf)
Dense to very dense silty SAND with gravel (unweathered till)	125	40	500

The results of our slope stability analysis, as shown by the lowest safety factors for each condition, are presented in the following table:

Table 2 – Slope Stability Analysis Results

Cross Section	**Minimum Safety Factors**	
	Existing Conditions	***Post Construction***
A-A'	1.88 (Seismic FS = 1.37)	1.88 (Seismic FS = 1.37)
B-B'	1.57 (Seismic FS = 1.20)	1.57 (Seismic FS = 1.20)
C-C'	2.15 (Seismic FS = 1.54)	1.91 (Seismic FS = 1.38)

Based on our analysis, the proposed construction must maintain a 10-foot buffer with a 15-foot building setback from the crest of the steep slope. No clearing should occur on the slope areas that are steeper than 40 percent or within their respective 10-foot buffer areas. In our opinion, a slope monitoring and inspection program would not be necessary as construction activities are not planned to take place on the steep slopes. The results of our analysis are attached in Appendix B.

4.4 Excavations

All excavations at the site associated with confined spaces, such as utility trenches, must be completed in accordance with local, state, and federal requirements. Based on regulations outlined in the Washington Industrial Safety and Health Act (WISHA), the upper medium dense soils would be classified as Type C soil. The dense silty sand and silty sand with gravel soils would be classified as Type A soil.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal:Vertical) or flatter, from the toe to the crest of the slope. 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. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Perched groundwater seepage may be observed within excavations extending to the dense till deposits during the winter months. In our opinion, the volume of water and rate of flow into the excavation 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 should be capable of maintaining a relatively dry excavation for construction purposes in these soils, if necessary.

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 and townhome structures may be supported on conventional spread footing foundations bearing on competent native soils, competent existing fill, or on structural fill placed above the competent soils. 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 material 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 Floor slabs

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 Stormwater facilities

As noted above, site stormwater will be collected and directed to one of two stormwater detention vaults located in the southeast or southwest corners of the site. The southeast vault is near the top of the steep slope. Stormwater plans were not available at the time of this report.

Detention Vault

We expect that the bottom of the excavations for the detention vaults will expose native, dense to very dense silty sand with gravel soils. 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 6 feet below current site grades. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used.

Vault walls should be designed as below-grade retaining walls. The magnitude of earth pressure development on engineered retaining walls will partly depend on the quality 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 3.

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 pounds per square foot (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 below-grade walls under seismic loading, an additional uniform lateral pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall in feet, can be used. These values assume a horizontal backfill condition and that no other surcharge loading such as traffic, sloping embankments, or adjacent buildings will act on the wall. If such conditions will 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 given in Section 4.5 of this report.

If it is not possible to discharge collected water at the footing invert elevation, the invert elevation of the wall drainpipe could be set equivalent to the outfall invert. 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.

Pipe Anchors

The discharge pipe for the southeast detention vault will extend down the eastern steep slope and connect to the existing storm system at the base of the slope.

As we understand, the pipe that will be used for the outfall will consist of an 18-inch diameter HDPE pipe. The pipe would be anchored or secured at the top and would then be placed on the slope surface. HDPE pipe will move on the slope due to thermal expansion and contraction. To limit movement, hillside anchors or guides need to be installed at set intervals on the installation alignment. Based on a preliminary analysis using a relatively straight alignment, we expect the hillside anchors will need to be placed approximately every 15 feet. We should re-evaluate this spacing based on the actual pipe alignment when it is finalized. This installation is similar to stormwater outfalls installed on steep slopes throughout the Puget Sound area.

Analysis indicates the 18-inch diameter HDPE pipe can be secured at the top using a cast-in-place concrete block or anchor. For the estimated 400 feet of pipe a concrete block with a weight equal to 233 cubic feet of unreinforced concrete will be needed. A typical concrete anchor design detail is shown on Figure 4.

The HDPE alignment down the slope must limit impact to the existing vegetation and trees. We recommend all trees that are currently on the slope remain and the HDPE pipe bend around the trunks of the trees, if necessary. To limit vegetation removal and maintain low vegetation surface cover, we recommend suspending the HDPE pipe a minimum distance of six inches (plus or minus two inches) above the slope surface using pipe anchor guides as shown on Figure 5. Removal of existing vegetation should be limited with vegetation only removed as needed to install the guide anchors. Areas disturbed by construction must be restored by planting or reseeding and covering with long-term erosion control matting.

4.8 Infiltration Feasibility

The native glacial till soils composed of silty sand characteristically exhibit low permeability and would not be a suitable receptor soil for discharge of development stormwater using infiltration/retention facilities. Conventional stormwater detention with controlled release to the drainage basin should be used to manage development stormwater.

4.9 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 the building perimeter. If a positive gradient cannot be provided, provisions for collection and disposal of surface water adjacent to the structure should be provided.

Subsurface

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

4.10 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, soils excavated on-site should generally be suitable for use as backfill material. However, the site soils are fine grained and moisture sensitive; therefore, moisture conditioning may be necessary to facilitate proper compaction. If utility construction takes place during the winter, it may be necessary to import suitable wet weather fill for utility trench backfilling.

4.11 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. As we understand, traffic will mainly consist of light passenger and commercial vehicles with only occasional heavy traffic in the form of moving trucks and trash removal vehicles. Based on this information, 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)
- Three and one-half inches full depth HMA

All paving materials should conform to Washington State Department of Transportation (WSDOT) specifications for 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 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.

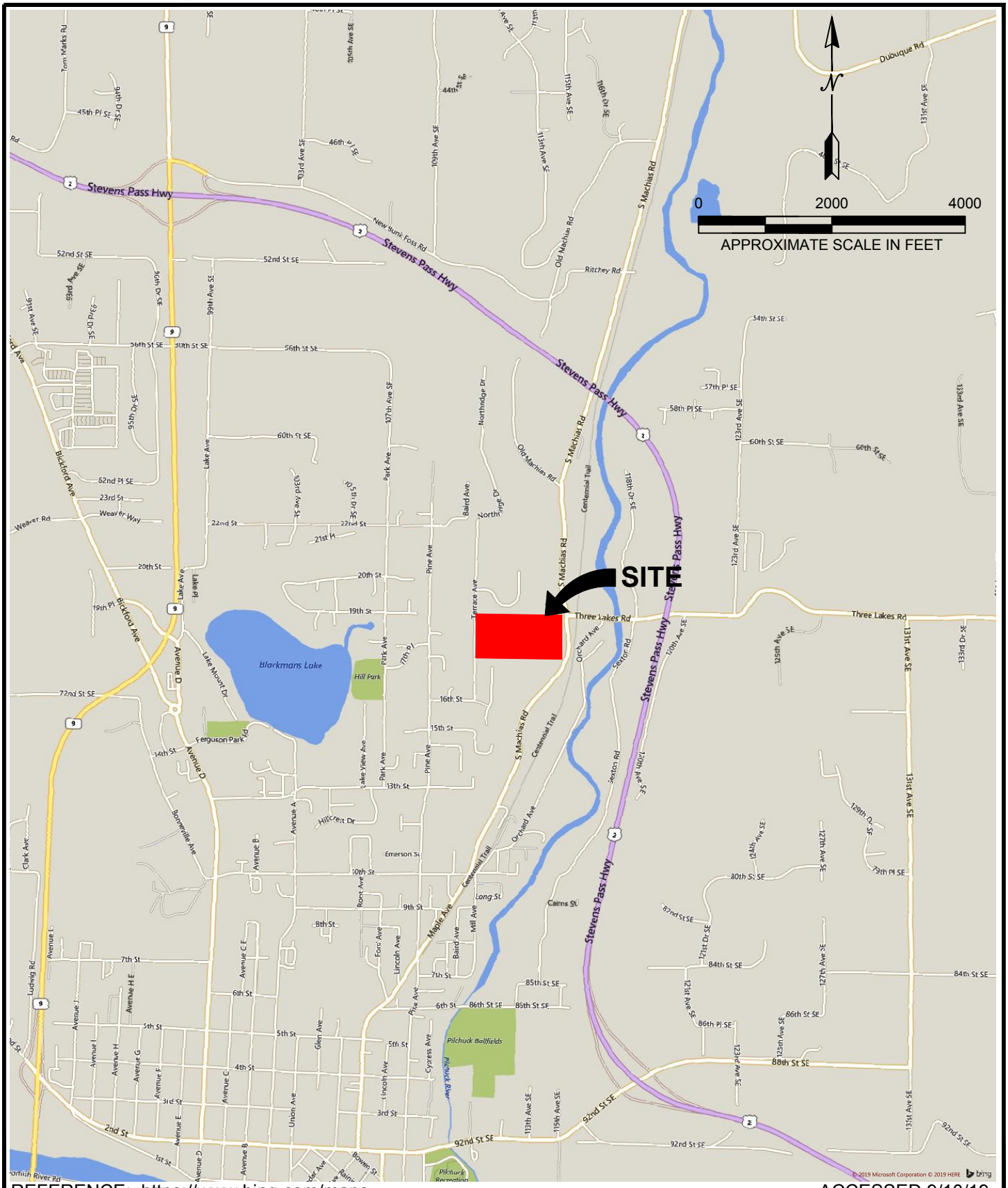
5.0 ADDITIONAL SERVICES

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. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Terrace Avenue Development project in Snohomish, 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 on-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: https://www.bing.com/maps ACCESSED 9/10/19

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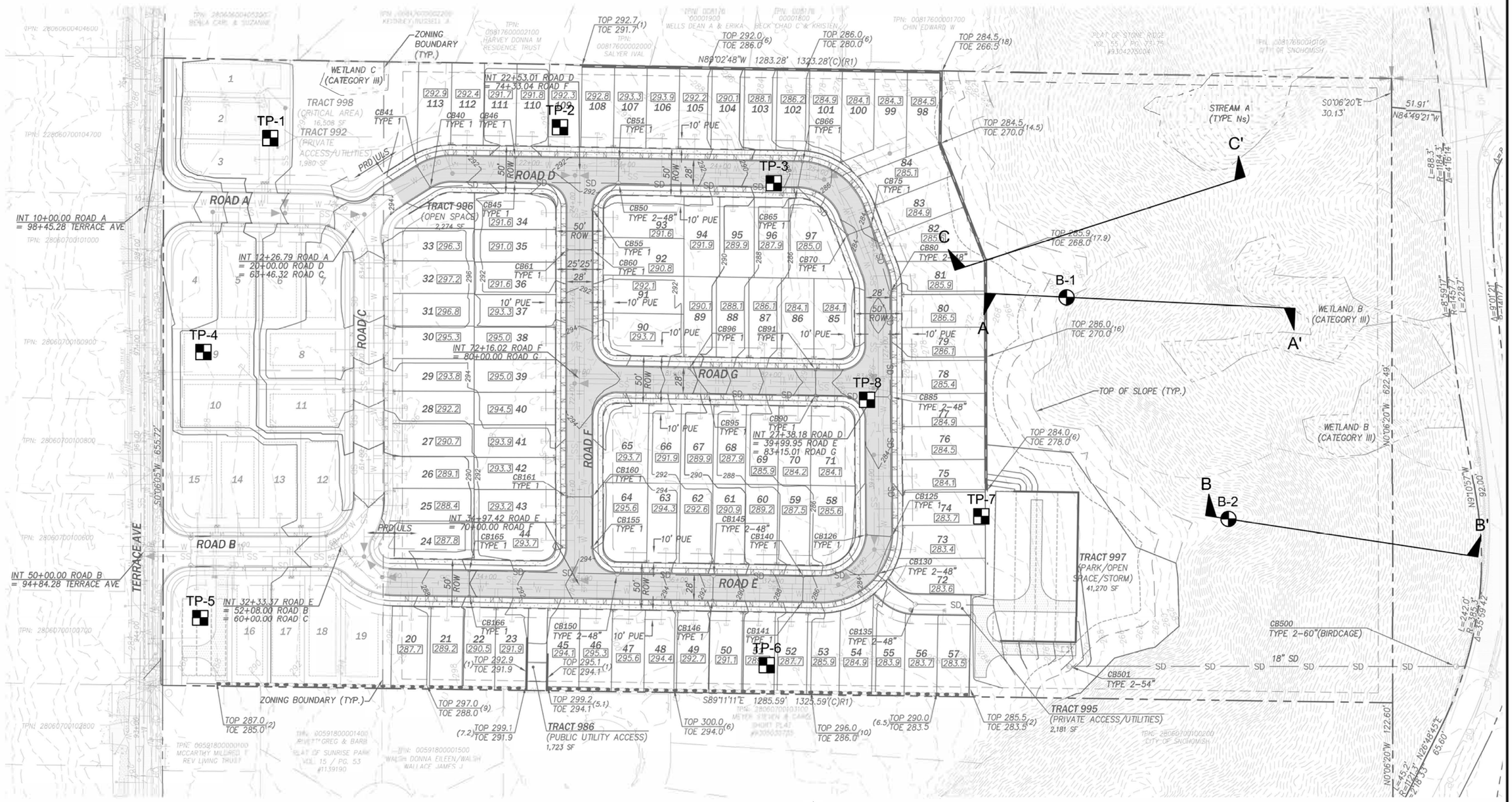
Geology and
Environmental Earth Sciences

VICINITY MAP
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure 1



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.

REFERENCE: SITE PLAN PROVIDED BY CPH CONSULTANTS.

LEGEND:

- APPROXIMATE TEST PIT LOCATION
- APPROXIMATE BORING LOCATION
- APPROXIMATE CROSS SECTION LOCATION

0 100 200

APPROXIMATE SCALE IN FEET

N

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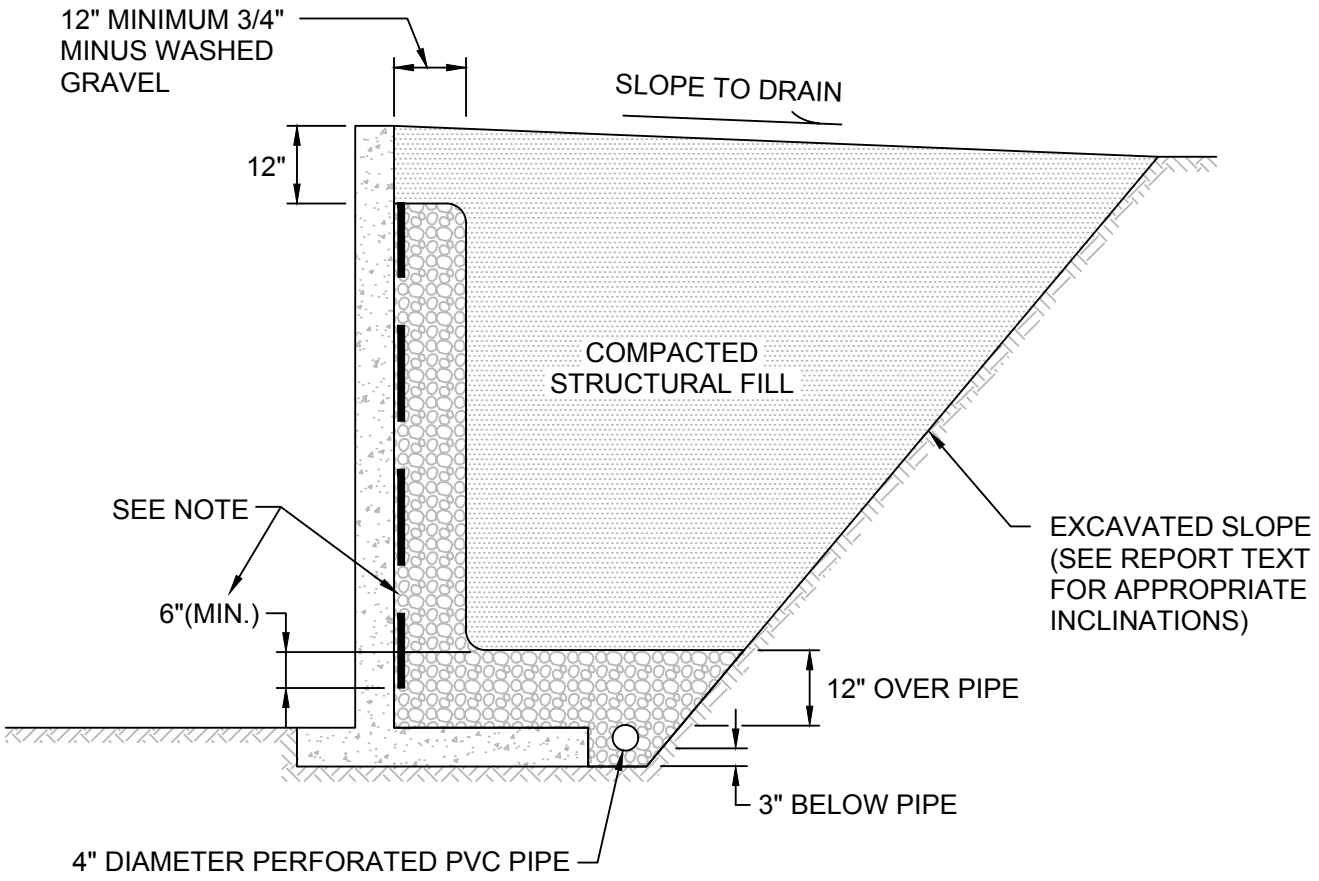
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure 2



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 SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

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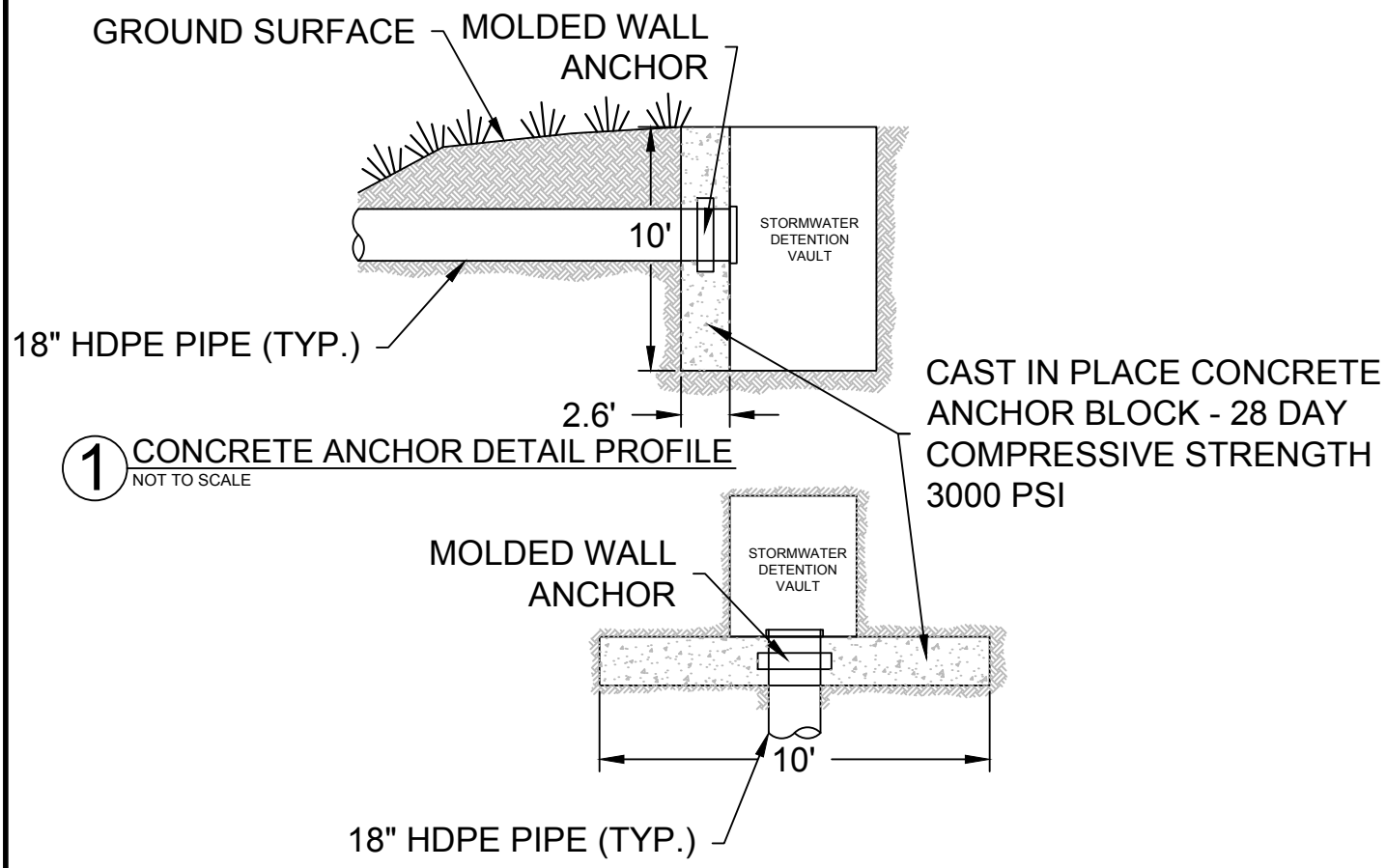
Environmental Earth Sciences

TYPICAL WALL DRAINAGE DETAIL
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure 3



1 CONCRETE ANCHOR DETAIL PROFILE
NOT TO SCALE

2 CONCRETE ANCHOR DETAIL PLAN
NOT TO SCALE

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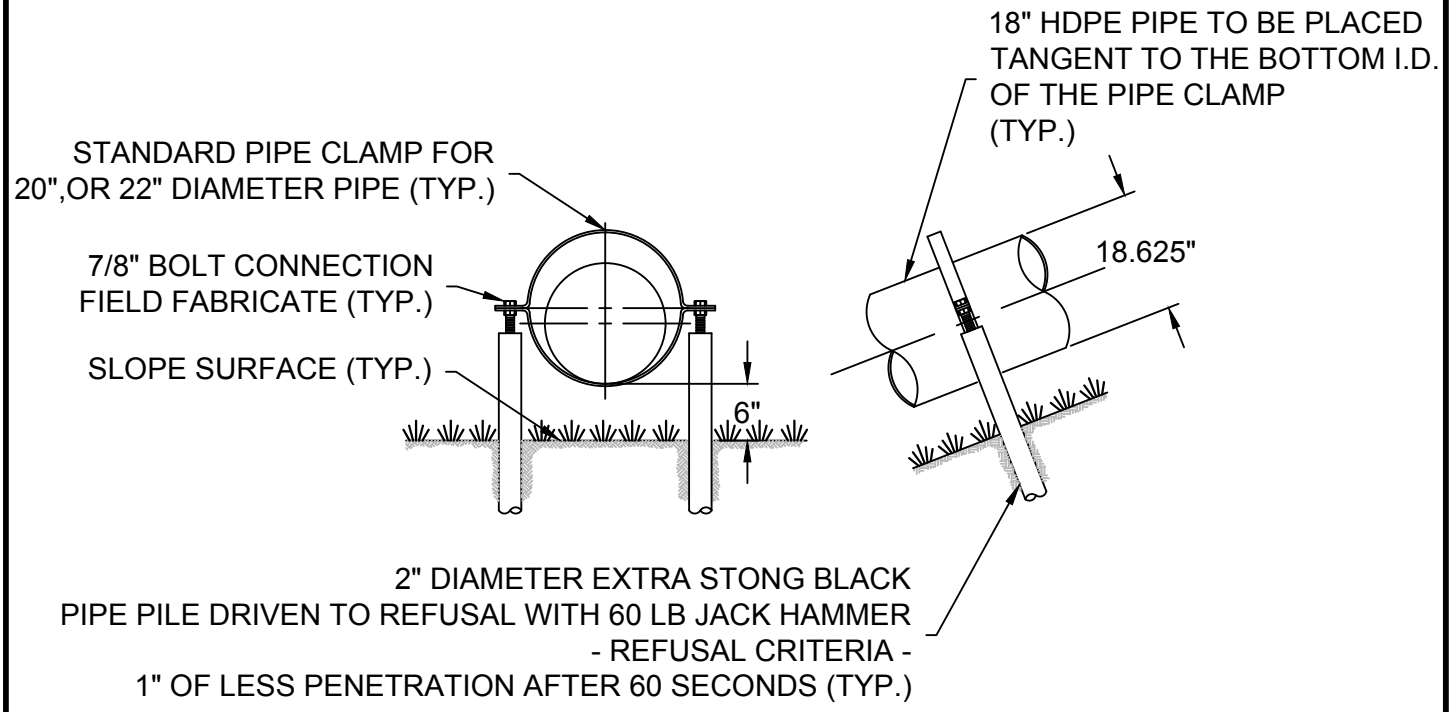
Environmental Earth Sciences

CONCRETE ANCHOR DETAIL
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure 4



1 HILLSIDE ANCHOR DETAIL
NOT TO SCALE

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

HILLSIDE ANCHOR DETAIL
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure 5

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Terrace Avenue Development
Snohomish, Washington

On August 29, 2019, we investigated subsurface conditions at the site by excavating 8 test pits with a track-mounted mini-excavator to depths of about three to ten feet below existing grades. On September 17, 2019 and September 18, 2019, we supplemented this data by observing soil conditions at 2 borings drilled to depths of about 100 feet below existing surface grades. The test pit and boring locations were approximately determined in the field by sighting and pacing from existing surface features. The approximate test pit and test boring locations are shown on Figure 2. The Test Pit and Test Boring Logs are presented as Figures A-2 through A-11.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test pit and test boring, obtained representative soil samples, and recorded water levels observed during excavation. During drilling, soil samples were obtained in general accordance with ASTM Test Designation D-1586. Using this procedure, a 2-inch (outside diameter) split barrel sampler is driven into the ground 18 inches using a 140-pound hammer free falling a height of 30 inches. The number of blows required to drive the sampler 12 inches after an initial 6-inch set is referred to as the Standard Penetration Resistance value or N value. This is an index related to the consistency of cohesive soils and relative density of cohesionless materials. N values obtained for each sampling interval are recorded on the Test Boring Logs, Figures A-10 and A-11. 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 and test borings were placed in sealed plastic bags 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 and Test Boring Logs. Grain size analyses were performed on select soil samples. The results are shown on Figures A-12 through A-14.

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

I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
‖	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
TERRACE AVENUE DEVELOPMENT
SNOHOMISH , WASHINGTON

Proj.No. T-8204	Date: MAY 2020	Figure A-1

LOG OF TEST PIT NO. TP-1

FIGURE A-2

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
	1	(7-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles, occasional boulder. (SM)	Medium dense	12.5
1				
2				
3	2	Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, mottled, trace cobbles, occasional boulder, light cementation. (SM)	Dense	9.5
4				
5	3			11.6
		Test Pit terminated at approximately 5 feet. No groundwater seepage observed. No caving observed.		
6				

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: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush & mulch **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
	1	(8-inches organic TOPSOIL) Light brown transitioning to reddish-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, occasional cobble, occasional boulder. (SM)	Medium dense	15.5
1				
2				
3	2	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, trace cobbles, light cementation. (SM)	Dense	12.6
4				
5	3	Test Pit terminated at approximately 5 feet. No groundwater seepage observed. No caving observed.		11.4
6				

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: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Blackberry bushes **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(8-inches organic TOPSOIL)		
1	1	FILL: Grayish-brown to gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, some mottling, trace organics, trace cobbles, occasional asphalt debris, occasional glass fragments, occasional plastic waste. (SM)		9.6
2				
3			Medium dense	
4	2			12.0
5	3			18.2
6	4			16.9
7	5	FILL: Black silty SAND, fine sand, moist, scattered organics, trace glass fragments. (SM)	Medium dense to dense	42.8
8	6			38.1
9		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, mottled. (SM)	Dense	
10	7			19.2
11		Test Pit terminated at approximately 10 feet. No groundwater seepage observed. No caving observed.		
12				

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-4

FIGURE A-5

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(7-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles, occasional boulder. (SM)		
1				
	1		Medium dense	12.9
2				
3	2			8.3
		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, dry to moist, mottled, trace cobbles, light cementation. (SM)	Dense	
4	3			11.5
		Test Pit terminated at approximately 4 feet. No groundwater seepage observed. No caving observed.		
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-5

FIGURE A-6

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(6-inches organic TOPSOIL) Light brown silty SAND with gravel, fine sand, fine to coarse gravel, dry to moist, scattered rootlets. (SM)		
1				
	1		Medium dense	11.8
2				
3	2			9.8
		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, dry to moist, mottled, scattered cobbles, light cementation. (SM)	Dense	
4	3			13.5
		Test Pit terminated at approximately 4 feet. No groundwater seepage observed. No caving observed.		
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-6

FIGURE A-7

PROJECT NAME: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(8-inches organic TOPSOIL) Light brown silty SAND, fine sand, dry to moist, scattered rootlets, trace gravel. (SM)		
1	1		Medium dense	12.3
2		Light gray silty SAND with gravel, fine sand, fine to coarse gravel, dry, light cementation. (SM)	Dense	
3	2			6.7
		Test Pit terminated at approximately 3 feet. No groundwater seepage observed. No caving observed.		

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: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Grass & brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(7-inches organic TOPSOIL)		
		Brown transitioning to gray silty SAND, fine sand, moist, scattered rootlets, trace gravel. (SM)		
1				
	1			26.2
2				
	2			15.0
3			Medium dense	
4	3			10.9
		Mottling observed below approximately 4.5 feet		
5				
6	4			12.9
		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, trace cobbles, light cementation. (SM)	Dense	
7	5			11.4
		Test Pit terminated at approximately 7 feet. No groundwater seepage observed. No caving observed.		
8				

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: Terrace Avenue Development **PROJ. NO:** T-8204 **LOGGED BY:** MJX

LOCATION: Snohomish, Washington **SURFACE CONDITIONS:** Brush **APPROX. ELEV:** NA

DATE LOGGED: August 29, 2019 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
1	1	(8-inches organic TOPSOIL) Brown to reddish-brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered rootlets, trace cobbles. (SM)	Medium dense	18.8
2	2	Brownish-gray silty SAND, fine to medium sand, moist, trace gravel. (SM)		16.0
4				
5	3			11.9
6	4	Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, mottled, trace cobbles, occasional boulder. (SM)	Dense	15.0
7	5			13.7
8		Test Pit terminated at approximately 7 feet. No groundwater seepage observed. No caving observed.		

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 BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10 30 50)	Moisture Content (%)
0		Black silty SAND, fine sand, moist, scattered organics. (SM) (Organic TOPSOIL)	Dense	31	30.9 4.7
		Brown SAND with silt, fine to medium sand, moist, trace organics. (SP-SM)	Medium Dense	28	6.5 10.2
5		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, occasional sand with silt layer. (SM) *Mottling observed in 5-foot sample*	Very Dense	50/6"	9.8
10				76	5.7
			Dense	46	10.4
15		Brownish-gray sandy SILT to SILT with sand, fine sand, moist, scattered gravel. (ML)	Hard	32	15.8
20			Very Stiff	26	8.8
		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist to wet, slightly mottled. (SM)	Dense	46	12.5
30			Very Dense	50/6"	15.3
35				50/6"	11.1

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10 30 50)	Moisture Content (%)
35		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist to wet, slightly mottled. (SM)	Very Dense		
40				50/5"	10.7
45				50/4"	11.0
50				50/6"	16.4
		Gray SILT, moist, occasional sand with silt seam. (ML)	Hard		
55				50/6"	20.0
		Gray silty SAND, fine to medium sand, moist to wet. (SM)	Very Dense		
60				92	14.8
65				93/6"	17.2
		Gray SILT, moist. (ML)	Hard		28.1
		Brown silty SAND, fine to medium sand, moist, occasional silt inclusions. (SM)	Very Dense		
70				50/4"	14.3

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-1

Figure No. A-10

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** Septermber 18, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 23 Feet, 50 Feet **Approx. Elev:** ~255 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10 30 50)	Moisture Content (%)
70		Brown silty SAND, fine to medium sand, moist, occasional silt inclusions. (SM)	Very Dense		
75				50/4"	16.7
80				50/6"	15.5
85				50/4"	19.6
90				50/6"	17.5
95				50/6"	20.3
100		*Material becomes dark gray.		50/6"	21.5
105		Test boring terminated at approximately 100 feet. Light to moderate perched groundwater seepage observed at approximately 23 feet and 50 feet.			

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0		Black silty SAND, fine sand, moist, scattered organics. (SM) (Organic TOPSOIL)	Dense	42	27.4
					5.5
		Light brown silty SAND with gravel, fine sand, fine to coarse gravel, dry. (SM)			
5		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist. (SM)	Very Dense	51	7.8
				50/6"	9.8
10				71	10.4
			Dense	42	13.1
15				41	10.9
20			Very Dense	91	6.9
25				50/5"	9.1
30				50/6"	7.1
35				50/4"	9.9

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10 30 50)	Moisture Content (%)
35		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist. (SM)			
40			Very Dense	50/4"	7.7
45				50/6"	8.4
		Gray SILT, moist to wet, occasional sand with silt interbeds. (ML)			
50			Hard	77	23.1
55				78	22.6
▼		Gray silty SAND, fine to medium sand, moist, occasional interbedded silt layer. (SM)			19.2
60		*Occasional organic in 60-foot sample*		50/5"	10.9
			Very Dense		
65				50/5"	7.5
70				50/5"	7.1

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-11

Project: Terrace Avenue Development **Project No:** T-8204 **Date Drilled:** September 17, 2019

Client: D.R. Horton **Driller:** Boretec **Logged By:** MJX

Location: Snohomish, Washington **Depth to Groundwater:** 6 Feet, 56 Feet **Approx. Elev:** ~240 Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot (10 30 50)	Moisture Content (%)
70		Grayish-brown silty SAND, fine to medium sand, moist, scattered silt inclusions. (SM)			
75				50/6"	8.0
80				83	9.0
85			Very Dense	50/5"	8.9
90				93/6"	7.9
95				50/4"	7.1
100				50/6"	6.1
105		Test boring terminated at approximately 100 feet. Light perched groundwater seepage observed at approximately 6 feet and 56 feet.			

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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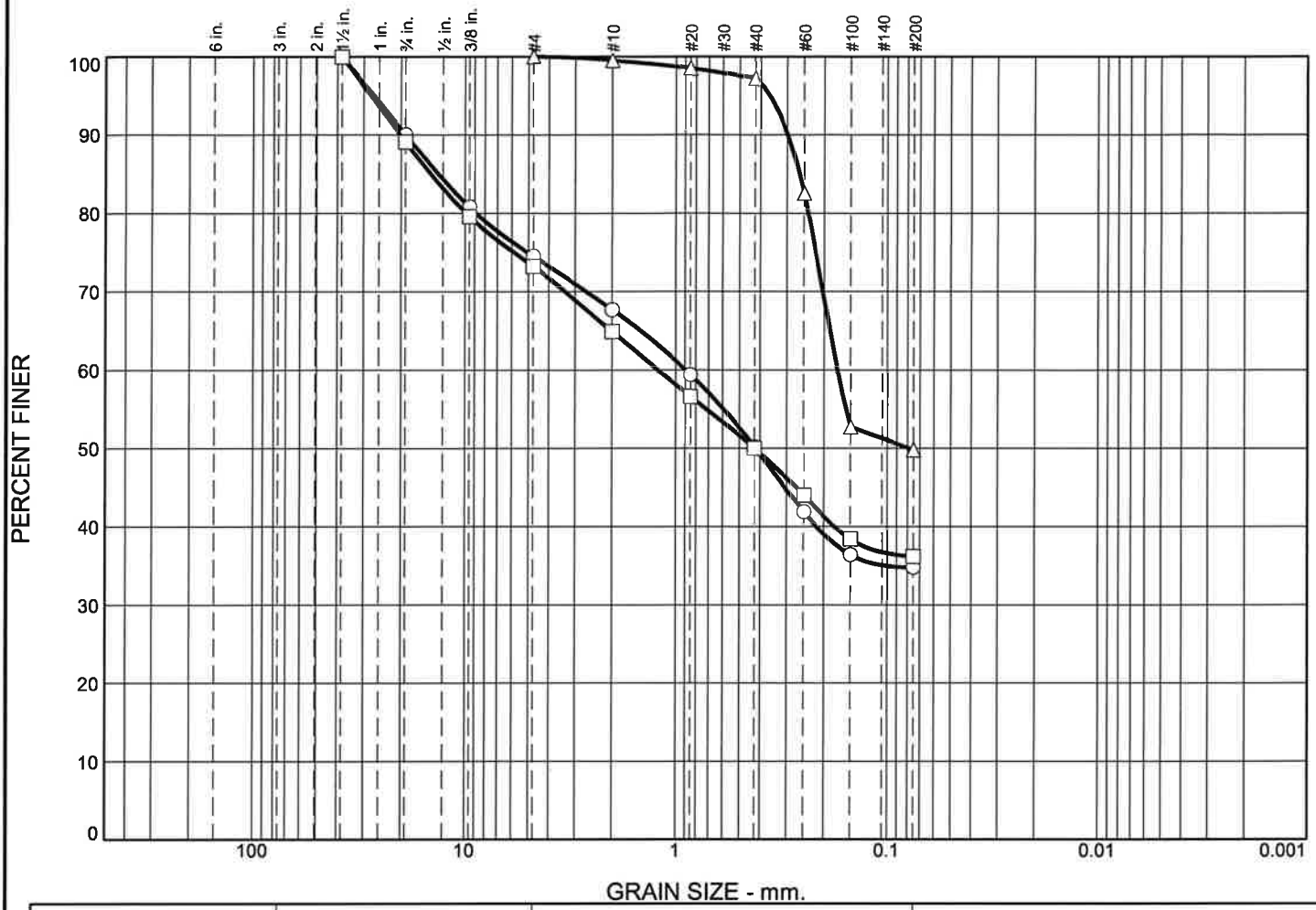
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	10.0	15.5	6.8	17.5	15.4	34.8	
□	0.0	10.9	15.9	8.3	14.9	13.8	36.2	
△	0.0	0.0	0.0	0.5	2.3	47.4	49.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			13.3443	0.8966	0.4195					
□			14.4649	1.2153	0.4250					
△			0.2631	0.1732	0.0787					

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

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Pit TP-3 **Depth:** -4 feet **Sample Number:** 2

□ **Location:** Test Pit TP-4 **Depth:** -1.5 feet **Sample Number:** 1

△ **Location:** Test Pit TP-7 **Depth:** -4 feet **Sample Number:** 3

Remarks:

○ Tested on September 10, 2019

□ Tested on September 10, 2019

△ Tested on September 10, 2019

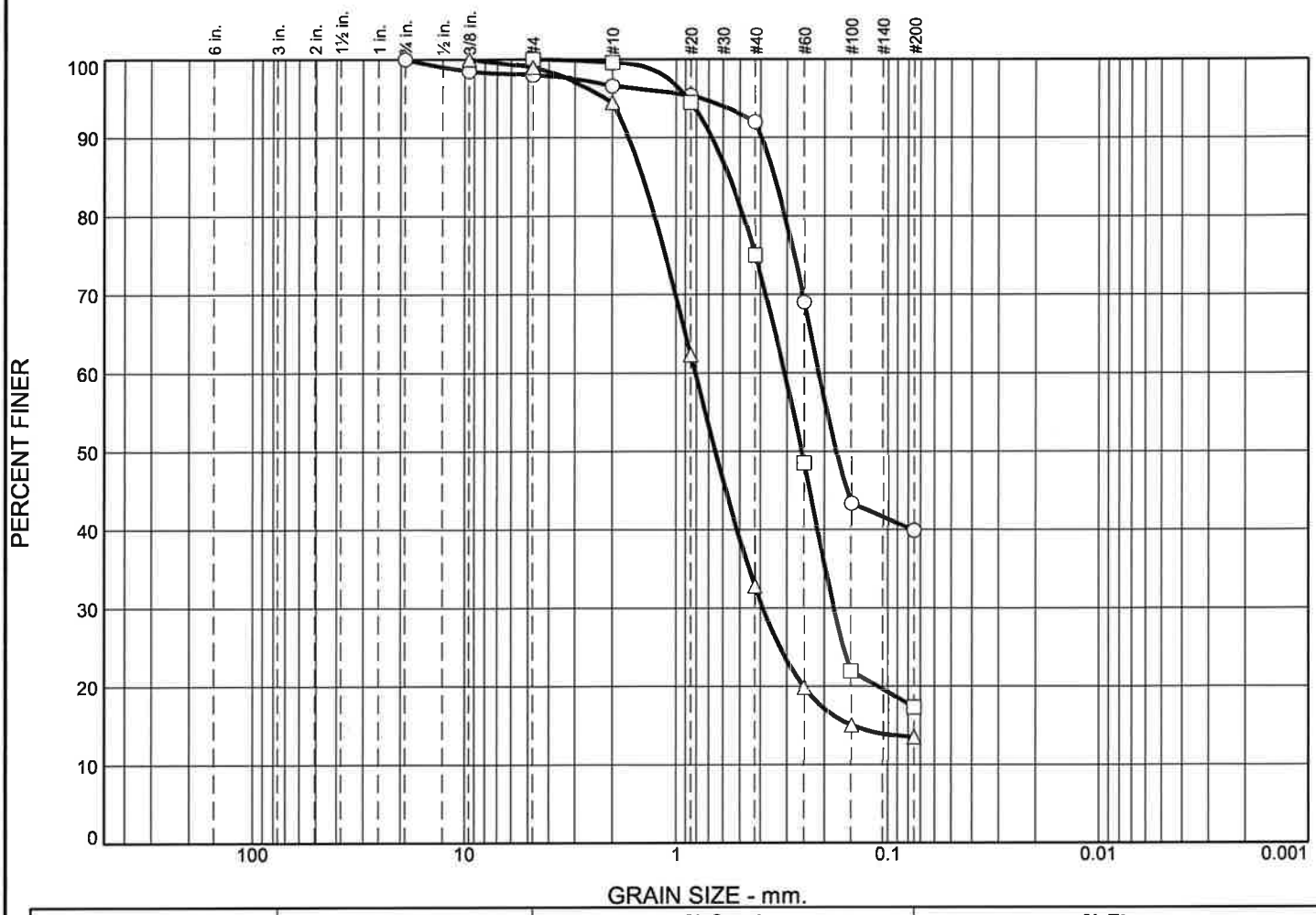
Terra Associates, Inc.

Kirkland, WA

Figure A-12

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.0	1.4	4.6	52.1	39.9	
□	0.0	0.0	0.0	0.4	24.6	57.7	17.3	
△	0.0	0.0	1.0	4.5	61.7	19.3	13.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3448	0.2133	0.1765					
□			0.5627	0.3082	0.2566	0.1805				
△			1.4424	0.8090	0.6511	0.3896	0.1469			

Material Description	USCS	AASHTO
○ silty SAND	SM	
□ Silty SAND	SM	
△ Silty SAND	SM	

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Pit TP-8 **Depth:** -3.5 feet **Sample Number:** 2

□ **Location:** Test Boring B-1 **Depth:** -3 feet **Sample Number:** 2

△ **Location:** Test Boring B-1 **Depth:** -60 feet **Sample Number:** 18

Remarks:

○ Tested on September 10, 2019

□ Tested on October 1, 2019

△ Tested October 1, 2019

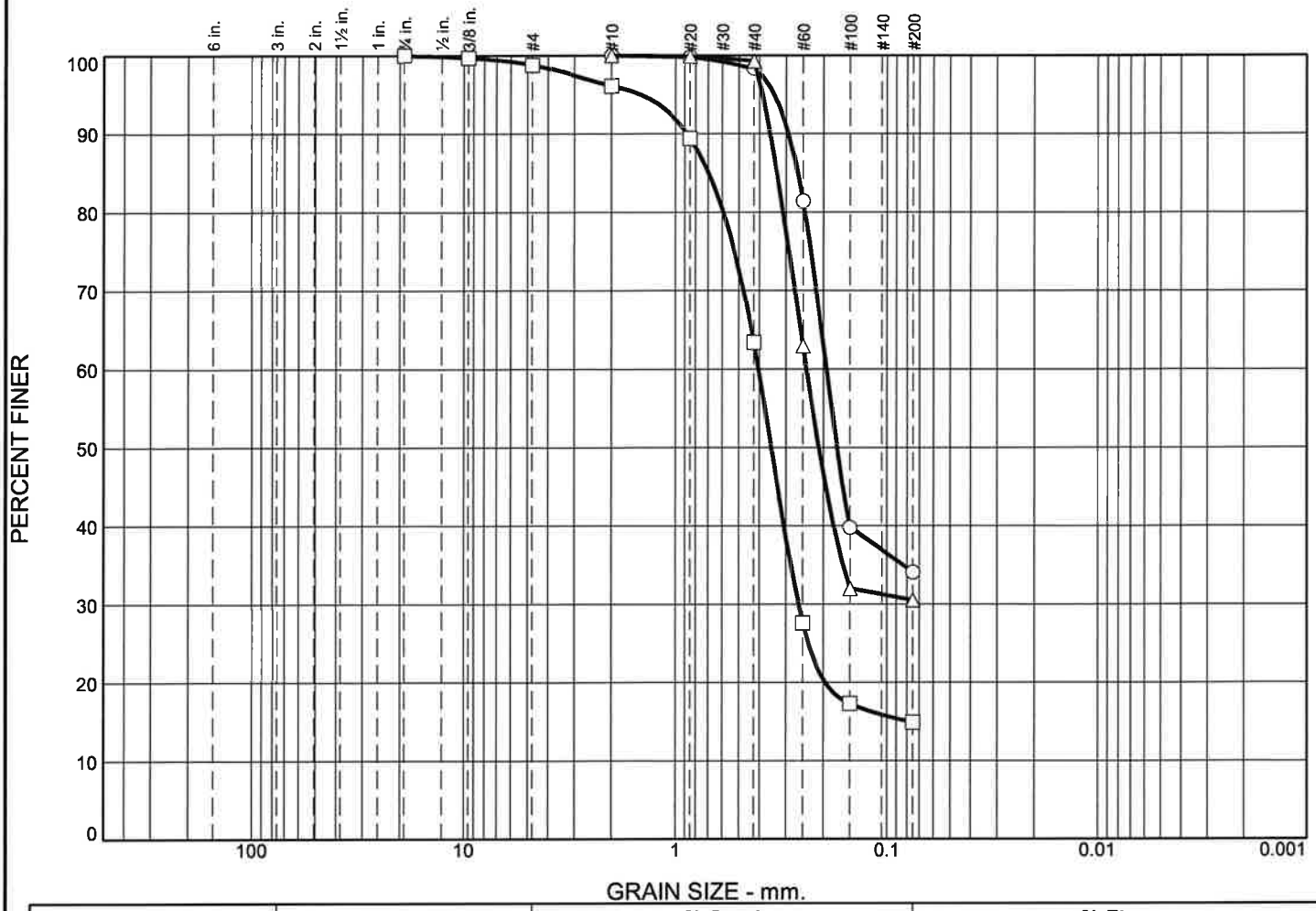
Terra Associates, Inc.

Kirkland, WA

Figure A-13

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	1.7	64.2	34.1	
□	0.0	0.0	1.2	2.7	32.7	48.5	14.9	
△	0.0	0.0	0.0	0.0	0.7	68.8	30.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2647	0.1935	0.1726					
□			0.6963	0.4038	0.3516	0.2619	0.0780			
△			0.3318	0.2408	0.2101					

Material Description	USCS	AASHTO
○ Silty SAND	SM	
□ Silty SAND		
△ Silty SAND	SM	

Project No. T-8204 **Client:** D.R. Horton

Project: Terrace Avenue Development

○ **Location:** Test Boring B-1 **Depth:** -100 feet **Sample Number:** 27

□ **Location:** Test Boring B-2 **Depth:** -70 feet **Sample Number:** 20

△ **Location:** Test Boring B-2 **Depth:** -80 feet **Sample Number:** 22

Remarks:

○ Tested on October 1, 2019

□ Tested on October 1, 2019

△ Tested on October 1, 2019

Terra Associates, Inc.

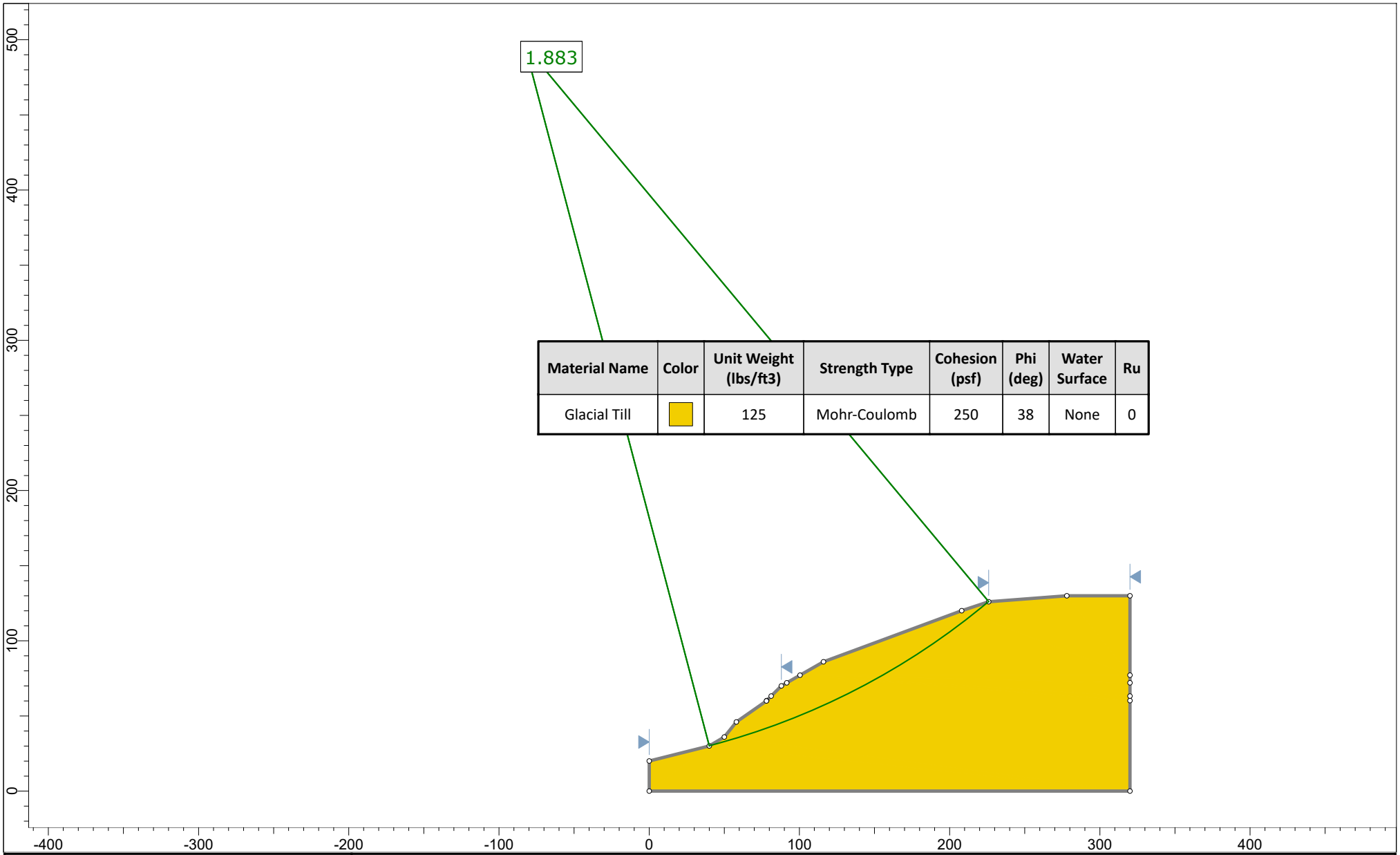
Kirkland, WA

Figure A-14

Tested By: FQ

APPENDIX B

SLIDE OUTPUT

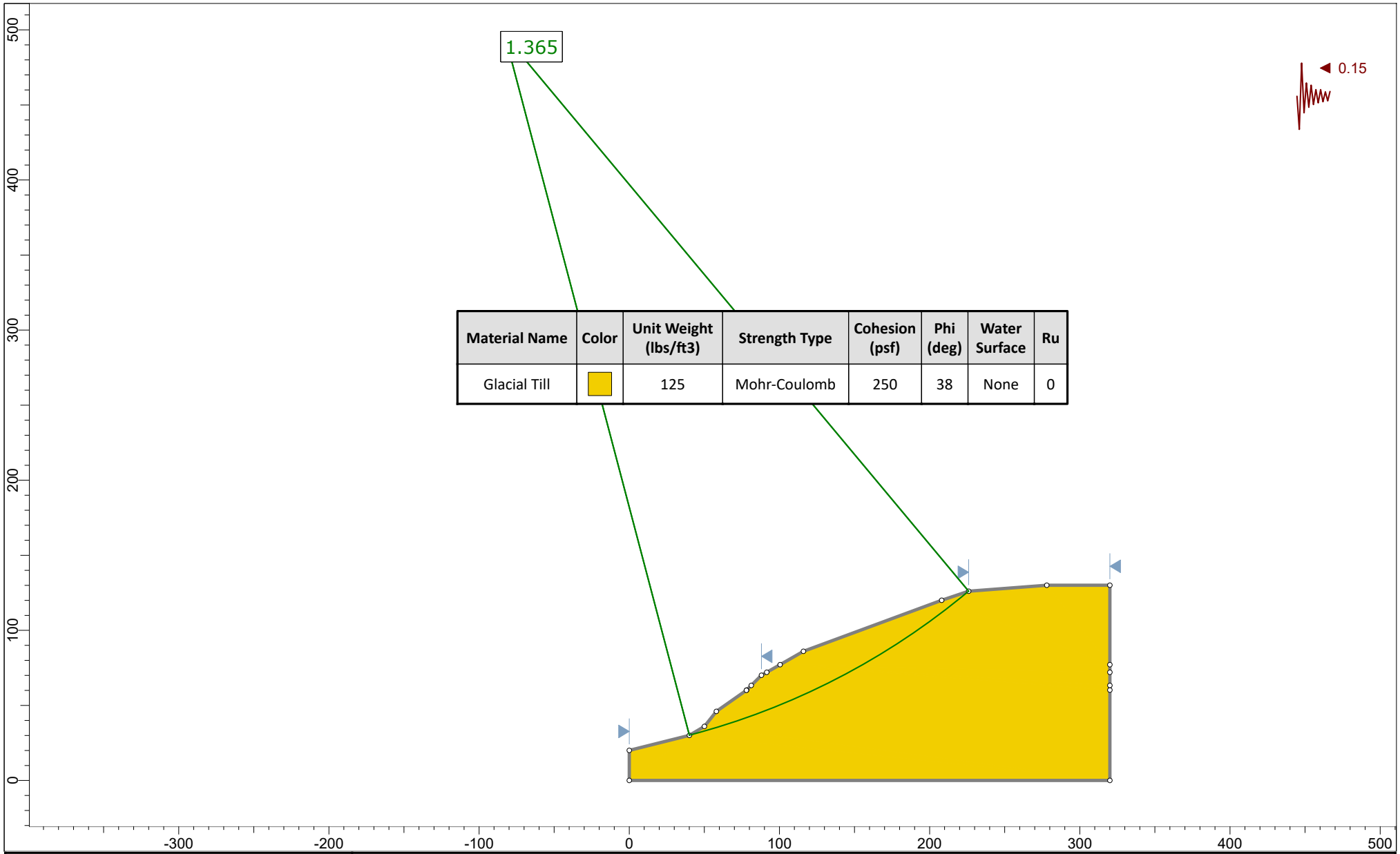


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Existing Conditions		
Drawn By C. Decker	*Scale* 1:1060	*Company* Terra Associates, Inc.	
Date October 2, 2019		*File Name* Cross-section A-A'.slmd	

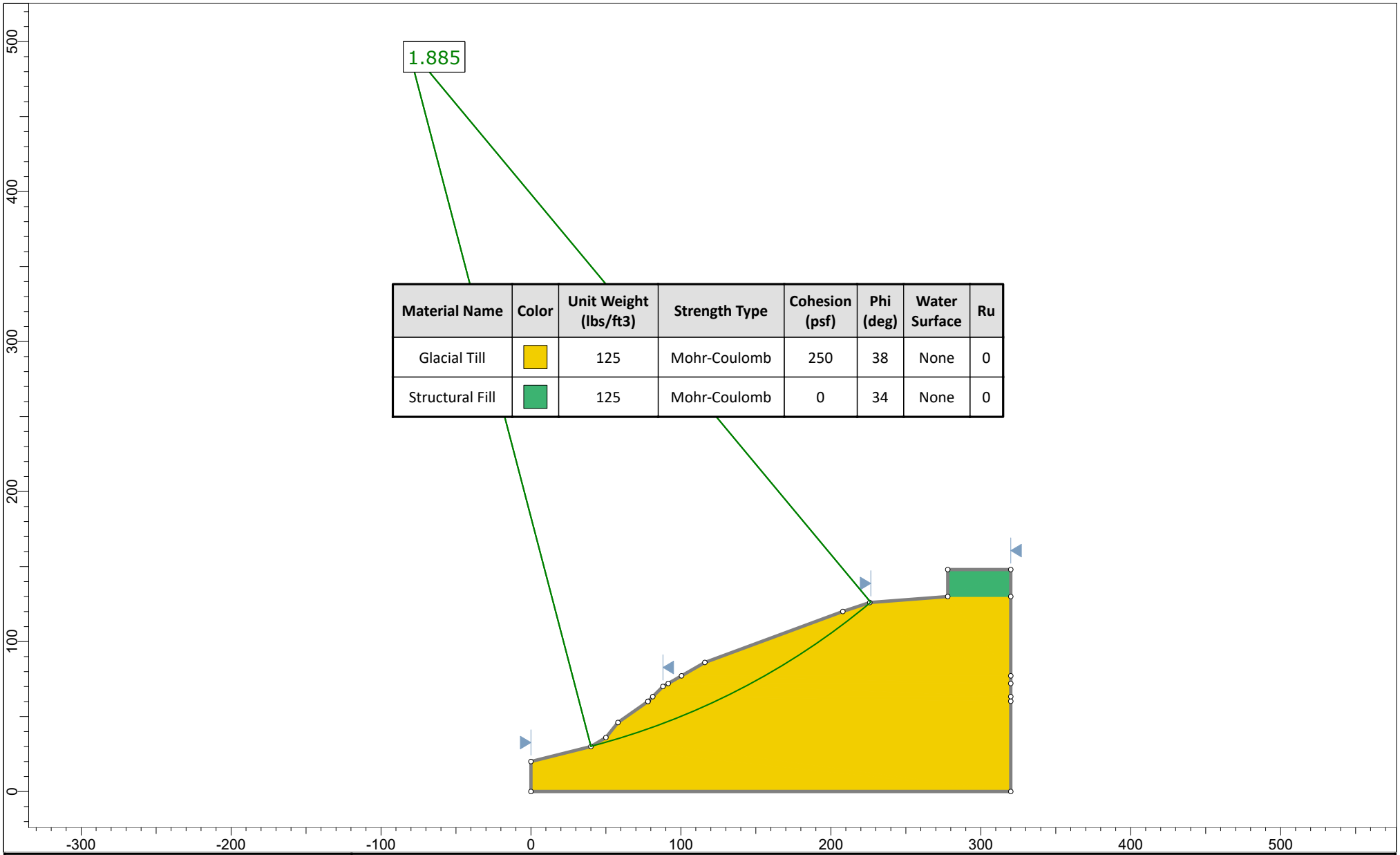


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Existing Conditions - Seismic		
Drawn By C. Decker	*Scale* 1:1060	*Company* Terra Associates, Inc.	
Date October 2, 2019		*File Name* Cross-section A-A'.slmd	

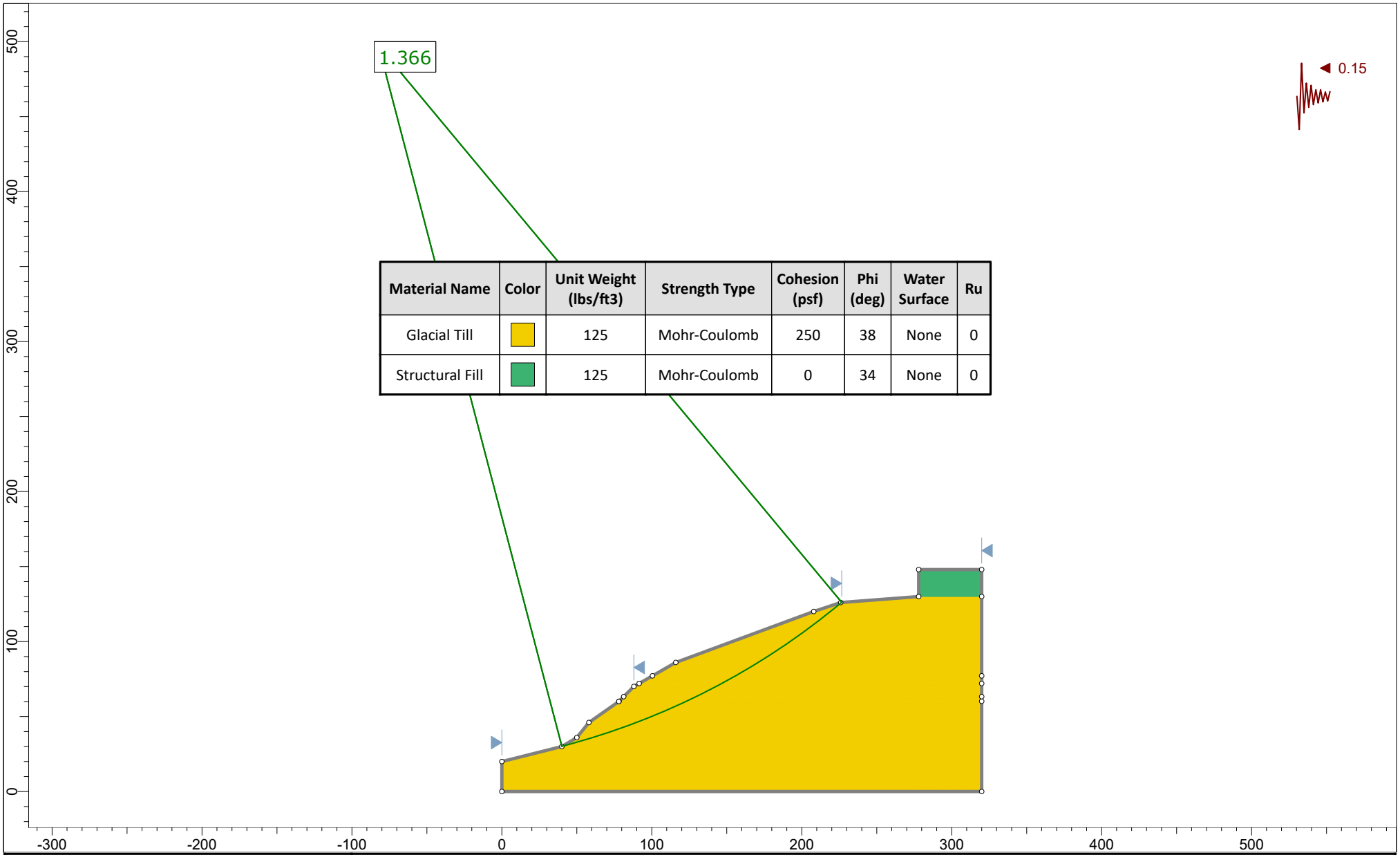


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Post Construction		
Drawn By C. Decker	*Scale* 1:1062	*Company* Terra Associates, Inc.	
Date May 15, 2020		*File Name* Cross-section A-A'.slmd	

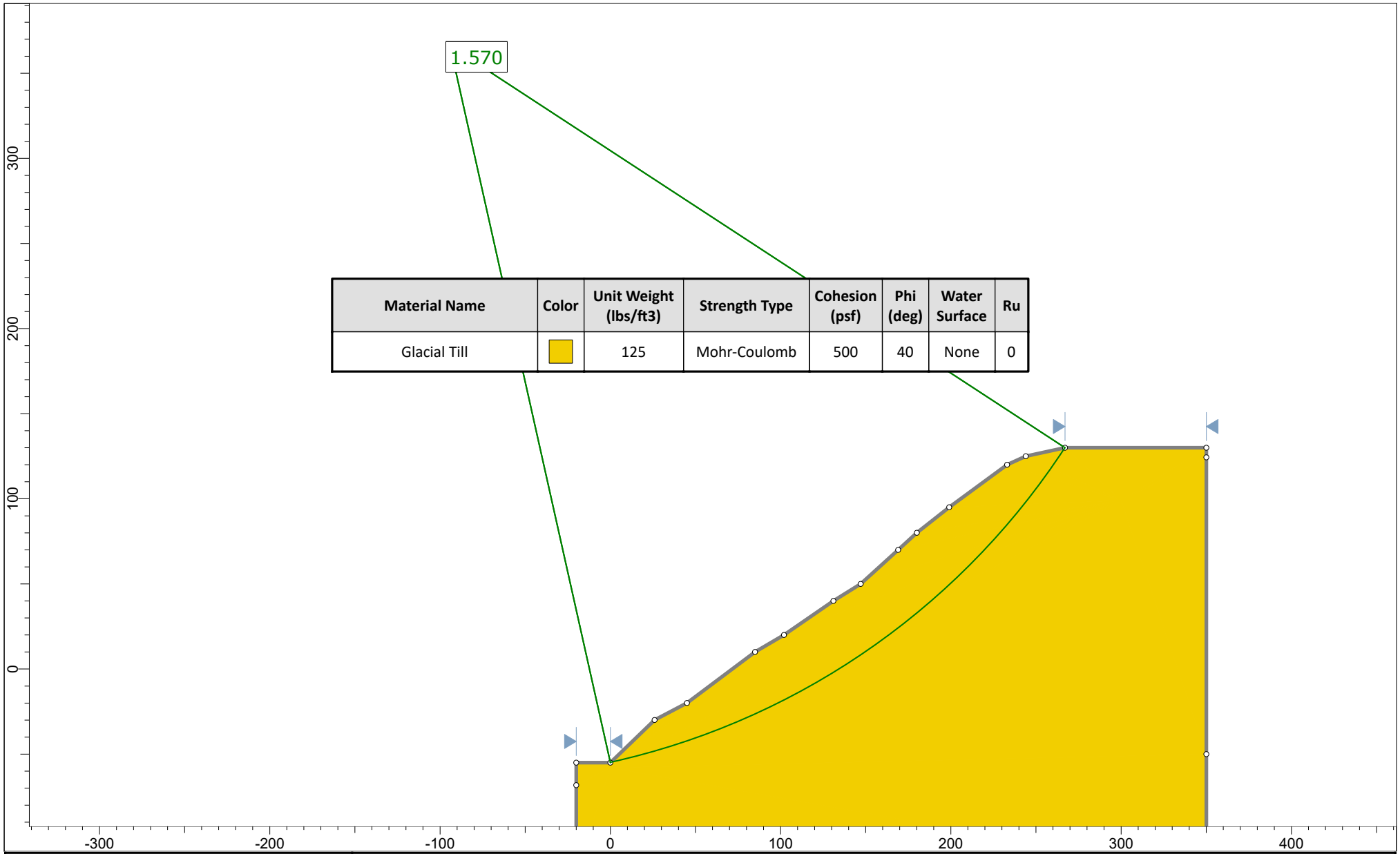


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section A-A' - Post Construction - Seismic		
Drawn By C. Decker	*Scale* 1:1062	*Company* Terra Associates, Inc.	
Date May 15, 2020		*File Name* Cross-section A-A'.slmd	

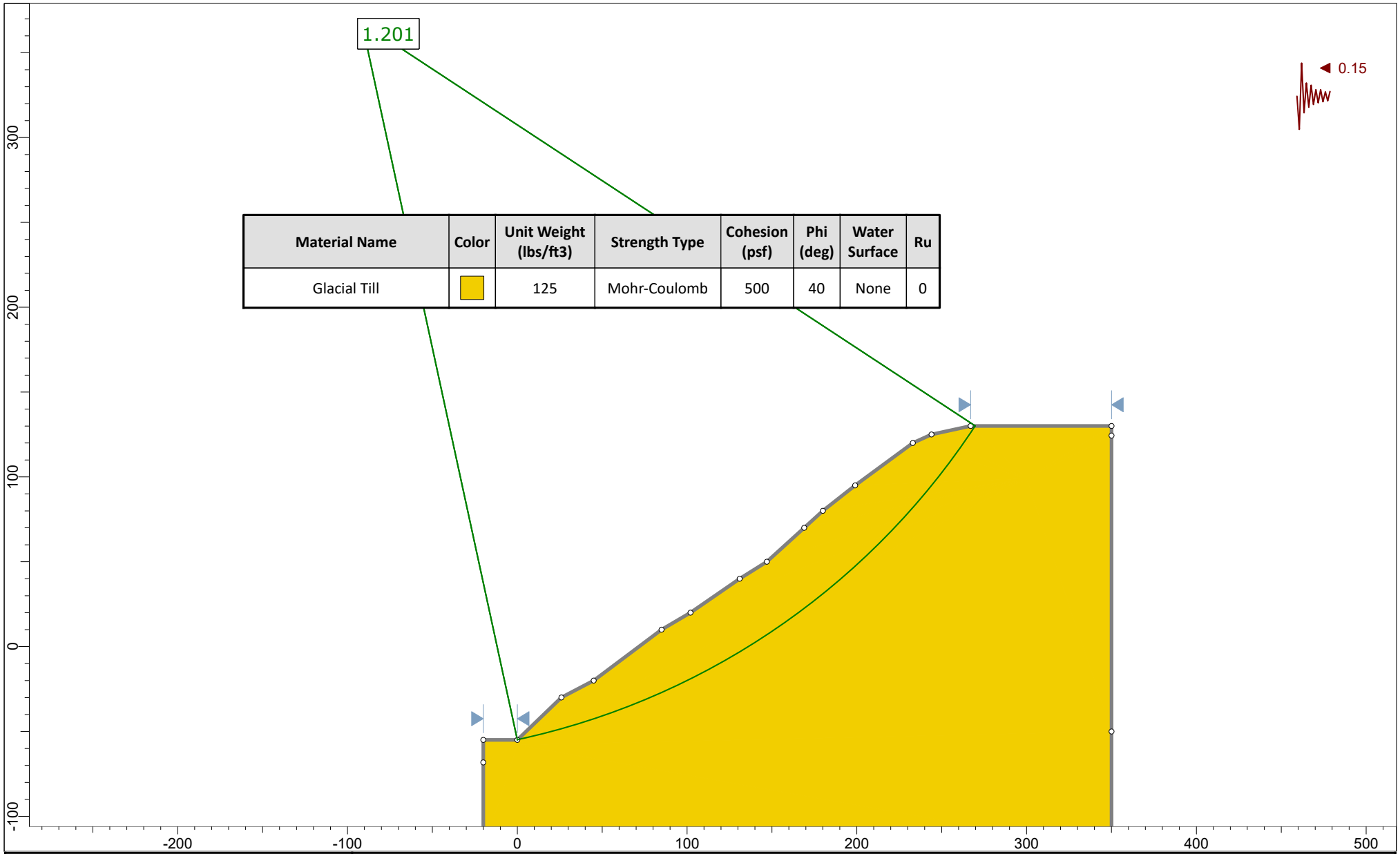


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section B-B' - Existing Conditions		
Drawn By	C. Decker	*Scale* 1:934	*Company* Terra Associates, Inc.
Date	May 15, 2020		*File Name* Cross Section B-B Detention Vault.slmd

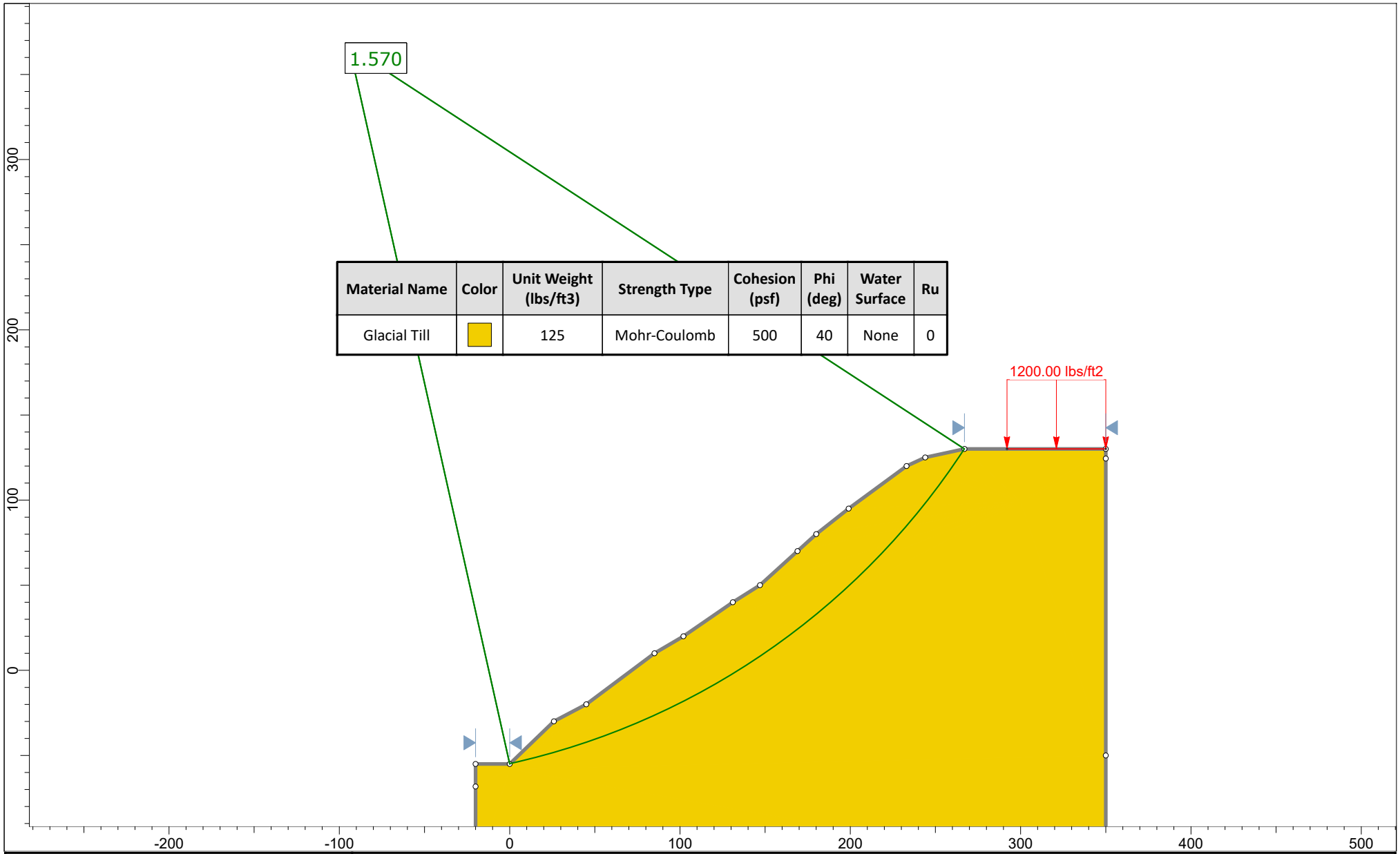


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section B-B' - Existing Conditions - Seismic		
Drawn By	C. Decker	*Scale* 1:937	*Company* Terra Associates, Inc.
Date	May 15, 2020		*File Name* Cross Section B-B Detention Vault.slmd

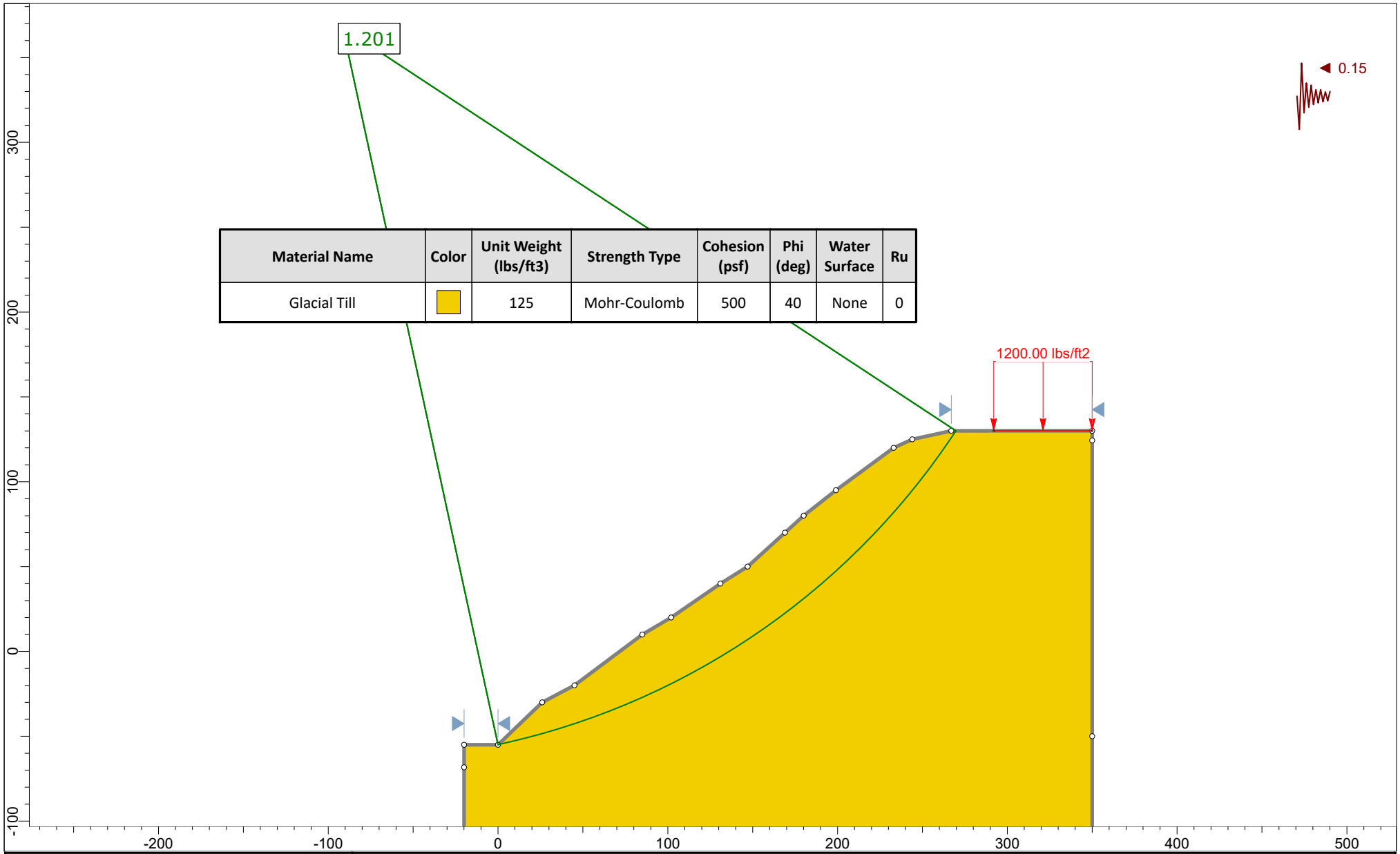


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section B-B' - Post Construction		
Drawn By C. Decker	*Scale* 1:934	*Company* Terra Associates, Inc.	
Date May 15, 2020		*File Name* Cross Section B-B Detention Vault.slmd	

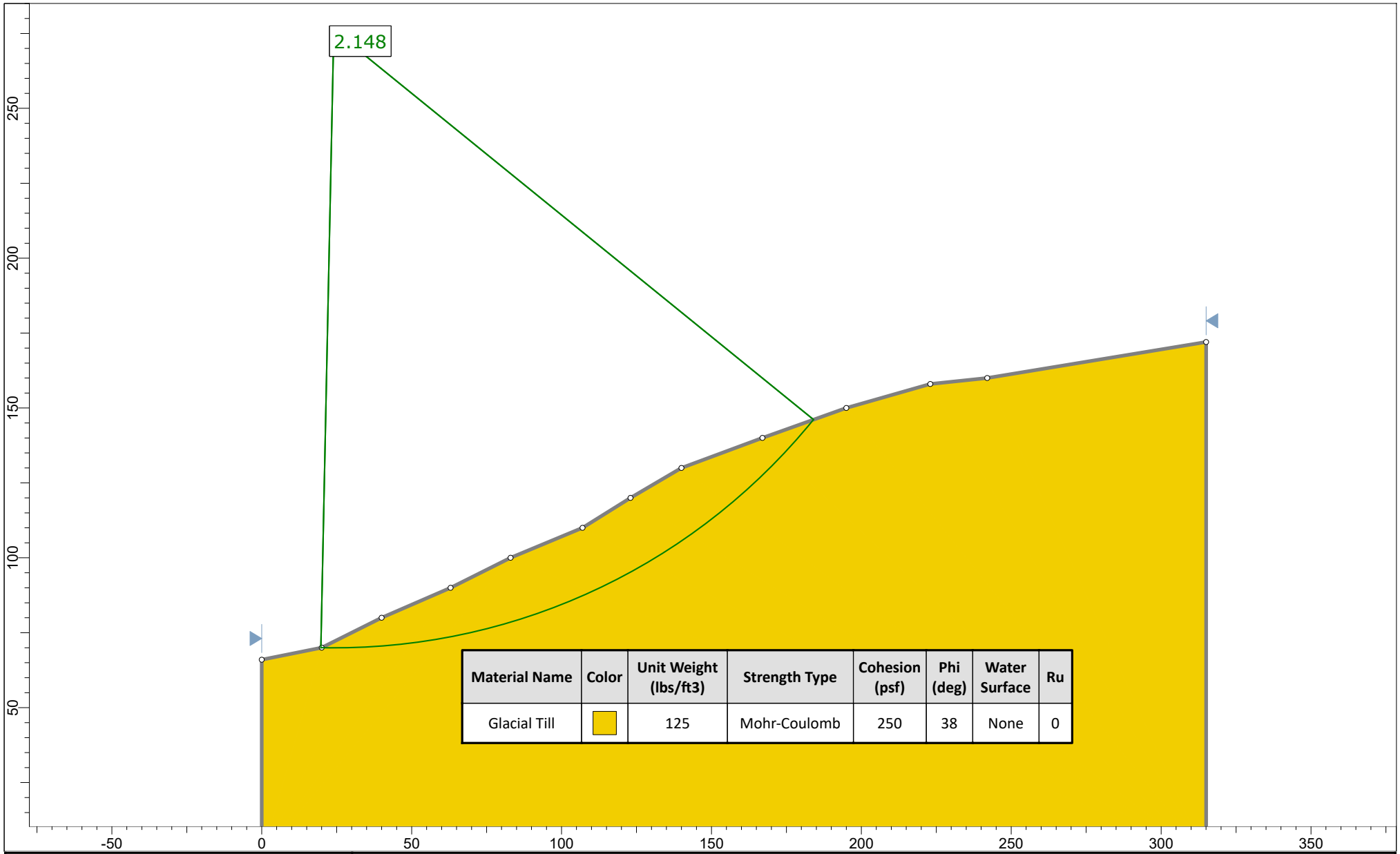


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	500	40	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Ave Development**		
Analysis Description	Cross Section B-B' - Post Construction - Seismic		
Drawn By	C. Decker	*Scale* 1:937	*Company* Terra Associates, Inc.
Date	May 15, 2020		*File Name* Cross Section B-B Detention Vault.slmd

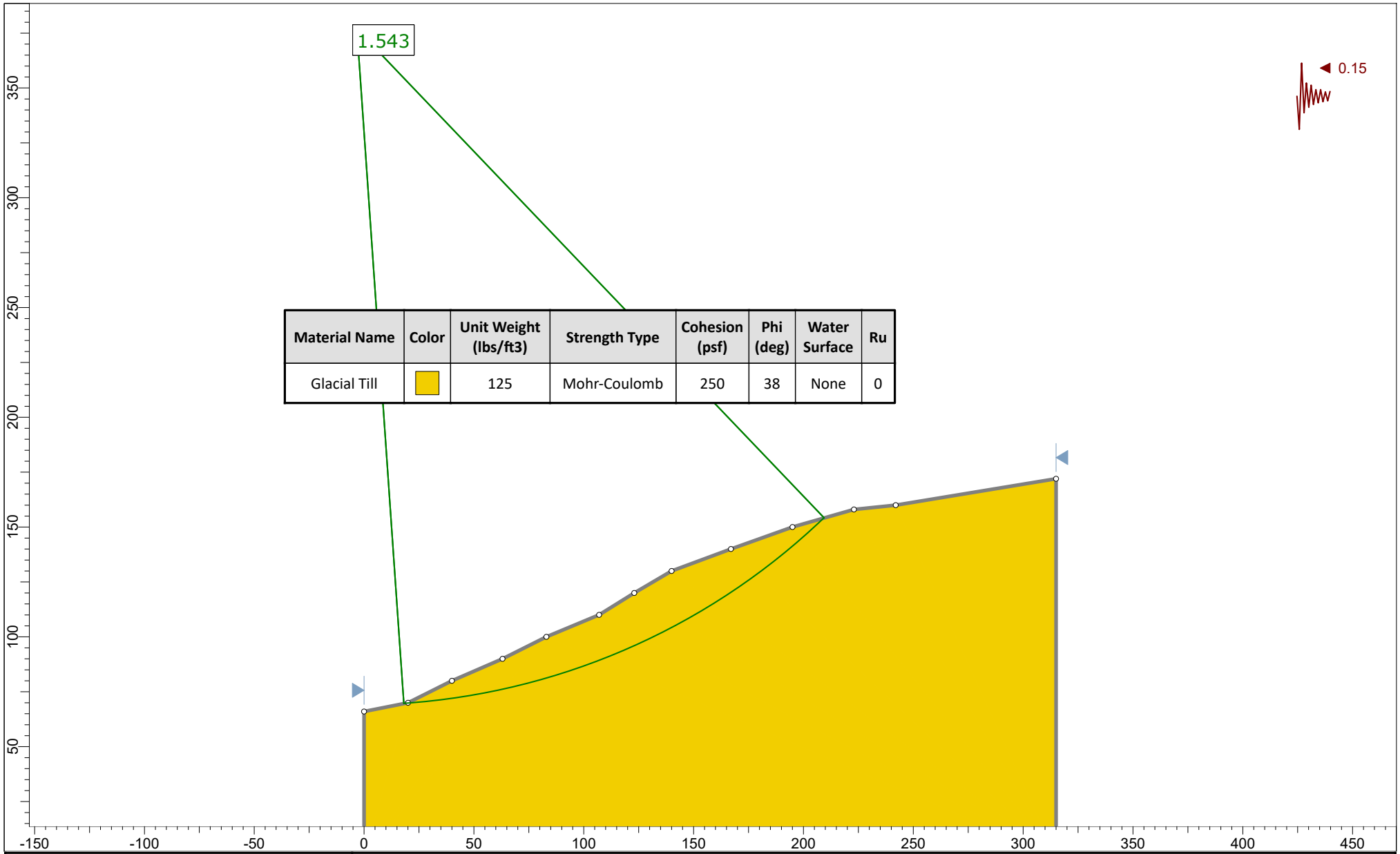


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**		
Analysis Description	Cross Section C-C' - Existing Conditions		
Drawn By	C. Decker	*Scale* 1:531	*Company* Terra Associates, Inc.
Date	5/6/2020, 2:14:41 PM		*File Name* Cross Section C-C'.slmd

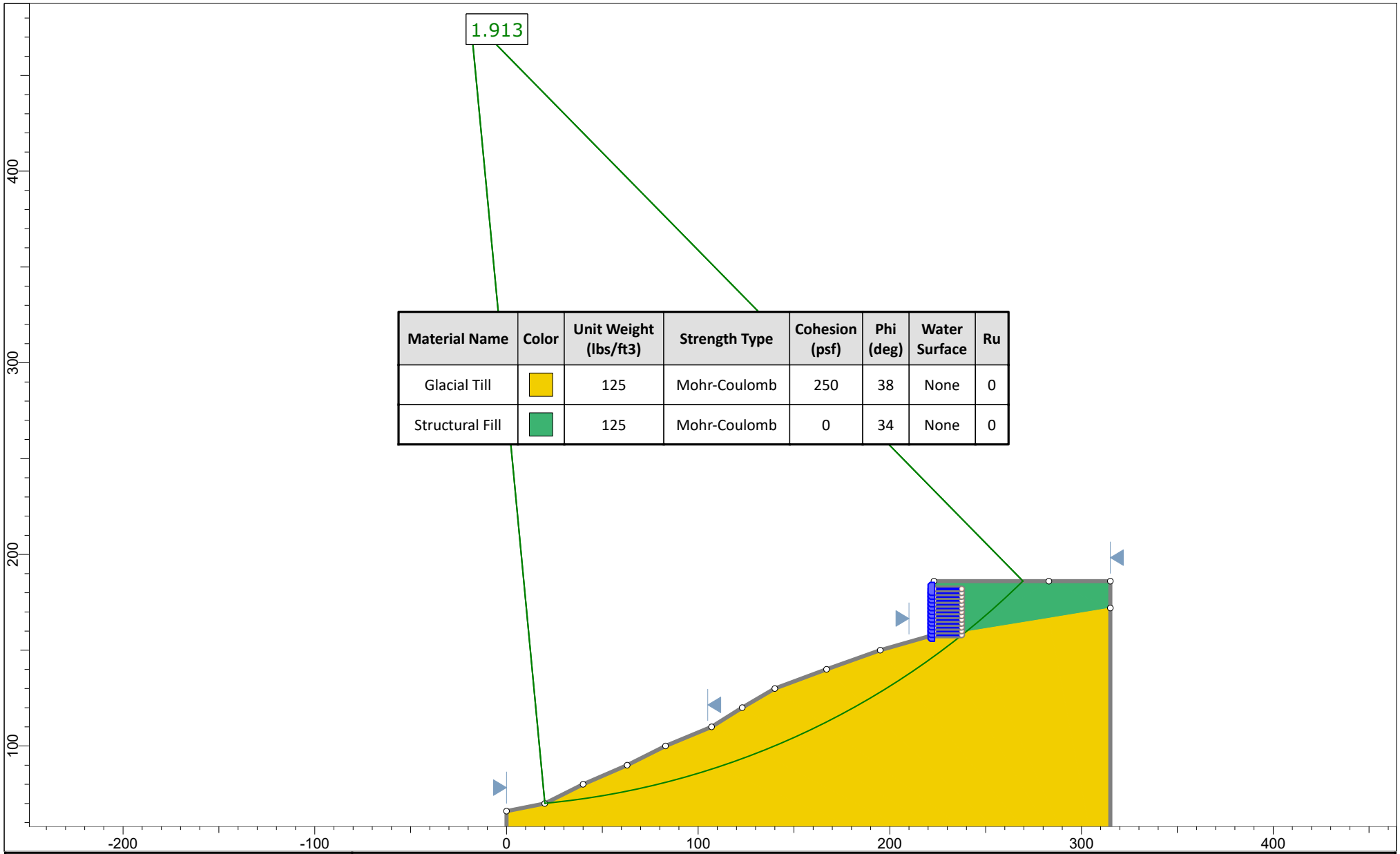


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**		
Analysis Description	Cross Section C-C' - Existing Conditions - Seismic		
Drawn By	C. Decker	Scale 1:724	Company Terra Associates, Inc.
Date	5/6/2020, 2:14:41 PM		File Name Cross Section C-C'.slmd

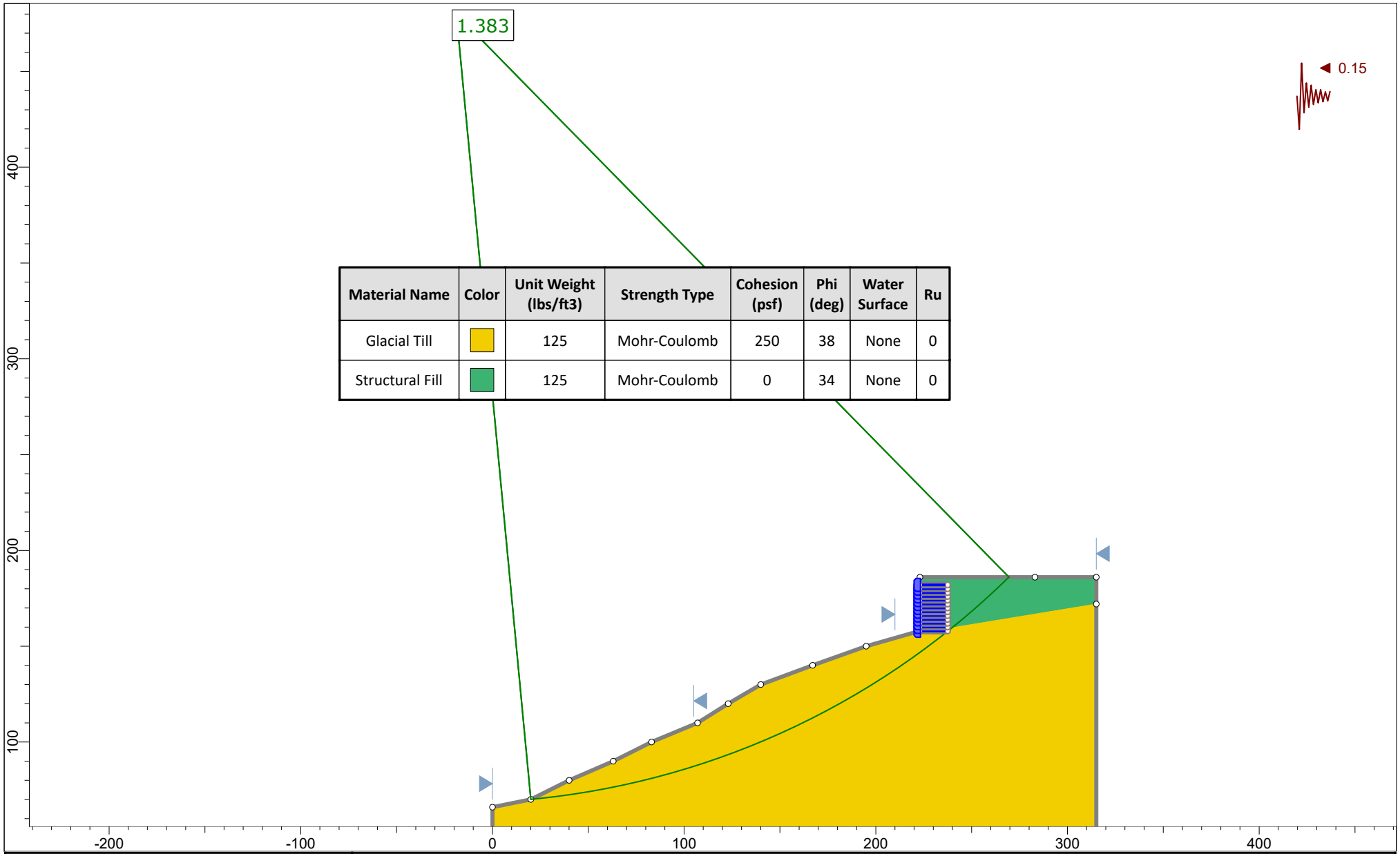


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**		
Analysis Description	Cross Section C-C' - Post Construction Conditions		
Drawn By	C. Decker	*Scale* 1:830	*Company* Terra Associates, Inc.
Date	5/6/2020, 2:14:41 PM		*File Name* Cross Section C-C'.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glacial Till		125	Mohr-Coulomb	250	38	None	0
Structural Fill		125	Mohr-Coulomb	0	34	None	0

rocscience

SLIDEINTERPRET 8.029

Project	**Terrace Avenue**		
Analysis Description	Cross Section C-C' - Post Construction Conditions - Seismic		
Drawn By C. Decker	*Scale* 1:830	*Company* Terra Associates, Inc.	
Date 5/6/2020, 2:14:41 PM		*File Name* Cross Section C-C'.slmd	

C|P|H
CONSULTANTS

APPENDIX B

WWHM INPUT PARAMETERS AND RESULTS

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

Walsh Hills - Land Use

Existing Basins

Basin	Total Area		Forest, Flat		Forest, Mod		Forest, Steep		Lawn, Flat		Lawn, Mod		Lawn, Steep		Rooftops		Roads, Flat		Roads, Mod		Sidewalks, Flat		Sidewalks, Mod	
	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC
East	354070	8.128	75248	1.727	56436	1.296	56436	1.296	45129	1.036	30086	0.691	0	0.000	45634	1.048	32485	0.746	0	0.000	12616	0.290	0	0.000
East Downstream	306543	7.037	13068	0.300	0	0.000	266759	6.124	0	0.000	0	0.000	0	0.000	0	0.000	26716	0.613	0	0.000	0	0.000	0	0.000
West	253592	5.822	27182	0.624	18120	0.416	0	0.000	84580	1.942	56386	1.294	0	0.000	9055	0.208	52357	1.202	1913	0.044	5912	0.136	0	0.000
Offsite North	40344	0.926	0	0.000	0	0.000	0	0.000	20960	0.481	0	0.000	0	0.000	0	0.000	8147	0.187	0	0.000	11237	0.258	0	0.000

Predeveloped Basins

Basin	Total Area		Forest, Flat		Forest, Mod		Forest, Steep		Lawn, Flat		Lawn, Mod		Lawn, Steep		Rooftops		Roads, Flat		Roads, Mod		Sidewalks, Flat		Sidewalks, Mod	
	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC
East	354070	8.128	141628	3.251	106221	2.438	106221	2.438	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
East Downstream	306543	7.037	13068	0.300	0	0.000	266759	6.124	0	0.000	0	0.000	0	0.000	0	0.000	26716	0.613	0	0.000	0	0.000	0	0.000
West	253592	5.822	152155	3.493	101437	2.329	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
Offsite North	40344	0.926	0	0.000	0	0.000	0	0.000	20960	0.481	0	0.000	0	0.000	0	0.000	8147	0.187	0	0.000	11237	0.258	0	0.000

Developed Basins

Onsite Basin	Total Area		Forest, Flat		Forest, Mod		Forest, Steep		Lawn, Flat		Lawn, Mod		Lawn, Steep		Rooftops		Roads, Flat		Roads, Mod		Sidewalks, Flat		Sidewalks, Mod	
	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC
East	450907	10.351	16508	0.379	0	0.000	0	0.000	72942	1.675	56882	1.306	33016	0.758	171655	3.941	35025	0.804	38929	0.894	12975	0.298	12975	0.298
East Downstream	306543	7.037	13068	0.300	0	0.000	266759	6.124	0	0.000	0	0.000	0	0.000	0	0.000	26716	0.613	0	0.000	0	0.000	0	0.000
West	148623	3.412	0	0.000	0	0.000	0	0.000	31492	0.723	20995	0.482	0	0.000	47742	1.096	21943	0.504	16608	0.381	5906	0.136	3938	0.090
Southwest Bypass	7896	0.181	0	0.000	0	0	0	0	1267	0.029	845	0.019	0	0.000	0	0.000	3059	0.070	2039	0.047	686	0.016	0	0.000
Offsite North	40344	0.926	0	0.000	0	0.000	0	0.000	20960	0.481	0	0.000	0	0.000	0	0.000	8147	0.187	0	0.000	11237	0.258	0	0.000

WWHM2012

PROJECT REPORT

Vault Analysis

General Model Information

Project Name:	Walsh Hills_Preliminary Engineering
Site Name:	Walsh Hills
Site Address:	
City:	City of Snohomish
Report Date:	5/18/2020
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.200
Version Date:	2017/04/14
Version:	4.2.13

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year
Low Flow Threshold for POC2:	50 Percent of the 2 Year
High Flow Threshold for POC2:	50 Year

Landuse Basin Data
Predeveloped Land Use

West

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	3.493
C, Forest, Mod	2.329
Pervious Total	5.822
Impervious Land Use	acre
Impervious Total	0
Basin Total	5.822

Element Flows To:

Surface	Interflow	Groundwater

Offsite North

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.481
Pervious Total	0.481
Impervious Land Use	acre
ROADS FLAT	0.187
SIDEWALKS FLAT	0.258
Impervious Total	0.445
Basin Total	0.926

Element Flows To:

Surface	Interflow	Groundwater

East

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	3.251
C, Forest, Mod	2.438
C, Forest, Steep	2.438
Pervious Total	8.127
Impervious Land Use	acre
Impervious Total	0
Basin Total	8.127

Element Flows To:

Surface	Interflow	Groundwater

East Downsream

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	0.3
C, Forest, Steep	6.124
Pervious Total	6.424
Impervious Land Use	acre
ROADS FLAT	0.613
Impervious Total	0.613
Basin Total	7.037

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

West

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.723
C, Lawn, Mod	0.482
Pervious Total	1.205
Impervious Land Use	acre
ROADS FLAT	0.504
ROADS MOD	0.381
ROOF TOPS FLAT	1.096
SIDEWALKS FLAT	0.136
SIDEWALKS MOD	0.09
Impervious Total	2.207
Basin Total	3.412

Element Flows To:

Surface	Interflow	Groundwater
West Vault	West Vault	

Offsite North

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.481
Pervious Total	0.481
Impervious Land Use	acre
ROADS FLAT	0.187
SIDEWALKS FLAT	0.258
Impervious Total	0.445
Basin Total	0.926

Element Flows To:

Surface	Interflow	Groundwater
West Vault	West Vault	

East

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	0.379
C, Lawn, Flat	1.675
C, Lawn, Mod	1.306
C, Lawn, Steep	0.758
Pervious Total	4.118
Impervious Land Use	acre
ROADS FLAT	0.804
ROADS MOD	0.894
ROOF TOPS FLAT	3.941
SIDEWALKS FLAT	0.298
SIDEWALKS MOD	0.298
Impervious Total	6.235
Basin Total	10.353

Element Flows To:

Surface	Interflow	Groundwater
East Vault	East Vault	

East Downstream

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	0.3
C, Pasture, Flat	6.124
Pervious Total	6.424
Impervious Land Use	acre
ROADS FLAT	0.613
Impervious Total	0.613
Basin Total	7.037

Element Flows To:

Surface	Interflow	Groundwater

Southwest Bypass

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.029
C, Lawn, Mod	0.019
Pervious Total	0.048
Impervious Land Use	acre
ROADS FLAT	0.07
ROADS MOD	0.047
SIDEWALKS FLAT	0.016
Impervious Total	0.133
Basin Total	0.181

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

West Vault

Width:	42.5 ft.
Length:	96 ft.
Depth:	7.2 ft.
Discharge Structure	
Riser Height:	6.7 ft.
Riser Diameter:	18 in.
Orifice 1 Diameter:	2.175 in. Elevation:0 ft.
Orifice 2 Diameter:	2.2 in. Elevation:3.1 ft.
Element Flows To:	
Outlet 1	Outlet 2

Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.093	0.000	0.000	0.000
0.0800	0.093	0.007	0.036	0.000
0.1600	0.093	0.015	0.051	0.000
0.2400	0.093	0.022	0.062	0.000
0.3200	0.093	0.030	0.072	0.000
0.4000	0.093	0.037	0.081	0.000
0.4800	0.093	0.045	0.088	0.000
0.5600	0.093	0.052	0.096	0.000
0.6400	0.093	0.059	0.102	0.000
0.7200	0.093	0.067	0.108	0.000
0.8000	0.093	0.074	0.114	0.000
0.8800	0.093	0.082	0.120	0.000
0.9600	0.093	0.089	0.125	0.000
1.0400	0.093	0.097	0.130	0.000
1.1200	0.093	0.104	0.135	0.000
1.2000	0.093	0.112	0.140	0.000
1.2800	0.093	0.119	0.145	0.000
1.3600	0.093	0.127	0.149	0.000
1.4400	0.093	0.134	0.154	0.000
1.5200	0.093	0.142	0.158	0.000
1.6000	0.093	0.149	0.162	0.000
1.6800	0.093	0.157	0.166	0.000
1.7600	0.093	0.164	0.170	0.000
1.8400	0.093	0.172	0.174	0.000
1.9200	0.093	0.179	0.177	0.000
2.0000	0.093	0.187	0.181	0.000
2.0800	0.093	0.194	0.185	0.000
2.1600	0.093	0.202	0.188	0.000
2.2400	0.093	0.209	0.192	0.000
2.3200	0.093	0.217	0.195	0.000
2.4000	0.093	0.224	0.198	0.000
2.4800	0.093	0.232	0.202	0.000
2.5600	0.093	0.239	0.205	0.000
2.6400	0.093	0.247	0.208	0.000
2.7200	0.093	0.254	0.211	0.000
2.8000	0.093	0.262	0.214	0.000
2.8800	0.093	0.269	0.217	0.000
2.9600	0.093	0.277	0.220	0.000
3.0400	0.093	0.284	0.223	0.000

3.1200	0.093	0.292	0.245	0.000
3.2000	0.093	0.299	0.271	0.000
3.2800	0.093	0.307	0.288	0.000
3.3600	0.093	0.314	0.302	0.000
3.4400	0.093	0.322	0.314	0.000
3.5200	0.093	0.329	0.326	0.000
3.6000	0.093	0.337	0.336	0.000
3.6800	0.093	0.344	0.346	0.000
3.7600	0.093	0.352	0.355	0.000
3.8400	0.093	0.359	0.364	0.000
3.9200	0.093	0.367	0.373	0.000
4.0000	0.093	0.374	0.381	0.000
4.0800	0.093	0.382	0.389	0.000
4.1600	0.093	0.389	0.397	0.000
4.2400	0.093	0.397	0.404	0.000
4.3200	0.093	0.404	0.411	0.000
4.4000	0.093	0.412	0.419	0.000
4.4800	0.093	0.419	0.426	0.000
4.5600	0.093	0.427	0.432	0.000
4.6400	0.093	0.434	0.439	0.000
4.7200	0.093	0.442	0.446	0.000
4.8000	0.093	0.449	0.452	0.000
4.8800	0.093	0.457	0.458	0.000
4.9600	0.093	0.464	0.465	0.000
5.0400	0.093	0.472	0.471	0.000
5.1200	0.093	0.479	0.477	0.000
5.2000	0.093	0.487	0.483	0.000
5.2800	0.093	0.494	0.488	0.000
5.3600	0.093	0.502	0.494	0.000
5.4400	0.093	0.509	0.500	0.000
5.5200	0.093	0.517	0.505	0.000
5.6000	0.093	0.524	0.511	0.000
5.6800	0.093	0.532	0.516	0.000
5.7600	0.093	0.539	0.522	0.000
5.8400	0.093	0.547	0.527	0.000
5.9200	0.093	0.554	0.532	0.000
6.0000	0.093	0.562	0.538	0.000
6.0800	0.093	0.569	0.543	0.000
6.1600	0.093	0.577	0.548	0.000
6.2400	0.093	0.584	0.553	0.000
6.3200	0.093	0.592	0.558	0.000
6.4000	0.093	0.599	0.563	0.000
6.4800	0.093	0.606	0.568	0.000
6.5600	0.093	0.614	0.573	0.000
6.6400	0.093	0.621	0.577	0.000
6.7200	0.093	0.629	0.627	0.000
6.8000	0.093	0.636	1.089	0.000
6.8800	0.093	0.644	1.795	0.000
6.9600	0.093	0.651	2.646	0.000
7.0400	0.093	0.659	3.560	0.000
7.1200	0.093	0.666	4.454	0.000
7.2000	0.093	0.674	5.249	0.000
7.2800	0.093	0.662	5.886	0.000

East Vault

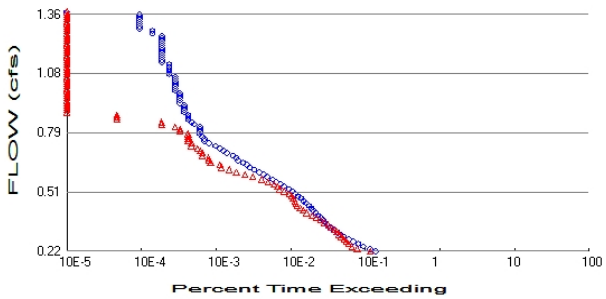
Width:	84 ft.	
Length:	156 ft.	
Depth:	13 ft.	
Discharge Structure		
Riser Height:	12.5 ft.	
Riser Diameter:	18 in.	
Orifice 1 Diameter:	1.9 in.	Elevation:0 ft.
Orifice 2 Diameter:	2.25 in.	Elevation:6.75 ft.
Element Flows To:		
Outlet 1	Outlet 2	

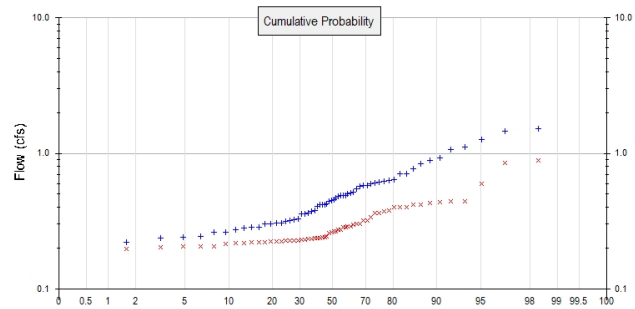
Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.300	0.000	0.000	0.000
0.1444	0.300	0.043	0.037	0.000
0.2889	0.300	0.086	0.052	0.000
0.4333	0.300	0.130	0.064	0.000
0.5778	0.300	0.173	0.074	0.000
0.7222	0.300	0.217	0.083	0.000
0.8667	0.300	0.260	0.091	0.000
1.0111	0.300	0.304	0.098	0.000
1.1556	0.300	0.347	0.105	0.000
1.3000	0.300	0.391	0.111	0.000
1.4444	0.300	0.434	0.117	0.000
1.5889	0.300	0.478	0.123	0.000
1.7333	0.300	0.521	0.129	0.000
1.8778	0.300	0.564	0.134	0.000
2.0222	0.300	0.608	0.139	0.000
2.1667	0.300	0.651	0.144	0.000
2.3111	0.300	0.695	0.148	0.000
2.4556	0.300	0.738	0.153	0.000
2.6000	0.300	0.782	0.158	0.000
2.7444	0.300	0.825	0.162	0.000
2.8889	0.300	0.869	0.166	0.000
3.0333	0.300	0.912	0.170	0.000
3.1778	0.300	0.956	0.174	0.000
3.3222	0.300	0.999	0.178	0.000
3.4667	0.300	1.042	0.182	0.000
3.6111	0.300	1.086	0.186	0.000
3.7556	0.300	1.129	0.189	0.000
3.9000	0.300	1.173	0.193	0.000
4.0444	0.300	1.216	0.197	0.000
4.1889	0.300	1.260	0.200	0.000
4.3333	0.300	1.303	0.203	0.000
4.4778	0.300	1.347	0.207	0.000
4.6222	0.300	1.390	0.210	0.000
4.7667	0.300	1.433	0.213	0.000
4.9111	0.300	1.477	0.217	0.000
5.0556	0.300	1.520	0.220	0.000
5.2000	0.300	1.564	0.223	0.000
5.3444	0.300	1.607	0.226	0.000
5.4889	0.300	1.651	0.229	0.000
5.6333	0.300	1.694	0.232	0.000
5.7778	0.300	1.738	0.235	0.000

5.9222	0.300	1.781	0.238	0.000
6.0667	0.300	1.825	0.241	0.000
6.2111	0.300	1.868	0.244	0.000
6.3556	0.300	1.911	0.247	0.000
6.5000	0.300	1.955	0.249	0.000
6.6444	0.300	1.998	0.252	0.000
6.7889	0.300	2.042	0.282	0.000
6.9333	0.300	2.085	0.316	0.000
7.0778	0.300	2.129	0.339	0.000
7.2222	0.300	2.172	0.357	0.000
7.3667	0.300	2.216	0.373	0.000
7.5111	0.300	2.259	0.388	0.000
7.6556	0.300	2.303	0.401	0.000
7.8000	0.300	2.346	0.414	0.000
7.9444	0.300	2.389	0.426	0.000
8.0889	0.300	2.433	0.437	0.000
8.2333	0.300	2.476	0.448	0.000
8.3778	0.300	2.520	0.458	0.000
8.5222	0.300	2.563	0.468	0.000
8.6667	0.300	2.607	0.478	0.000
8.8111	0.300	2.650	0.488	0.000
8.9556	0.300	2.694	0.497	0.000
9.1000	0.300	2.737	0.506	0.000
9.2444	0.300	2.781	0.514	0.000
9.3889	0.300	2.824	0.523	0.000
9.5333	0.300	2.867	0.531	0.000
9.6778	0.300	2.911	0.539	0.000
9.8222	0.300	2.954	0.547	0.000
9.9667	0.300	2.998	0.555	0.000
10.111	0.300	3.041	0.563	0.000
10.256	0.300	3.085	0.570	0.000
10.400	0.300	3.128	0.578	0.000
10.544	0.300	3.172	0.585	0.000
10.689	0.300	3.215	0.592	0.000
10.833	0.300	3.259	0.600	0.000
10.978	0.300	3.302	0.607	0.000
11.122	0.300	3.345	0.614	0.000
11.267	0.300	3.389	0.620	0.000
11.411	0.300	3.432	0.627	0.000
11.556	0.300	3.476	0.634	0.000
11.700	0.300	3.519	0.640	0.000
11.844	0.300	3.563	0.647	0.000
11.989	0.300	3.606	0.653	0.000
12.133	0.300	3.650	0.660	0.000
12.278	0.300	3.693	0.666	0.000
12.422	0.300	3.736	0.672	0.000
12.567	0.300	3.780	0.952	0.000
12.711	0.300	3.823	2.204	0.000
12.856	0.300	3.867	3.826	0.000
13.000	0.300	3.910	5.335	0.000
13.144	0.300	3.954	6.352	0.000
13.289	0.000	0.000	7.002	0.000

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 6.303
Total Impervious Area: 0.445

Mitigated Landuse Totals for POC #1
Total Pervious Area: 1.734
Total Impervious Area: 2.785

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.446369
5 year	0.681813
10 year	0.866804
25 year	1.135996
50 year	1.363813
100 year	1.616337

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.276715
5 year	0.37405
10 year	0.448112
25 year	0.553294
50 year	0.640552
100 year	0.735866

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.583	0.226
1950	0.625	0.266
1951	0.376	0.236
1952	0.427	0.222
1953	0.491	0.220
1954	1.268	0.285
1955	0.599	0.364
1956	0.360	0.298
1957	0.606	0.373
1958	1.072	0.402

1959	0.373	0.245
1960	0.488	0.340
1961	1.519	0.429
1962	0.451	0.273
1963	0.772	0.303
1964	0.416	0.238
1965	0.241	0.217
1966	0.238	0.193
1967	0.484	0.321
1968	0.486	0.419
1969	1.462	0.318
1970	0.318	0.205
1971	0.516	0.233
1972	0.572	0.378
1973	0.443	0.216
1974	0.711	0.285
1975	0.511	0.224
1976	0.286	0.302
1977	0.264	0.239
1978	0.303	0.203
1979	0.884	0.438
1980	0.419	0.228
1981	0.324	0.219
1982	0.326	0.439
1983	0.579	0.257
1984	0.356	0.290
1985	0.504	0.361
1986	0.928	0.596
1987	0.417	0.401
1988	0.357	0.240
1989	0.467	0.206
1990	0.306	0.224
1991	0.303	0.239
1992	0.408	0.220
1993	0.305	0.226
1994	0.244	0.231
1995	0.287	0.234
1996	0.631	0.419
1997	1.121	0.882
1998	0.457	0.264
1999	0.281	0.223
2000	0.612	0.274
2001	0.176	0.196
2002	0.262	0.230
2003	0.220	0.206
2004	0.548	0.403
2005	0.273	0.291
2006	0.832	0.440
2007	0.709	0.267
2008	0.642	0.854
2009	0.316	0.228

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	1.5188	0.8818
2	1.4620	0.8542
3	1.2679	0.5956

4	1.1211	0.4403
5	1.0720	0.4395
6	0.9278	0.4380
7	0.8845	0.4289
8	0.8317	0.4194
9	0.7719	0.4193
10	0.7115	0.4029
11	0.7094	0.4024
12	0.6423	0.4014
13	0.6308	0.3778
14	0.6245	0.3733
15	0.6120	0.3640
16	0.6060	0.3609
17	0.5994	0.3402
18	0.5828	0.3206
19	0.5786	0.3184
20	0.5718	0.3029
21	0.5482	0.3022
22	0.5158	0.2981
23	0.5107	0.2906
24	0.5042	0.2900
25	0.4910	0.2851
26	0.4876	0.2848
27	0.4862	0.2736
28	0.4837	0.2732
29	0.4672	0.2672
30	0.4575	0.2656
31	0.4506	0.2636
32	0.4425	0.2568
33	0.4265	0.2448
34	0.4189	0.2396
35	0.4168	0.2391
36	0.4159	0.2387
37	0.4083	0.2379
38	0.3762	0.2360
39	0.3733	0.2339
40	0.3605	0.2334
41	0.3572	0.2309
42	0.3565	0.2295
43	0.3263	0.2277
44	0.3238	0.2276
45	0.3182	0.2262
46	0.3158	0.2260
47	0.3065	0.2245
48	0.3051	0.2239
49	0.3030	0.2234
50	0.3027	0.2224
51	0.2868	0.2202
52	0.2858	0.2199
53	0.2814	0.2190
54	0.2730	0.2171
55	0.2635	0.2157
56	0.2623	0.2064
57	0.2444	0.2056
58	0.2415	0.2051
59	0.2382	0.2029
60	0.2205	0.1964
61	0.1756	0.1934

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.2232	2911	2477	85	Pass
0.2347	2447	1665	68	Pass
0.2462	2026	1406	69	Pass
0.2577	1723	1281	74	Pass
0.2693	1455	1187	81	Pass
0.2808	1279	1111	86	Pass
0.2923	1102	1019	92	Pass
0.3038	994	956	96	Pass
0.3154	892	891	99	Pass
0.3269	800	822	102	Fail
0.3384	728	746	102	Fail
0.3499	671	685	102	Fail
0.3614	622	609	97	Pass
0.3730	583	535	91	Pass
0.3845	539	470	87	Pass
0.3960	493	413	83	Pass
0.4075	462	351	75	Pass
0.4191	427	311	72	Pass
0.4306	402	285	70	Pass
0.4421	374	260	69	Pass
0.4536	347	252	72	Pass
0.4651	317	242	76	Pass
0.4767	296	233	78	Pass
0.4882	265	218	82	Pass
0.4997	243	204	83	Pass
0.5112	223	175	78	Pass
0.5227	201	152	75	Pass
0.5343	174	141	81	Pass
0.5458	157	127	80	Pass
0.5573	136	106	77	Pass
0.5688	121	87	71	Pass
0.5804	104	66	63	Pass
0.5919	93	52	55	Pass
0.6034	81	40	49	Pass
0.6149	69	32	46	Pass
0.6264	60	25	41	Pass
0.6380	55	24	43	Pass
0.6495	49	18	36	Pass
0.6610	42	17	40	Pass
0.6725	40	17	42	Pass
0.6840	36	14	38	Pass
0.6956	30	14	46	Pass
0.7071	27	13	48	Pass
0.7186	24	12	50	Pass
0.7301	21	10	47	Pass
0.7417	17	10	58	Pass
0.7532	15	9	60	Pass
0.7647	15	9	60	Pass
0.7762	14	9	64	Pass
0.7877	13	9	69	Pass
0.7993	13	7	53	Pass
0.8108	13	7	53	Pass
0.8223	13	6	46	Pass

0.8338	11	4	36	Pass
0.8453	10	4	40	Pass
0.8569	9	1	11	Pass
0.8684	9	1	11	Pass
0.8799	9	1	11	Pass
0.8914	8	0	0	Pass
0.9030	8	0	0	Pass
0.9145	8	0	0	Pass
0.9260	8	0	0	Pass
0.9375	7	0	0	Pass
0.9490	7	0	0	Pass
0.9606	7	0	0	Pass
0.9721	7	0	0	Pass
0.9836	7	0	0	Pass
0.9951	6	0	0	Pass
1.0066	6	0	0	Pass
1.0182	6	0	0	Pass
1.0297	6	0	0	Pass
1.0412	6	0	0	Pass
1.0527	6	0	0	Pass
1.0643	6	0	0	Pass
1.0758	5	0	0	Pass
1.0873	5	0	0	Pass
1.0988	5	0	0	Pass
1.1103	5	0	0	Pass
1.1219	5	0	0	Pass
1.1334	4	0	0	Pass
1.1449	4	0	0	Pass
1.1564	4	0	0	Pass
1.1679	4	0	0	Pass
1.1795	4	0	0	Pass
1.1910	4	0	0	Pass
1.2025	4	0	0	Pass
1.2140	4	0	0	Pass
1.2256	4	0	0	Pass
1.2371	4	0	0	Pass
1.2486	4	0	0	Pass
1.2601	4	0	0	Pass
1.2716	3	0	0	Pass
1.2832	3	0	0	Pass
1.2947	2	0	0	Pass
1.3062	2	0	0	Pass
1.3177	2	0	0	Pass
1.3292	2	0	0	Pass
1.3408	2	0	0	Pass
1.3523	2	0	0	Pass
1.3638	2	0	0	Pass

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.

Water Quality

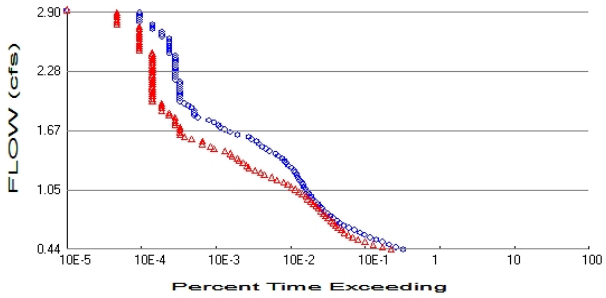
Water Quality BMP Flow and Volume for POC #1

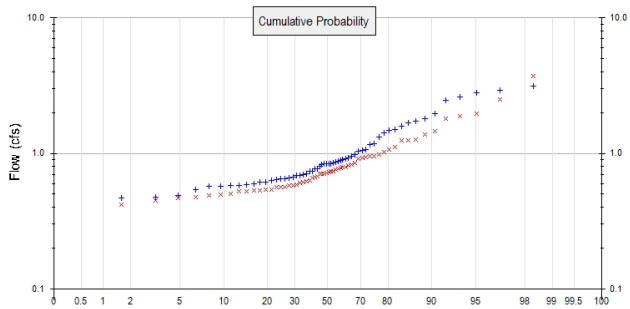
On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
West Vault POC	☐	634.36			☐	0.00			
Total Volume Infiltrated		634.36	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

POC 2





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #2
Total Pervious Area: 14.551
Total Impervious Area: 0.613

Mitigated Landuse Totals for POC #2
Total Pervious Area: 10.542
Total Impervious Area: 6.848

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	**Flow(cfs)**
2 year	0.871571
5 year	1.362886
10 year	1.764412
25 year	2.368625
50 year	2.895773
100 year	3.494827

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	**Flow(cfs)**
2 year	0.737465
5 year	1.110962
10 year	1.420248
25 year	1.891717
50 year	2.30845
100 year	2.787563

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #2

Year	**Predeveloped**	**Mitigated**
1949	1.054	0.947
1950	1.154	0.934
1951	0.771	0.609
1952	0.799	0.681
1953	0.839	0.727
1954	2.908	1.875
1955	1.074	0.920
1956	0.836	0.634
1957	1.183	0.983
1958	2.624	1.807
1959	0.741	0.588

1960	0.915	0.735
1961	3.148	3.733
1962	0.888	0.707
1963	1.471	1.256
1964	0.921	0.605
1965	0.569	0.490
1966	0.467	0.420
1967	0.832	0.759
1968	0.977	0.774
1969	2.785	2.498
1970	0.592	0.537
1971	1.042	0.824
1972	0.859	1.023
1973	0.698	0.719
1974	1.596	1.108
1975	0.902	0.790
1976	0.580	0.580
1977	0.540	0.495
1978	0.645	0.531
1979	1.718	1.387
1980	0.843	0.707
1981	0.628	0.500
1982	0.766	0.666
1983	1.316	0.908
1984	0.656	0.656
1985	0.956	0.794
1986	1.960	1.467
1987	0.869	0.844
1988	0.665	0.543
1989	0.850	0.703
1990	0.639	0.576
1991	0.689	0.566
1992	0.734	0.618
1993	0.568	0.466
1994	0.486	0.523
1995	0.645	0.561
1996	1.425	0.958
1997	2.455	1.952
1998	0.708	0.735
1999	0.591	0.475
2000	0.687	0.776
2001	0.276	0.359
2002	0.615	0.526
2003	0.476	0.451
2004	0.827	0.812
2005	0.615	0.535
2006	1.792	1.249
2007	1.490	1.066
2008	1.685	1.264
2009	0.577	0.559

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	3.1479	3.7334
2	2.9084	2.4978
3	2.7849	1.9525
4	2.6240	1.8753

5	2.4548	1.8066
6	1.9601	1.4666
7	1.7924	1.3868
8	1.7177	1.2636
9	1.6847	1.2558
10	1.5956	1.2488
11	1.4904	1.1081
12	1.4714	1.0661
13	1.4247	1.0232
14	1.3156	0.9827
15	1.1827	0.9585
16	1.1543	0.9469
17	1.0742	0.9342
18	1.0537	0.9195
19	1.0421	0.9085
20	0.9769	0.8438
21	0.9561	0.8245
22	0.9206	0.8124
23	0.9151	0.7942
24	0.9015	0.7897
25	0.8882	0.7756
26	0.8691	0.7744
27	0.8588	0.7586
28	0.8503	0.7354
29	0.8427	0.7352
30	0.8389	0.7270
31	0.8355	0.7189
32	0.8317	0.7075
33	0.8275	0.7074
34	0.7994	0.7032
35	0.7715	0.6815
36	0.7659	0.6656
37	0.7410	0.6565
38	0.7335	0.6341
39	0.7079	0.6180
40	0.6980	0.6090
41	0.6888	0.6052
42	0.6866	0.5884
43	0.6653	0.5804
44	0.6564	0.5756
45	0.6451	0.5658
46	0.6449	0.5607
47	0.6394	0.5592
48	0.6279	0.5425
49	0.6154	0.5370
50	0.6147	0.5352
51	0.5925	0.5308
52	0.5913	0.5263
53	0.5796	0.5225
54	0.5775	0.4997
55	0.5694	0.4949
56	0.5681	0.4897
57	0.5396	0.4747
58	0.4859	0.4662
59	0.4763	0.4509
60	0.4673	0.4198
61	0.2757	0.3590

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.4358	6821	4738	69	Pass
0.4606	5505	3619	65	Pass
0.4855	4470	2712	60	Pass
0.5103	3604	2112	58	Pass
0.5352	2982	1691	56	Pass
0.5600	2453	1443	58	Pass
0.5849	2087	1267	60	Pass
0.6097	1797	1116	62	Pass
0.6346	1516	1007	66	Pass
0.6594	1279	919	71	Pass
0.6843	1102	853	77	Pass
0.7091	983	793	80	Pass
0.7340	888	741	83	Pass
0.7588	792	675	85	Pass
0.7837	725	622	85	Pass
0.8085	668	580	86	Pass
0.8334	602	539	89	Pass
0.8582	565	499	88	Pass
0.8831	521	469	90	Pass
0.9079	498	425	85	Pass
0.9328	453	397	87	Pass
0.9576	429	364	84	Pass
0.9824	401	341	85	Pass
1.0073	378	306	80	Pass
1.0321	361	275	76	Pass
1.0570	340	249	73	Pass
1.0818	324	219	67	Pass
1.1067	310	196	63	Pass
1.1315	300	171	57	Pass
1.1564	283	140	49	Pass
1.1812	266	119	44	Pass
1.2061	257	94	36	Pass
1.2309	245	84	34	Pass
1.2558	234	71	30	Pass
1.2806	222	59	26	Pass
1.3055	200	55	27	Pass
1.3303	187	49	26	Pass
1.3552	176	43	24	Pass
1.3800	165	41	24	Pass
1.4049	145	35	24	Pass
1.4297	133	33	24	Pass
1.4546	111	28	25	Pass
1.4794	99	20	20	Pass
1.5043	88	18	20	Pass
1.5291	81	14	17	Pass
1.5540	74	14	18	Pass
1.5788	64	10	15	Pass
1.6037	58	8	13	Pass
1.6285	41	7	17	Pass
1.6534	33	7	21	Pass
1.6782	28	7	25	Pass
1.7031	24	7	29	Pass
1.7279	23	6	26	Pass

1.7527	20	6	30	Pass
1.7776	17	6	35	Pass
1.8024	12	6	50	Pass
1.8273	11	5	45	Pass
1.8521	11	5	45	Pass
1.8770	11	4	36	Pass
1.9018	10	4	40	Pass
1.9267	9	4	44	Pass
1.9515	8	4	50	Pass
1.9764	7	3	42	Pass
2.0012	7	3	42	Pass
2.0261	7	3	42	Pass
2.0509	7	3	42	Pass
2.0758	7	3	42	Pass
2.1006	7	3	42	Pass
2.1255	7	3	42	Pass
2.1503	7	3	42	Pass
2.1752	7	3	42	Pass
2.2000	6	3	50	Pass
2.2249	6	3	50	Pass
2.2497	6	3	50	Pass
2.2746	6	3	50	Pass
2.2994	6	3	50	Pass
2.3243	6	3	50	Pass
2.3491	6	3	50	Pass
2.3740	6	3	50	Pass
2.3988	6	3	50	Pass
2.4237	6	3	50	Pass
2.4485	6	3	50	Pass
2.4734	5	3	60	Pass
2.4982	5	2	40	Pass
2.5230	5	2	40	Pass
2.5479	5	2	40	Pass
2.5727	5	2	40	Pass
2.5976	5	2	40	Pass
2.6224	5	2	40	Pass
2.6473	4	2	50	Pass
2.6721	4	2	50	Pass
2.6970	4	2	50	Pass
2.7218	3	2	66	Pass
2.7467	3	2	66	Pass
2.7715	3	1	33	Pass
2.7964	2	1	50	Pass
2.8212	2	1	50	Pass
2.8461	2	1	50	Pass
2.8709	2	1	50	Pass
2.8958	2	1	50	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #2

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

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
East Vault POC	☐	1493.94			☐	0.00			
Total Volume Infiltrated		1493.94	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

```
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   Walsh Hills_Preliminary Engineering.wdm
MESSU      25   PreWalsh Hills_Preliminary Engineering.MES
           27   PreWalsh Hills_Preliminary Engineering.L61
           28   PreWalsh Hills_Preliminary Engineering.L62
           30   POCWalsh Hills_Preliminary Engineering1.dat
           31   POCWalsh Hills_Preliminary Engineering2.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      10
      PERLND      11
      PERLND      16
      IMPLND       1
      IMPLND       8
      PERLND      12
      COPY       501
      COPY       502
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        West                        MAX                    1    2   30    9
    2        East                        MAX                    1    2   31    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  502         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           ***
   10     C, Forest, Flat         1    1    1    1   27    0
   11     C, Forest, Mod          1    1    1    1   27    0
   16     C, Lawn, Flat           1    1    1    1   27    0
   12     C, Forest, Steep        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 ***
   10         0    0    1    0    0    0    0    0    0    0    0    0
   11         0    0    1    0    0    0    0    0    0    0    0    0
   16         0    0    1    0    0    0    0    0    0    0    0    0
   12         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  *********
   10         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   11         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   16         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   12         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 ***
   10         0    0    0    0    0    0    0    0    0    0    0
   11         0    0    0    0    0    0    0    0    0    0    0
   16         0    0    0    0    0    0    0    0    0    0    0
   12         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
   10              0       4.5      0.08       400      0.05       0.5     0.996
   11              0       4.5      0.08       400       0.1       0.5     0.996
   16              0       4.5      0.03       400      0.05       0.5     0.996
   12              0       4.5      0.08       400      0.15       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   10              0         0         2         2         0         0         0
   11              0         0         2         2         0         0         0
   16              0         0         2         2         0         0         0
   12              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                                  ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   10            0.2       0.5      0.35         6       0.5       0.7
   11            0.2       0.5      0.35         6       0.5       0.7
   16            0.1      0.25      0.25         6       0.5      0.25
   12            0.2       0.3      0.35         6       0.3       0.7
  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
   10              0         0         0         0       2.5         1         0
   11              0         0         0         0       2.5         1         0
   16              0         0         0         0       2.5         1         0
   12              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
    8      SIDEWALKS/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
    8         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
    8         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
    8         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
    8            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    1              0         0
    8              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    1              0         0
    8              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
West***
PERLND  10                       3.493     COPY   501     12
PERLND  10                       3.493     COPY   501     13
PERLND  11                       2.329     COPY   501     12
PERLND  11                       2.329     COPY   501     13
Offsite North***
PERLND  16                       0.481     COPY   501     12
PERLND  16                       0.481     COPY   501     13
IMPLND   1                       0.187     COPY   501     15
IMPLND   8                       0.258     COPY   501     15
East***
PERLND  10                       3.251     COPY   502     12
PERLND  10                       3.251     COPY   502     13
PERLND  11                       2.438     COPY   502     12
PERLND  11                       2.438     COPY   502     13
PERLND  12                       2.438     COPY   502     12
PERLND  12                       2.438     COPY   502     13
```

```
East Downsream***
PERLND  10                        0.3     COPY   502     12
PERLND  10                        0.3     COPY   502     13
PERLND  12                      6.124     COPY   502     12
PERLND  12                      6.124     COPY   502     13
IMPLND   1                      0.613     COPY   502     15

******Routing******
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
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     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                              ***
  END GEN-INFO
  *** Section RCHRES***

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

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  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
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><-------><-------><-------><-------><-------><-------><------->      ***
  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
  <------><------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
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***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
COPY   502 OUTPUT MEAN   1 1     48.4      WDM    502 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  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


END MASS-LINK

END RUN
```

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   Walsh Hills_Preliminary Engineering.wdm
MESSU      25   MitWalsh Hills_Preliminary Engineering.MES
           27   MitWalsh Hills_Preliminary Engineering.L61
           28   MitWalsh Hills_Preliminary Engineering.L62
           31   POCWalsh Hills_Preliminary Engineering2.dat
           30   POCWalsh Hills_Preliminary Engineering1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      16
      PERLND      17
      IMPLND       1
      IMPLND       2
      IMPLND       4
      IMPLND       8
      IMPLND       9
      PERLND      10
      PERLND      18
      PERLND      13
      RCHRES       1
      RCHRES       2
      COPY         2
      COPY       502
      COPY       602
      COPY         1
      COPY       501
      COPY       601
      DISPLY       2
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    2        East Vault                  MAX                    1    2   31    9
    1        West Vault                  MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
    2         1    1
  502         1    1
  602         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
   17     C, Lawn, Mod            1    1    1    1   27    0
   10     C, Forest, Flat         1    1    1    1   27    0
   18     C, Lawn, Steep          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
   17         0    0    1    0    0    0    0    0    0    0    0    0
   10         0    0    1    0    0    0    0    0    0    0    0    0
   18         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
   17         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   10         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   18         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
   17         0    0    0    0    0    0    0    0    0    0    0
   10         0    0    0    0    0    0    0    0    0    0    0
   18         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
   17              0       4.5      0.03       400       0.1       0.5     0.996
   10              0       4.5      0.08       400      0.05       0.5     0.996
   18              0       4.5      0.03       400      0.15       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
   17              0         0         2         2         0         0         0
   10              0         0         2         2         0         0         0
   18              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
   17            0.1      0.25      0.25         6       0.5      0.25
   10            0.2       0.5      0.35         6       0.5       0.7
```

```
  18            0.1      0.15      0.25         6       0.3      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
  17              0         0         0         0       2.5         1         0
  10              0         0         0         0       2.5         1         0
  18              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
    2      ROADS/MOD              1    1    1   27    0
    4      ROOF TOPS/FLAT         1    1    1   27    0
    8      SIDEWALKS/FLAT         1    1    1   27    0
    9      SIDEWALKS/MOD          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
    2         0    0    1    0    0    0
    4         0    0    1    0    0    0
    8         0    0    1    0    0    0
    9         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
    2         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
    8         0    0    4    0    0    0    1    9
    9         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
    2         0    0    0    0    0
    4         0    0    0    0    0
    8         0    0    0    0    0
    9         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
    2            400      0.05       0.1      0.08
    4            400      0.01       0.1       0.1
    8            400      0.01       0.1       0.1
    9            400      0.05       0.1      0.08
  END IWAT-PARM2
```

```
  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    1             0         0
    2             0         0
    4             0         0
    8             0         0
    9             0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    1             0         0
    2             0         0
    4             0         0
    8             0         0
    9             0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
West***
PERLND  16                      0.723     RCHRES   2      2
PERLND  16                      0.723     RCHRES   2      3
PERLND  17                      0.482     RCHRES   2      2
PERLND  17                      0.482     RCHRES   2      3
IMPLND   1                      0.504     RCHRES   2      5
IMPLND   2                      0.381     RCHRES   2      5
IMPLND   4                      1.096     RCHRES   2      5
IMPLND   8                      0.136     RCHRES   2      5
IMPLND   9                       0.09     RCHRES   2      5
Offsite North***
PERLND  16                      0.481     RCHRES   2      2
PERLND  16                      0.481     RCHRES   2      3
IMPLND   1                      0.187     RCHRES   2      5
IMPLND   8                      0.258     RCHRES   2      5
East***
PERLND  10                      0.379     RCHRES   1      2
PERLND  10                      0.379     RCHRES   1      3
PERLND  16                      1.675     RCHRES   1      2
PERLND  16                      1.675     RCHRES   1      3
PERLND  17                      1.306     RCHRES   1      2
PERLND  17                      1.306     RCHRES   1      3
PERLND  18                      0.758     RCHRES   1      2
PERLND  18                      0.758     RCHRES   1      3
IMPLND   1                      0.804     RCHRES   1      5
IMPLND   2                      0.894     RCHRES   1      5
IMPLND   4                      3.941     RCHRES   1      5
IMPLND   8                      0.298     RCHRES   1      5
IMPLND   9                      0.298     RCHRES   1      5
East Downstream***
PERLND  10                        0.3     COPY   502     12
PERLND  10                        0.3     COPY   602     12
PERLND  10                        0.3     COPY   502     13
PERLND  10                        0.3     COPY   602     13
PERLND  13                      6.124     COPY   502     12
PERLND  13                      6.124     COPY   602     12
PERLND  13                      6.124     COPY   502     13
PERLND  13                      6.124     COPY   602     13
IMPLND   1                      0.613     COPY   502     15
IMPLND   1                      0.613     COPY   602     15
Southwest Bypass***
PERLND  16                      0.029     COPY   501     12
PERLND  16                      0.029     COPY   601     12
PERLND  16                      0.029     COPY   501     13
PERLND  16                      0.029     COPY   601     13
```

```
PERLND  17                        0.019     COPY   501     12
PERLND  17                        0.019     COPY   601     12
PERLND  17                        0.019     COPY   501     13
PERLND  17                        0.019     COPY   601     13
IMPLND   1                         0.07     COPY   501     15
IMPLND   1                         0.07     COPY   601     15
IMPLND   2                        0.047     COPY   501     15
IMPLND   2                        0.047     COPY   601     15
IMPLND   8                        0.016     COPY   501     15
IMPLND   8                        0.016     COPY   601     15

******Routing******
PERLND  16                        0.723     COPY     1     12
PERLND  17                        0.482     COPY     1     12
IMPLND   1                        0.504     COPY     1     15
IMPLND   2                        0.381     COPY     1     15
IMPLND   4                        1.096     COPY     1     15
IMPLND   8                        0.136     COPY     1     15
IMPLND   9                         0.09     COPY     1     15
PERLND  16                        0.723     COPY     1     13
PERLND  17                        0.482     COPY     1     13
PERLND  16                        0.481     COPY     1     12
IMPLND   1                        0.187     COPY     1     15
IMPLND   8                        0.258     COPY     1     15
PERLND  16                        0.481     COPY     1     13
PERLND  10                        0.379     COPY     2     12
PERLND  16                        1.675     COPY     2     12
PERLND  17                        1.306     COPY     2     12
PERLND  18                        0.758     COPY     2     12
IMPLND   1                        0.804     COPY     2     15
IMPLND   2                        0.894     COPY     2     15
IMPLND   4                        3.941     COPY     2     15
IMPLND   8                        0.298     COPY     2     15
IMPLND   9                        0.298     COPY     2     15
PERLND  10                        0.379     COPY     2     13
PERLND  16                        1.675     COPY     2     13
PERLND  17                        1.306     COPY     2     13
PERLND  18                        0.758     COPY     2     13
RCHRES   2                            1     COPY   501     16
RCHRES   1                            1     COPY   502     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     INPUT  TIMSER 1
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     East Vault              1    1    1    1   28    0    1
    2     West Vault              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
    2         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
    2         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
    2        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      0.03       0.0       0.0       0.5       0.0
    2              2      0.02       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
    2            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      2
   91    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.093664  0.000000  0.000000
  0.080000  0.093664  0.007493  0.036310
  0.160000  0.093664  0.014986  0.051350
  0.240000  0.093664  0.022479  0.062890
  0.320000  0.093664  0.029972  0.072619
  0.400000  0.093664  0.037466  0.081191
  0.480000  0.093664  0.044959  0.088940
  0.560000  0.093664  0.052452  0.096066
  0.640000  0.093664  0.059945  0.102699
  0.720000  0.093664  0.067438  0.108929
  0.800000  0.093664  0.074931  0.114821
  0.880000  0.093664  0.082424  0.120426
  0.960000  0.093664  0.089917  0.125780
  1.040000  0.093664  0.097410  0.130916
  1.120000  0.093664  0.104904  0.135858
  1.200000  0.093664  0.112397  0.140627
  1.280000  0.093664  0.119890  0.145239
  1.360000  0.093664  0.127383  0.149709
  1.440000  0.093664  0.134876  0.154049
  1.520000  0.093664  0.142369  0.158270
  1.600000  0.093664  0.149862  0.162382
  1.680000  0.093664  0.157355  0.166392
  1.760000  0.093664  0.164848  0.170307
  1.840000  0.093664  0.172342  0.174135
  1.920000  0.093664  0.179835  0.177880
  2.000000  0.093664  0.187328  0.181548
  2.080000  0.093664  0.194821  0.185144
  2.160000  0.093664  0.202314  0.188671
  2.240000  0.093664  0.209807  0.192133
  2.320000  0.093664  0.217300  0.195534
```

```
2.400000  0.093664  0.224793  0.198876
2.480000  0.093664  0.232287  0.202164
2.560000  0.093664  0.239780  0.205398
2.640000  0.093664  0.247273  0.208583
2.720000  0.093664  0.254766  0.211720
2.800000  0.093664  0.262259  0.214811
2.880000  0.093664  0.269752  0.217858
2.960000  0.093664  0.277245  0.220863
3.040000  0.093664  0.284738  0.223828
3.120000  0.093664  0.292231  0.245328
3.200000  0.093664  0.299725  0.271177
3.280000  0.093664  0.307218  0.288219
3.360000  0.093664  0.314711  0.302285
3.440000  0.093664  0.322204  0.314683
3.520000  0.093664  0.329697  0.325971
3.600000  0.093664  0.337190  0.336446
3.680000  0.093664  0.344683  0.346291
3.760000  0.093664  0.352176  0.355629
3.840000  0.093664  0.359669  0.364546
3.920000  0.093664  0.367163  0.373103
4.000000  0.093664  0.374656  0.381350
4.080000  0.093664  0.382149  0.389325
4.160000  0.093664  0.389642  0.397058
4.240000  0.093664  0.397135  0.404573
4.320000  0.093664  0.404628  0.411893
4.400000  0.093664  0.412121  0.419033
4.480000  0.093664  0.419614  0.426009
4.560000  0.093664  0.427107  0.432833
4.640000  0.093664  0.434601  0.439517
4.720000  0.093664  0.442094  0.446071
4.800000  0.093664  0.449587  0.452503
4.880000  0.093664  0.457080  0.458820
4.960000  0.093664  0.464573  0.465029
5.040000  0.093664  0.472066  0.471137
5.120000  0.093664  0.479559  0.477150
5.200000  0.093664  0.487052  0.483071
5.280000  0.093664  0.494545  0.488905
5.360000  0.093664  0.502039  0.494658
5.440000  0.093664  0.509532  0.500332
5.520000  0.093664  0.517025  0.505931
5.600000  0.093664  0.524518  0.511459
5.680000  0.093664  0.532011  0.516917
5.760000  0.093664  0.539504  0.522310
5.840000  0.093664  0.546997  0.527640
5.920000  0.093664  0.554490  0.532909
6.000000  0.093664  0.561983  0.538119
6.080000  0.093664  0.569477  0.543272
6.160000  0.093664  0.576970  0.548371
6.240000  0.093664  0.584463  0.553417
6.320000  0.093664  0.591956  0.558412
6.400000  0.093664  0.599449  0.563358
6.480000  0.093664  0.606942  0.568257
6.560000  0.093664  0.614435  0.573108
6.640000  0.093664  0.621928  0.577916
6.720000  0.093664  0.629421  0.627710
6.800000  0.093664  0.636915  1.089578
6.880000  0.093664  0.644408  1.795468
6.960000  0.093664  0.651901  2.646048
7.040000  0.093664  0.659394  3.560014
7.120000  0.093664  0.666887  4.454104
7.200000  0.093664  0.674380  5.249503
END FTABLE  2
FTABLE      1
 92    4
   Depth      Area    Volume  Outflow1 Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
0.000000  0.300826  0.000000  0.000000
0.144444  0.300826  0.043453  0.037232
0.288889  0.300826  0.086905  0.052654
0.433333  0.300826  0.130358  0.064488
```

0.577778	0.300826	0.173811	0.074464
0.722222	0.300826	0.217264	0.083253
0.866667	0.300826	0.260716	0.091199
1.011111	0.300826	0.304169	0.098507
1.155556	0.300826	0.347622	0.105308
1.300000	0.300826	0.391074	0.111696
1.444444	0.300826	0.434527	0.117738
1.588889	0.300826	0.477980	0.123485
1.733333	0.300826	0.521433	0.128975
1.877778	0.300826	0.564885	0.134242
2.022222	0.300826	0.608338	0.139309
2.166667	0.300826	0.651791	0.144199
2.311111	0.300826	0.695243	0.148928
2.455556	0.300826	0.738696	0.153511
2.600000	0.300826	0.782149	0.157962
2.744444	0.300826	0.825601	0.162291
2.888889	0.300826	0.869054	0.166507
3.033333	0.300826	0.912507	0.170618
3.177778	0.300826	0.955960	0.174634
3.322222	0.300826	0.999412	0.178558
3.466667	0.300826	1.042865	0.182399
3.611111	0.300826	1.086318	0.186160
3.755556	0.300826	1.129770	0.189847
3.900000	0.300826	1.173223	0.193463
4.044444	0.300826	1.216676	0.197013
4.188889	0.300826	1.260129	0.200500
4.333333	0.300826	1.303581	0.203928
4.477778	0.300826	1.347034	0.207299
4.622222	0.300826	1.390487	0.210616
4.766667	0.300826	1.433939	0.213882
4.911111	0.300826	1.477392	0.217098
5.055556	0.300826	1.520845	0.220267
5.200000	0.300826	1.564298	0.223392
5.344444	0.300826	1.607750	0.226473
5.488889	0.300826	1.651203	0.229513
5.633333	0.300826	1.694656	0.232514
5.777778	0.300826	1.738108	0.235476
5.922222	0.300826	1.781561	0.238401
6.066667	0.300826	1.825014	0.241291
6.211111	0.300826	1.868466	0.244147
6.355556	0.300826	1.911919	0.246969
6.500000	0.300826	1.955372	0.249760
6.644444	0.300826	1.998825	0.252520
6.788889	0.300826	2.042277	0.282341
6.933333	0.300826	2.085730	0.316773
7.077778	0.300826	2.129183	0.339277
7.222222	0.300826	2.172635	0.357675
7.366667	0.300826	2.216088	0.373772
7.511111	0.300826	2.259541	0.388336
7.655556	0.300826	2.302994	0.401785
7.800000	0.300826	2.346446	0.414371
7.944444	0.300826	2.389899	0.426263
8.088889	0.300826	2.433352	0.437582
8.233333	0.300826	2.476804	0.448414
8.377778	0.300826	2.520257	0.458826
8.522222	0.300826	2.563710	0.468871
8.666667	0.300826	2.607163	0.478592
8.811111	0.300826	2.650615	0.488022
8.955556	0.300826	2.694068	0.497190
9.100000	0.300826	2.737521	0.506119
9.244444	0.300826	2.780973	0.514831
9.388889	0.300826	2.824426	0.523343
9.533333	0.300826	2.867879	0.531670
9.677778	0.300826	2.911331	0.539825
9.822222	0.300826	2.954784	0.547819
9.966667	0.300826	2.998237	0.555664
10.11111	0.300826	3.041690	0.563369
10.25556	0.300826	3.085142	0.570941
10.40000	0.300826	3.128595	0.578388
10.54444	0.300826	3.172048	0.585718

```
  10.68889  0.300826  3.215500  0.592935
  10.83333  0.300826  3.258953  0.600046
  10.97778  0.300826  3.302406  0.607056
  11.12222  0.300826  3.345859  0.613969
  11.26667  0.300826  3.389311  0.620790
  11.41111  0.300826  3.432764  0.627523
  11.55556  0.300826  3.476217  0.634172
  11.70000  0.300826  3.519669  0.640739
  11.84444  0.300826  3.563122  0.647229
  11.98889  0.300826  3.606575  0.653644
  12.13333  0.300826  3.650028  0.659986
  12.27778  0.300826  3.693480  0.666259
  12.42222  0.300826  3.736933  0.672466
  12.56667  0.300826  3.780386  0.952302
  12.71111  0.300826  3.823838  2.204298
  12.85556  0.300826  3.867291  3.826508
  13.00000  0.300826  3.910744  5.335756
  13.14444  0.300826  3.954197  6.351986
  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***
COPY     2 OUTPUT MEAN   1 1     48.4      WDM    702 FLOW     ENGL      REPL
COPY   502 OUTPUT MEAN   1 1     48.4      WDM    802 FLOW     ENGL      REPL
COPY   602 OUTPUT MEAN   1 1     48.4      WDM    902 FLOW     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
RCHRES   2 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1002 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1003 STAG     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

WATER QUALITY DETAILS

Water quality details will be provided with final engineering.

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APPENDIX D

CONVEYANCE CALCULATIONS

Conveyance calculations will be provided with final engineering.

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APPENDIX E

OPERATION AND MAINTENANCE MANUAL

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

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

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.

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. Any holes - other than designed holes - in the structure.	designed. Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing. Gate cannot be moved up and down by one maintenance person. Chain/rod leading to gate is missing or damaged. Gate is rusted over 50% of its surface area.	Gate is watertight and works as designed. Gate moves up and down easily and is watertight. Chain is in place and works as designed. 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
	Bars.	Bars are missing or entire barrier missing. Bars are loose and rust is causing 50% deterioration to any part of barrier.	inch. Bars in place according to design. 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(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(12) Maintenance Standards - Wetvaults (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Frame and/or Top Slab	inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
	Access Ladder Damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned. Confined space warning sign missing.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.

Table V-4.5.2(15) Maintenance Standards - Manufactured Media Filters

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault	Sediment Accu-	Sediment depth exceeds 0.25-inches.	No sediment depos-

Table V-4.5.2(15) Maintenance Standards - Manufactured Media Filters (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	mulation on Media.		its which would impede permeability of the compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.

Table V-4.5.2(15) Maintenance Standards - Manufactured Media Filters (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and mis-aligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
Below Ground Cartridge Type	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

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.

Table V-4.5.2(19) Maintenance Standards - Media Filter Drain (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/-flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation to not impede flow. Mow grass to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach	If possible, trim back overhanging limbs and remove

Table V-4.5.2(19) Maintenance Standards - Media Filter Drain (MFD) (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
		embankment.	brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint				
Earthen side slopes and berms	B, S		Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes	• Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				depth), temporary erosion control measures should be put in place until permanent repairs can be made. • Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3	Restore to design height

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			inches (relative to undisturbed sections of berm)	
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to extent that infiltration rate is	• Remove excess sediment • Replace any vegetation damaged or

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			reduced (see "Ponded water") or surface storage capacity significantly impacted	destroyed by sediment accumulation and removal • Mulch newly planted vegetation • Identify and control the sediment source (if feasible) • If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	A		Grade board or top of weir damaged or not level	Restore to level position
Ponded water	B, S		Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1. Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2. Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3. Check for other water inputs (e.g., groundwater, illicit connections). 4. Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased. If steps #1-4 do not solve the problem,

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g., tilled). Consultation with an engineer is recommended.
Bioretention soil media	As needed		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint	• Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. • Never drive equipment or apply heavy loads in facility footprint. • Because the risk of compaction is higher during saturated soil

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. â€¢ Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. â€¢ If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the facility and away from the inlet structure	Reconfigure/ repair blocks to direct water to facility and away from structure
Curb cut inlet/outlet	M during the wet season and before severe storm	Weekly during fall leaf drop	Accumulated leaves at curb cuts	Clear leaves (particularly important for key inlets and low points along long, linear facilities)

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	is forecasted			
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace
	W		Pipe is clogged	Remove roots or debris
	A, S		Sediment, debris, trash, or mulch reducing capacity of inlet/outlet	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
		Weekly during fall leaf drop	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	Maintain access for inspections	• Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				cut or swale)
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded water"	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more	• Determine cause of poor vegetation growth and correct condition • Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jur-

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			or less than 75% survival rate).	isdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		Presence of diseased plants and plant material	• Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • See Pacific North-

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				west Plant Disease Management Handbook for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".
Trees and shrubs		All pruning seasons (timing varies by species)	Pruning as needed	• Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques • All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist
	A		Large trees and shrubs interfere with operation of the facility or access for maintenance	• Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. • Remove trees and

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				shrubs, if necessary.

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	Fall and Spring		Standing dead vegetation is present	• Remove standing dead vegetation • Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season) • If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. • Determine cause of dead vegetation and address issue, if possible • If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.
	Fall and		Planting	• When working

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	Spring		beneath mature trees	around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
	Fall and Spring		Presence of or need for stakes and guys (tree growth, maturation, and support needs)	• Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage • Monitor tree support systems: Repair and adjust as needed to

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				provide support and prevent damage to tree. • Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. • Backfill stake holes after removal.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or drive, consider relocating the plant to a more appropriate location. • Remove or transplant if continual safety hazard • Consultation with a landscape architect is recommended for removal, transplant, or substitution of

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				plants
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	Vegetation compromises conveyance	Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning)
Ornamental grasses (perennial)		Winter and Spring	Dead material from previous year's growing cycle or dead collapsed foliage	• Leave dry foliage for winter interest • Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow
Ornamental grasses (evergreen)		Fall and Spring	Dead growth present in spring	• Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				• Clean, rake, and comb grasses when they become too tall • Cut back to ground or thin every 2-3 years as needed
Noxious weeds		M (March - October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions • Apply mulch after weed removal (see "Mulch")
Weeds		M (March - October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" section for more information on IPM protocols)
Excessive vegetation		Once in early to mid- May and once in early- to mid-September	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil	• Edge or trim groundcovers and shrubs at facility edge • Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks • While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging
	As needed		Excessive vegetation density inhibits stormwater flow beyond design ponding or	• Determine whether pruning or other routine maintenance is adequate to maintain proper plant density and aesthetics

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			becomes a hazard for pedestrian and vehicular circulation and safety	• Determine if planting type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) • Remove plants that are weak, broken or not true to form; replace in-kind • Thin grass or plants impacting facility function without leaving visual holes or bare soil areas • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
	As needed		Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass	Remove vegetation and sediment buildup

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Mulch				
Mulch		Following weeding	Bare spots (without mulch cover) are present or mulch depth less than 2 inches	• Supplement mulch with hand tools to a depth of 2 to 3 inches • Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels) • Keep all mulch away from woody stems
Watering				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	Redirect sprinklers or move drip irrigation to desired areas
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		

				• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist
				• Use soaker hoses or spot water with a shower type wand when irrigation system is not present
				  ◦ Pulse water to enhance soil absorption, when feasible
				  ◦ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
				• Add a tree bag or slow-release watering device (e.g.,

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present

Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree
				• 3 to 5 gallons per shrub
				• 2 gallons water per square foot for groundcover areas
				• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist
				• Use soaker hoses or spot water with a shower type wand when irrigation system is not present
				  ◦ Pulse water to enhance soil absorption, when feasible
				  ◦ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, fol-

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				lowed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear • Water during drought conditions or more often if necessary to main-

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				tain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • To facilitate maintenance, manually remove standing water and direct to the storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered only as a temporary measure while addressing the standing water cause. If overflow to

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				a surface water will occur within 2 weeks after pesticide use, apply for coverage under the Aquatic Mosquito Control NPDES General Permit.
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.) • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				up pet waste.
Insect pests	Every site visit associated with vegetation management		Signs of pests, such as wilting leaves, chewed leaves and bark, spotting or other indicators	• Reduce hiding places for pests by removing diseased and dead plants • For infestations, follow IPM protocols (see "Additional Maintenance Resources" section for more information on IPM protocols)

Note that the inspection and routine maintenance frequencies listed above are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities".

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

IPM - Integrated Pest Management

ISA - International Society of Arboriculture

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APPENDIX F

DOWNSTREAM DRAINAGE ANALYSIS

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

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OFFSITE DRAINAGE ANALYSIS

FOR

WALSH HILLS

CITY OF SNOHOMISH, WA

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INTRODUCTION

This drainage report is provided to describe the existing stormwater conditions and proposed drainage improvements associated with the *Walsh Hills* PRD and Unit Lot Subdivision project. The project site is comprised of a single property (Snohomish County tax parcel no. 280607001-03600) with a total area of approximately 19.3 acres. The project proposes to re-develop the property site into 19 detached single-family residential lots and 94 fee-simple single-family residential lots, private tracts, and public right-of-way dedication. This report is provided to identify the applicable storm drainage standards and to summarize the analysis and design provisions proposed for the project to comply with the 2012 Department of Ecology Stormwater Management Manual for Western Washington, as amended in December 2014, as specified by the Snohomish Municipal Code (SMC), section 15.16.020.

The vicinity map provided below as Figure 1 illustrates the general location of the property. The site is located at 1705 and 1711 Terrace Avenue, Snohomish WA, 98290. More generally the site is located in a portion of the NE ¼, Section 7, Township 28 North, Range 6 East, W.M. and a portion of the NW ¼, Section 7, Township 28 North, Range 6 East, W.M. in Snohomish County, Washington. (see Vicinity Map below).

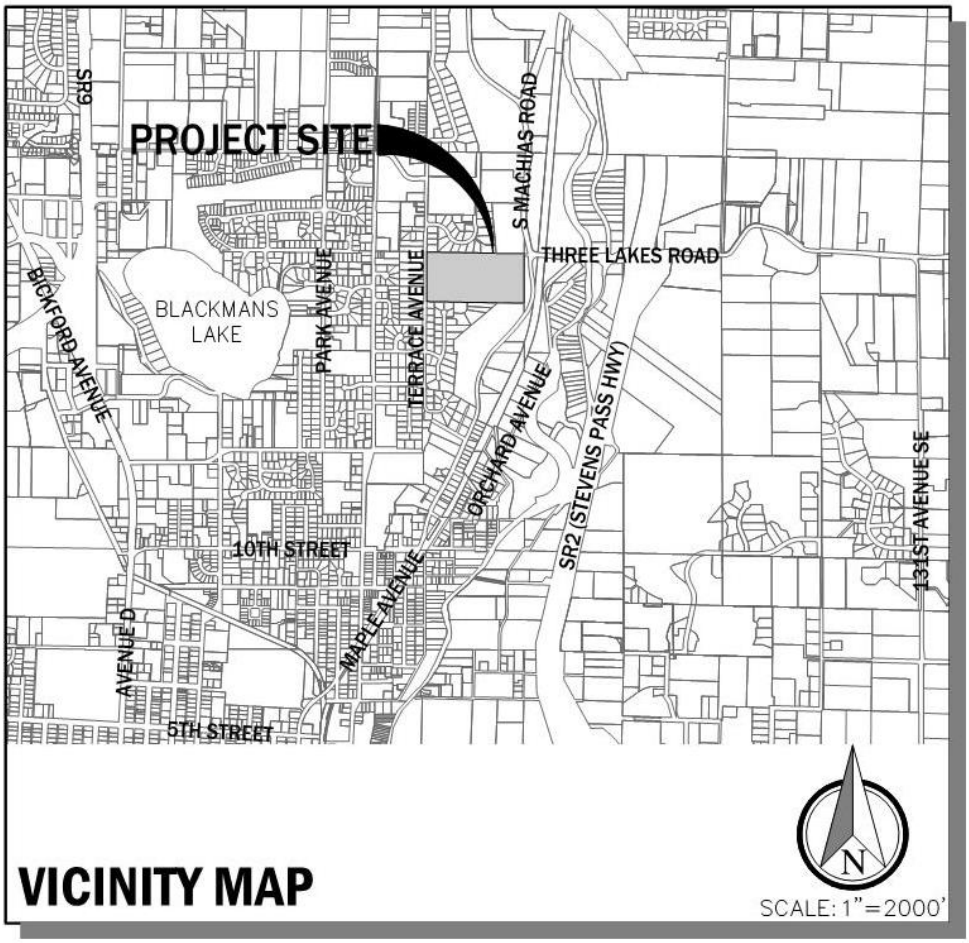


Figure 1 – Vicinity Map

TASK 1 – DEFINE AND MAP THE STUDY AREA

Existing Site Conditions

The project site is currently comprised of a single tax parcel (Snohomish County tax parcel no. 280607001-03600) totaling approximately 19.3 acres adjacent to the east side of Terrace Avenue. Steep slopes encumber the eastern limits of the site and development will be restricted to the western portion of the property. The developable area of the site slopes moderately away from a topographic high near its central region. This central area is currently occupied by a series of paved driveways and an assemblage of buildings. It contains a number of buildings supporting the Snohomish Chalet and Delta Foundation, a retirement and assisted living community. The north and east perimeters of the site are heavily forested and the western frontage has a sparse grouping of trees and open lawn areas. A number of trees of varying type, age, and health conditions exist on portions of the site. The front approximately 230 feet of the site along the east frontage of Terrace Avenue is currently zoned Single Family Residential (SF). The majority and remaining portion of the site is zoned Medium Density Residential (MD).

The site is comprised of two drainage sub-basins that flow primarily as sheet and shallow concentrated flows. The east basin flows from a ridge running through the project site north to south, to lower elevations in the east, flowing down steep slopes towards Machias Road. The west basin flows from that same ridge to lower elevations in the west, towards Terrace Avenue. Steep topography in the eastern portion of the site will be contained in a Critical Area tract and will remain undeveloped with the proposed project.

The soils of the project area are characterized generally by the Natural Resource Conservation Services (NRCS) as Tokul gravelly medial loam, 0 to 8 percent slopes and Tokul-Winston gravelly loam, 25 to 65 percent slopes.

Developed Site Conditions

The site is planned to be improved with paved public roads, storm drainage systems, and public and private utility infrastructure in support of 113 individual single-family residential lots. Primary and emergency access to the site will be provided from Terrace Avenue. Flow control for the east basin will be provided by a vault located in the southeast portion of the site, which will be conveyed east down the steep slopes with an HDPE tightline and then discharge to an existing culvert on the west side of Machias Road.

Flow control for the west basin will be provided by a vault located in the southwest portion of the site which will discharge to the proposed storm system in Terrace Avenue. This proposed public storm system continues southerly along Terrace Avenue and discharges to an existing culvert on the east side of Terrace Avenue approximately 450 feet downstream of the project site.

TASK 2 – REVIEW ALL AVAILABLE INFORMATION ON THE STUDY AREA

Snohomish County Planning and Development Services Property Report and other resources were reviewed to identify any potential sensitive areas in the proximity of the project site.

- Wetlands: Delineated wetlands and associated buffers exist onsite. No development within the wetlands or buffer is proposed.
- Streams and 100-year Floodplains: Two streams were identified by the biologist to be on-site. These streams are located within wetlands in the eastern portion of the site. The Pilchuck River and it's floodplain are located just east of the adjacent wetland along the east side of Machias Road.
- Erosion Hazard Areas: Snohomish County PDS portal shows erosion hazard areas in the eastern portion of the site.
- Landslide Hazard Areas: Snohomish County PDS portal shows steep slopes and potential landsclide hazard areas in the eastern portion of the site.
- Seismic Hazard Areas: No seismic hazard areas were identified on the project site.
- Coal Mine Hazard Areas: No coal mine hazard areas are identified on the project site.
- Critical Aquifer Recharge Area: The project site is not within a critical aquifer recharge area per Snohomish County PDS portal.

The soils of the project area are characterized generally by the Natural Resource Conservation Services (NRCS) as Tokul gravelly medial loam, 0 to 8 percent slopes and Tokul-Winston gravelly loam, 25 to 65 percent slopes. A site-specific investigation and reporting of the existing geotechnical conditions was performed by Terra Associates, Inc. (May 15, 2020; revised July 17, 2020). Copies of the geotechnical engineering report and the more general NRCS soils data are provided in Appendix A of the accompanying preliminary Stormwater Site Plan.

The City's current (2013) Stormwater Comprehensive Plan was part of the records research for the project. City staff identified two projects from this planning document that had relevance to the project and/or existing Terrace Avenue drainage systems: area C-5a, 16th Street and C-5b, Holly Vista Drive. The scope and purpose of these two project and evaluation of potential impacts of the project on each are provided Task 4 off this report.

The project completed a formal pre-application review with Snohomish County. That early review and input from the County was in preparation of the Land Disturbing Activity (LDA) permit application which will be required for the storm water discharge and drainage tight line that will collect and convey the controlled runoff from the eastern portion of the site. That pre-review produced two separate *Drainage Rehabilitation and Investigation Service Request Records* in the vicinity of the project. The most recent one of those is from 2012—nearly 8 years ago and the other was from 1997/1998. Copies of each of these are included in Appendix DS1 The issues reported for each of these is believed to have been remedied based on recent field observations, notes in the report, and the age of these complaints.

TASK 3 – FIELD INSPECT THE STUDY AREA

A field inspection was performed on October 21, 2019 on a cloudy day with a temperature of approximately 50 degrees. The conditions were wet at the time of the site visit and was actively raining during the site visit. Photos taken during the field inspection are provided in Appendix B.

Onsite Drainage Basin

The site is partially developed and has a series of paved driveways and an assemblage of buildings. It contains a number of buildings supporting the Snohomish Chalet and Delta Foundation, a retirement and assisted living community. The eastern portion of the site contains a forested area of steep slopes that will remain undeveloped with this project. There are numerous trees of various sizes, age, and species located through the property. The site contains two drainage basins created by a ridge running north and south, with high elevations near the central portion of the site. Runoff from the east basin falls generally east across the site towards the steep slopes before reaching a roadside ditch adjacent to the west side of South Machias Road. Runoff from the west basin of the site flows generally west before reaching a roadside ditch adjacent to the east side of Terrace Avenue. No catch basins, swales, or other conveyance systems were observed onsite.

Downstream Drainage Basin

The project site is comprised of two drainage sub-basin that flow primarily as sheet and shallow concentrated from the higher elevations created by the ridge running north to south, towards the lower elevations to the east and west.

Runoff from the western portion of the site reaches the roadside ditch adjacent to the east side of Terrace Avenue and flows south through sections of ditch and culverts for approximately 750 feet before eventually entering an underground system near the intersection of 16th Street and Terrace Avenue. Runoff continues in this system of culverts and underground pipes south, reaching approximately 0.25 miles downstream of the project at the intersection of 15th Street and Suncrest Drive where it is believed to enter the existing storm infrastructure along Suncrest Drive. Runoff within the storm system is conveyed southeasterly via below grade pipes to Morgantown Park where it ultimately discharges to the Pilchuck River. This general routing was confirmed with the basin and system maps provided by the City and found in the current Stormwater Comprehensive Plan.

Runoff from the eastern portion of the site flows east down the steep slope towards a section of roadside ditch adjacent to the west side of South Machias Road. That section of ditch flows south for approximately 350 feet where the ditch appears to end and runoff enters a culvert. The culvert conveys runoff east under South Machias Road. Runoff appears to enter a closed depression between the east side of South Machias Road and the Centennial Trail. Standing water was observed but it is unclear where it flowed to next.

Upstream Drainage Basin

The project is located in the upper limits of the Pilchuck River drainage basin. It contains a topographic ridge near its central region that generally drains the site east and west. There are no existing upstream drainage subbasins that would contribute runoff to the site.

TASK 4 – DESCRIBE THE DRAINAGE SYSTEM, AND ITS EXISTING AND PREDICTED DRAINAGE AND WATER QUALITY PROBLEMS

Project Drainage Systems

The proposed stormwater infrastructure for the project includes two onsite, below-grade detention vaults. These vaults have been sized to control the allowable release of stormwater from the site at or below pre-developed (i.e., forested) peak design rates. Two vaults are currently proposed to maintain the general drainage patterns which flow east and west from higher elevations near the middle of the site. Runoff from improved areas of the site will be collected by standard catch basin inlets and conveyed by below-grade pipes to one of the two onsite vaults—one in the southeast and the other in the southwest.

The east vault will safely convey discharge volumes via a mostly above-grade HDPE pipe (tight line). This tight line will outlet to a new dissipator structure. The dissipator structure will have a direct connection to the existing storm drainage system located in the west shoulder of Machias Road. A 12-inch CMP culvert conveys runoff from this existing street drainage system under Machias road, to a rock-reinforced daylight outfall. Flows from this rock pad travels is disperse and travels as shallow concentrated flow to a low point at the southeast quadrant of the Machias Road and Three Lakes Road intersection. This local low is a result of an impoundment by the embankment of the Centennial trail. There was no visible outlet from this impoundment area and it is believed, based on the elevation differential and observed water levels (or lack thereof) following notable rain events, that water seeps through the embankment which is also use to be an old rail road grade.

Runoff from the west basin will be collected and conveyed to the detention vault located in southwest portion of the site. The outlet from this west vault connects to an existing 12-inch concrete culvert approximately 440 feet south of the site. The culvert is part of the existing street drainage system along the east shoulder of Terrace Avenue that is comprised of a mixture of open ditches, culverts, and close pipes and catch basins. These collective facilities flow south within the right-of-way to a catch basin in the southwest corner of the intersection (CB 5150). Stormwater is discharged from this shallow catch basin via a 12-inch ductile iron pipe. The outfall end of this pipe was not located/observed in the field, but it is understood from the City's Stormwater Comprehensive Plan (SCP) that it daylights to an open ditch that meanders south over both public and private property.

Predicted Drainage and Water Quality Problems – West

Stormwater Comprehensive Plan (SCP) project *C-5a, 16th Street* involves the installation of new, formal storm drainage collection and conveyance facilities on both sides of 16th Street west of Terrace Avenue. Currently there are no formal drainage facilities on 16th Street. The existing storm drainage facilities located on the west side of Terrace Avenue, of which the project drains to, does not connect or outlet to 16th Street. As such, the project does not result in any change in the current runoff/drainage conditions within the 16th Street corridor.

Holly Vista Drive is an existing subdivision south of the site and immediately upstream and adjacent to Terrace Avenue. The SCP in its basis of design for project *C-5b, Holly Vista Drive* explains that this older subdivision was originally approved with roadside ditches to collect and convey runoff to other City drainage facilities. Many of these ditches have been filled in by homeowners over time resulting in ineffective stormwater controls. The *C-5b* project would install a new system of catch basins and pipe to Runoff from most of Holly Vista Drive area is collected and conveyed by some of the same reaches as the Terrace Avenue systems, including the lower segments downstream of CB 5150.

The project's drainage facilities will be designed in accordance with City surface water standards including flow control and basic water quality treatment. Additionally, the peak design runoff rates with developed conditions are significantly lower than the corresponding pre-developed (i.e., forested) design flow rates. Preliminary model results show the 2-year peak design rate for the developed condition being less than 63 percent of the pre-developed rate, and the developed 50-year peak design rate is less than 50 percent of the corresponding rate for pre-developed conditions. So, even without the City's construction of SCP project C-5b, the Walsh Hill drainage systems will provide additional mitigation for existing constraints in the downstream drainage systems.

Predicted Drainage and Water Quality Problems – East

Currently, stormwater runoff from the eastern portion of the site travels as sheet and shallow concentrated flows over a mixture of pavement and maintained landscape areas and then directly over the steep slopes that are covered by denser native vegetation. The project's drainage controls will mitigate potential runoff impacts from the project by collecting runoff from the improved areas and conveying it in a closed pipe system to a discharge beyond the toe of the steep slope. The site is also being graded to diret surface runoff from improved areas away from the top of the steep slope. This greatly reduces the amount of water draining directly onto and/or as shallow subsurface over the existing steep slope which will limit further the potential for the shallow surface slides like those that have occurred in the past.

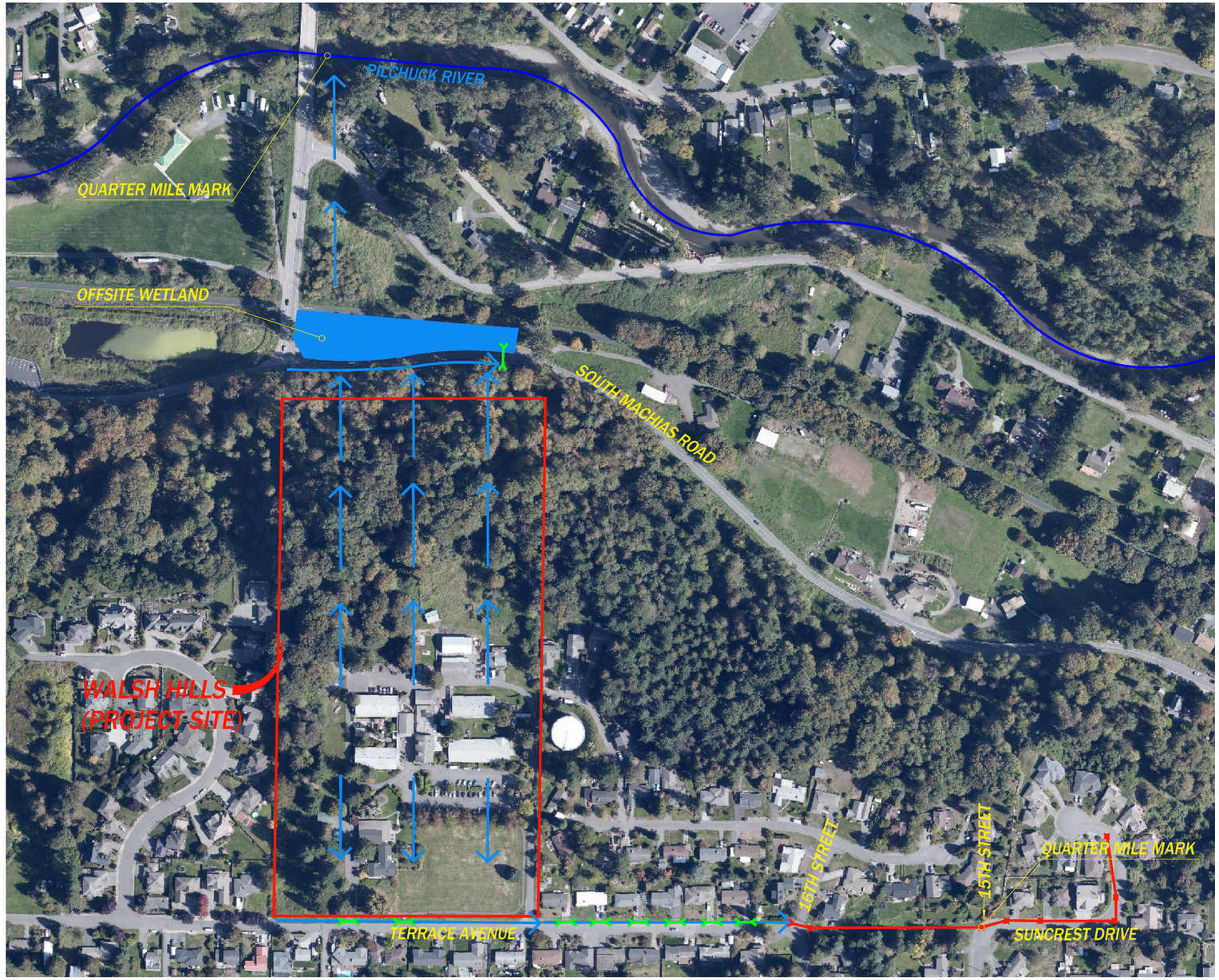
Snohomish County confirmed that there are no recent drainage complaints or known problems downstream of the east portion of the site. The two older drainage complaints (2012 and 1997) are believe to have been remedied or are conditions that no longer exist.

FIGURES

SE 1/4, NE 1/4, SEC. 17, TWP. 25 N, R. 5 E., W.M.

WALSH HILLS

CITY OF SNOHOMISH SNOHOMISH COUNTY, WASHINGTON



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Land Use Consulting • Project Management
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N

0 150 300
PLAN IN FEET

FIGURE 7 - DOWNSTREAM MAP

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APPENDIX D1

Agency Records for Existing Storm Drainage Systems

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

Improvement/Project Summary

Project:	C-5a: 16th Street	
Stakeholders:	Local Property Owners & City of Snohomish	
Location/Address:	16th St. between Pine Ave. and Terrace Ave.	
Date:	August 2013	
Problem Description:	**Photo/Map/Sketch:**	
There is no drainage system along this section of 16th St. Stormwater runoff approaches private properties along 16th St.		
City Actions and/or Analysis Process and Results:		
The City Public Works Department has received calls from citizens complaining about the stormwater accumulation along 16th St.		
Recommended Improvement:		
Construct a stromwater collection and conveyance system along 16th St. The system would consist of catch basins and a storm drain main that would connect to the roadside ditch along Pine Ave.		
Cost Estimate (see Appendix B for cost breakdown)		
Total (design, permitting, construction, tax, contingency):	**$122,000**	
Challenges, Impacts or Enhancements (Rate from 1 to 10, high scores indicate challenges/impacts on project completion. Total < 35 preferred.)		
Wetlands:	0	No impact to wetlands.
Easement Acquisition:	0	Easements are not required.
Fish/Wildlife Habitat including Water Quality:	0	Fish/wildlife habitat will not be impacted.
Construction:	5	16th St. will be partially closed during construction.
O&M:	7	Periodic pipeline and catch basin maintenance required.
Public Acceptance (based on cost, safety and property damage):	3	Community likely in favor of project.
Permitting:	2	Only construction permits required.
Overall Score	**17**	

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Improvement/Project Summary

Project:	C-5b: Holly Vista Drive	
Stakeholders:	Local Property Owners & City of Snohomish	
Location/Address:	Holly Vista Dr.	
Date:	August 2013	
Problem Description:	**Photo/Map/Sketch:**	
There is no drainage system along Holly Vista Dr. Stormwater runoff sheet flows across the roadway and onto private property.		
City Actions and/or Analysis Process and Results:		
The City Public Works Department has received calls from citizens with complaints about the stormwater flooding their property.		
Recommended Improvement:		
Construct a stromwater collection and conveyance system along Holly Vista Dr. The system would consist of catch basins and a storm drain main that would connect to an existing storm manhole located on Suncrest Dr. A detention pipe is anticipated to be needed to control flooding downstream.		
Cost Estimate (see Appendix B for cost breakdown)		
Total (design, permitting, construction, tax, contingency):	**$394,000**	
Challenges, Impacts or Enhancements (Rate from 1 to 10, high scores indicate challenges/impacts on project completion. Total < 35 preferred.)		
Wetlands:	0	No impact to wetlands.
Easement Acquisition:	0	Easements are not required.
Fish/Wildlife Habitat including Water Quality:	0	Fish/wildlife habitat will not be impacted.
Construction:	5	Holly Vista Dr. will be partially closed during construction.
O&M:	7	Periodic pipeline, catch basin, and detention pipe maintenance required.
Public Acceptance (based on cost, safety and property damage):	5	Community likely in favor of project.
Permitting:	2	Only construction permits anticipated to be required.
Overall Score	**19**	

acquisition, potential impacts to fish/wildlife habitat and water quality, constructability, operation and maintenance, perception of public acceptance, ability to obtain permits. A project summary sheet including overall score and estimated costs is included in Appendix A. Construction costs were estimated and are presented in Appendix B. Table 6-1: Proposed Drainage Improvements includes a summary for each project.

6.5.1 Area C-1: 87th Avenue SE (Sinclair Avenue)

In order to alleviate the ponding problem at the northeast corner of 87th Avenue SE and 50th Street, approximately 400 linear feet of 12- to 16-inch diameter storm drain pipeline would be installed from the outlet end of the culvert crossing 87th Avenue SE to the storm drain conveyance system along Bickford Avenue. The pipeline can be installed along the west shoulder of 87th Avenue SE. Eliminating the runoff from businesses located west of 87th Avenue SE from accessing the culvert crossing 87th Avenue SE is needed to control flooding within the ROW and to nearby private property. The access ditch would be redirected and runoff from the west properties would utilize an existing ditch that empties into the Bickford Avenue drainage system (see Figure C-1). This recommended improvement would restore the public stormwater system that historically flowed to Bickford Avenue.

6.5.2 Area C-2: Swifty Creek (at Second Street)

The repair or replacement of the existing 24-inch Swifty Creek storm drain pipeline from Second Street to a manhole located south of the intersection of First Street and Union Avenue is not feasible because a majority of the pipeline is on private property. A new pipeline within city right of way and an acquired easement could be constructed. The easement would need to be secured for approximately the first 180 to 200 linear feet of pipeline to cross one private property adjacent to Second Street. The remaining 800 linear feet or so of pipeline would be constructed along Glen and Union Avenues and crossing First and Second Streets. The lower end of the new pipeline would connect into an existing 60-inch manhole, where the existing 24-inch pipeline extends to the Snohomish River. The existing 24-inch pipeline would be plugged at the Swifty Creek end and at the existing 60-inch manhole. Approximately 4 new manholes would be installed at horizontal bends along the pipeline route (see Figure C-2). Additional catch basins would be installed along Union Avenue, between First and Second Streets, which would empty into the proposed storm drain pipeline. The additional catch basins would improve drainage along Union Avenue. Also, existing catch basins along Glen Avenue would be removed from the combined sewer system and connected into the new pipeline.

6.5.3 Area C-3: Maple Avenue (Unopened Fairview Street)

The largest contributor to the ditch overloading and subsequent overflow along the unopened section of Fairview Street is the storm drain system from the Suncrest Drive neighborhood. To remove this runoff load from the ditch, a new 12-inch storm drain pipeline would be installed to bypass the ditch and empty directly into the storm main located in Maple Avenue. The pipeline, approximately 280 linear feet, would originate at the existing receiving manhole for the Suncrest Avenue neighborhood runoff and discharge into the Maple Avenue storm main, via a new manhole. The new pipeline would be installed within the unopened gravel Fairview Street right of way (see Figure C-3).

6.5.4 Area C-4: Park Avenue/Blackmans Lake

The existing 12-inch storm drain pipeline, from the catch basin located at the southwest corner of Park Avenue and 19th Street to the Blackmans Lake inlet manhole, would be replaced with a 24-inch pipeline. The replacement pipeline would be approximately 180 feet in length. The existing catch basin and manhole would be replaced if they were determined to be undersized (see Figure C-4).

6.5.5 Area C-5: Two projects: 16th Street and Holly Vista Drive

Area C-5a: 16th Street. A stormwater collection and conveyance system would be installed along 16th Street, from Terrace Avenue to Pine Avenue. The system would consist of approximately 6 to 8 properly

located catch basins along both sides of the roadway and a 12-inch storm drain pipeline (approximately 285 feet in length) that would receive stormwater from the catch basins. The pipeline would empty into the Pine Avenue roadway ditch (see Figure C-5a).

Area C-5b: Holly Vista Drive. The drainage improvements associated with Holly Vista Drive can be divided into three sections:

- Holly Vista Drive (north of 16th Street) and 16th Street (between Terrace Avenue and Holly Vista Drive),
- Holly Vista Drive (south of 16th Street), and
- Unopened Terrace Avenue (from 15th Street/Suncrest Drive to 16th Street)

Improvements along Holly Vista Drive north and 16th Street would involve constructing a 12- to 18-inch storm drain pipeline along the west shoulder of Holly Vista Drive. This pipeline section would be approximately 550 feet in length. The pipeline would turn west on 16th street and extend approximately 75 feet to an existing manhole at Terrace Avenue. Approximately 9 to 12 catch basins and 2 to 3 storm manholes would be installed. Stormwater collected in the new system would flow through a series of existing ditches and pipes to the proposed stormwater improvements for the unopened Terrace Avenue.

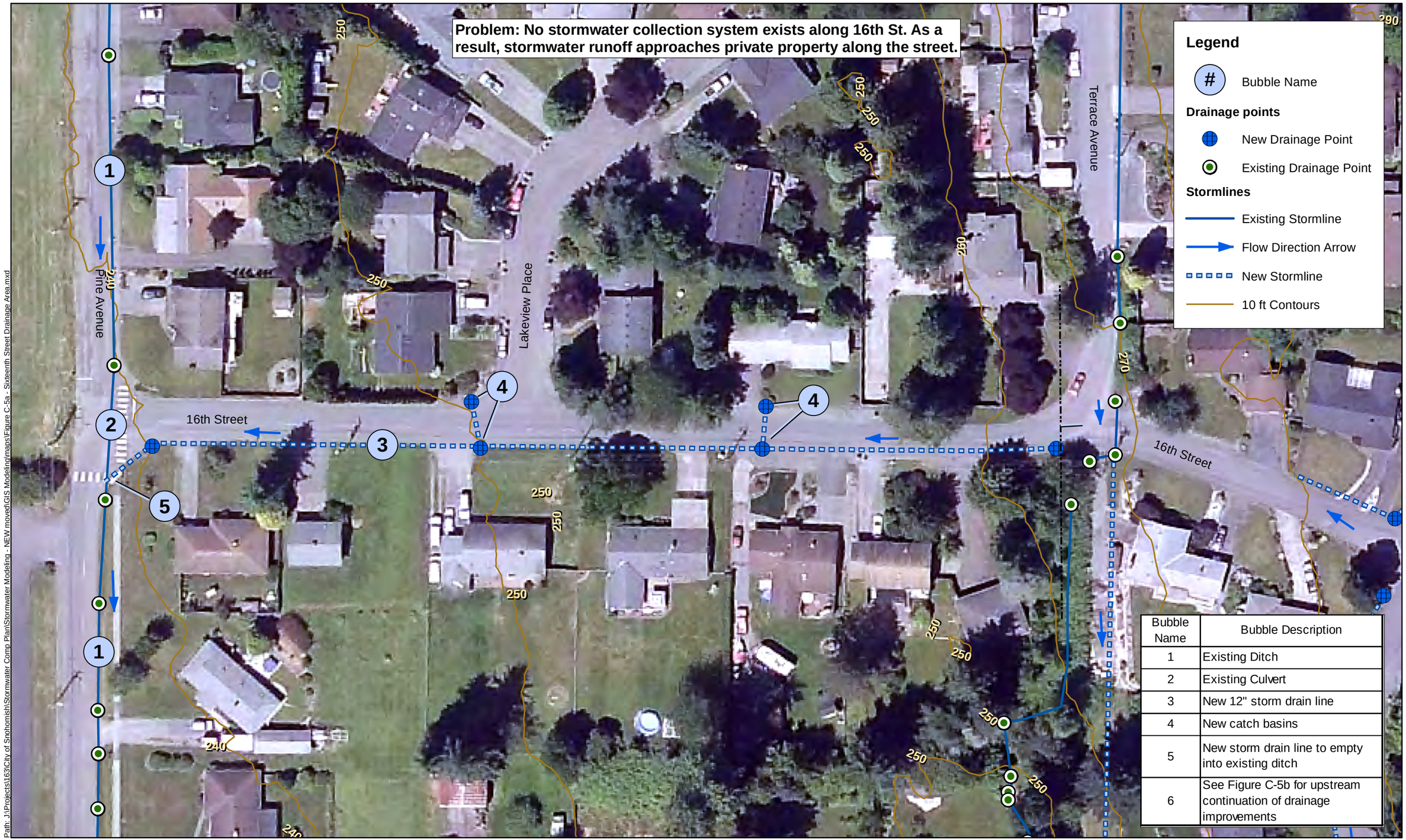
The Holly Vista Drive south improvement section would involve constructing a 12- to 18-inch storm drain pipeline along the west shoulder of Holly Vista Drive for approximately 180 feet to the cul-de-sac at the south end of Holly Vista Drive. From the cul-de-sac, the pipeline would extend southwest through a platted utility easement approximately 170 feet, to an existing storm drain manhole located on Suncrest Drive. The 170-foot pipe section would be installed within an existing city easement. Approximately 4 to 6 catch basins and 2 to 3 storm drain manholes would be installed.

The improvements along the unopened section of Terrace Avenue would involve installing approximately 430 linear feet of 12- to 18-inch storm drain pipeline from an existing manhole on 16th Street to an existing storm manhole on Suncrest Drive. Prior to reaching the manhole on Suncrest Drive the storm drain pipeline would enter an approximate 8-foot diameter by 100-foot long pipe detention vault and exit the vault to the manhole. The detention vault would be needed to control the additional flow from the Holly Vista Drive area to the existing stormwater drainage system downstream of the manhole and prevent overloading of the existing system. Stormwater from this area would enter the drainage system improvements for Area C-3 (Maple Avenue Washout Area) and empty into the 12 inch stormwater main located on Maple Avenue. The Suncrest drive manhole would be same manhole utilized by the storm drain pipeline for the Holly Vista Drive south section. Also, the existing storm drain outlet for Terrace Avenue to an existing ditch extending along the unopened Terrace Avenue road section would be removed. Terrace Avenue drainage would flow through the new storm drain pipeline. The unopened Terrace Avenue section is cleared and covered with grass and weeds (see Figure C-5b).

6.5.6 Area C-6: Cypress Avenue

Three existing shallow catch basins on the north end of Cypress Avenue drain to a common catch basin located in a private road. The private catch basin is not properly maintained and plugs periodically. The proper operation of the Cypress Avenue catch basins is dependent on the private catch basin.

On the south end of Cypress Avenue, six shallow catch basins drain into the existing CSO pipeline that extends north/south along Cypress Avenue. To improve drainage and eliminate the maintenance issues associated with the three north end catch basins, replacing the catch basins with larger and deeper ones and installing new pipelines are proposed. The catch basin flows would be redirected and connected into the five catch basin system that drains into the CSO pipeline. The proposed solution is presented on Figure C-6.



Bubble Name	Bubble Description
1	Existing Ditch
2	Existing Culvert
3	New 12" storm drain line
4	New catch basins
5	New storm drain line to empty into existing ditch
6	See Figure C-5b for upstream continuation of drainage improvements

80 40 0 80 160 240 Feet

Path: J:\Projects\163\City of Snohomish\Stormwater Comp Plan\Stormwater Modeling - NEW moved\GIS Modeling\maps\Figure C-5a - Sixteenth Street Drainage Area.mxd

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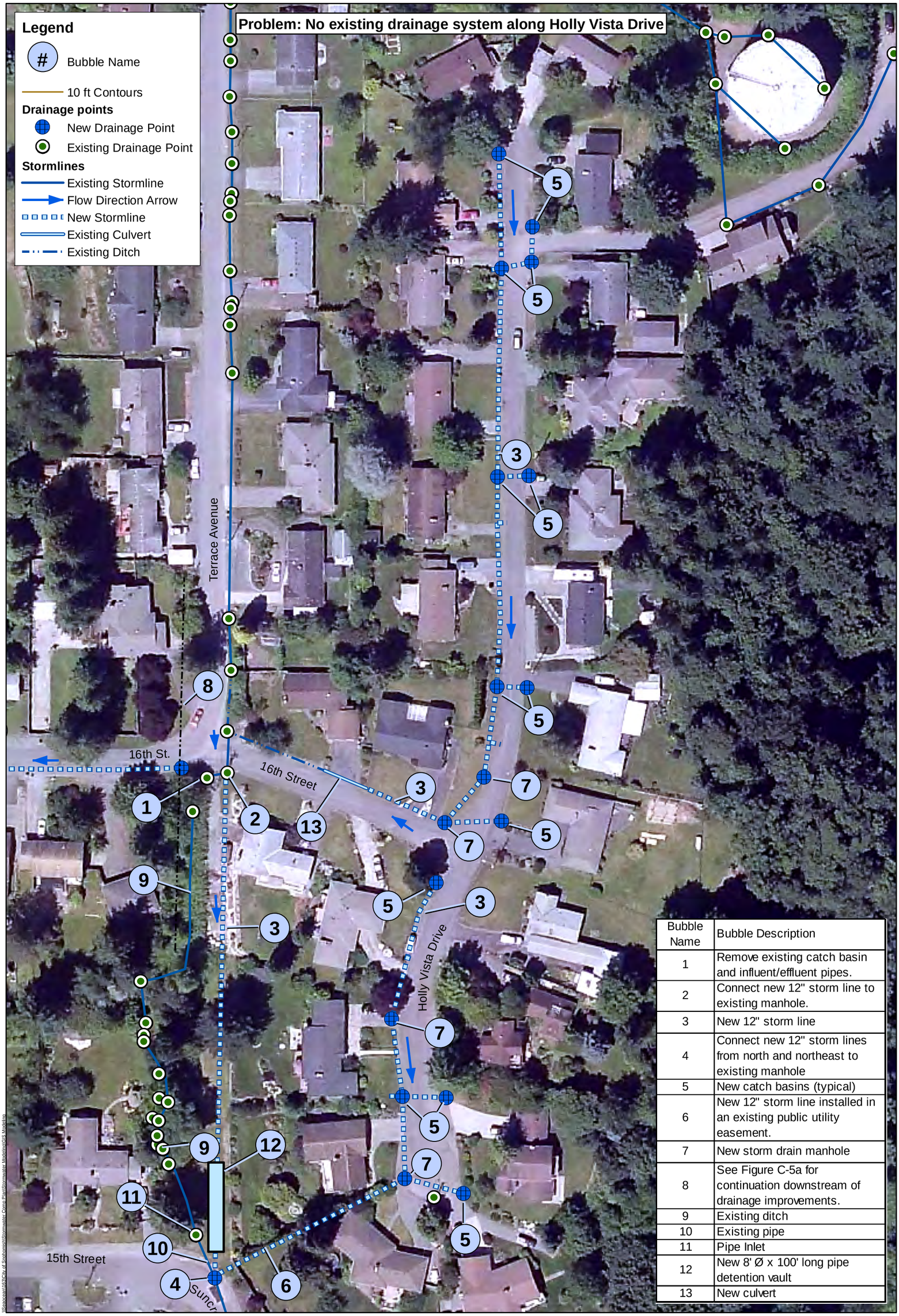
Figure C-5a

16th Street Drainage

Stormwater Comprehensive Plan

City of Snohomish



Bubble Name	Bubble Description
1	Remove existing catch basin and influent/effluent pipes.
2	Connect new 12" storm line to existing manhole.
3	New 12" storm line
4	Connect new 12" storm lines from north and northeast to existing manhole
5	New catch basins (typical)
6	New 12" storm line installed in an existing public utility easement.
7	New storm drain manhole
8	See Figure C-5a for continuation downstream of drainage improvements.
9	Existing ditch
10	Existing pipe
11	Pipe Inlet
12	New 8' Ø x 100' long pipe detention vault
13	New culvert

75 37.5 0 75 150 Feet

SNOHOMISH

Job No. 33763575

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Figure C-5b

Holly Vista Drive

Stormwater Comprehensive Plan

City of Snohomish

Drainage Rehabilitation and Investigation Service Request Record

SWM Number:	19960587	Mr Gerry Fagerlin	
First Contact Date:	12/20/1996	7101 S. Machias Rd	
Researched Date:	1/14/1997	Snohomish, WA	98290-
DRI Staff Review Date:	5/7/1997	**Completed:** 1/8/1998	

Problem (as you told us):

Drainage runs from the S. Machias Road, across his property and under the Centennial Trail, and he is concerned that our work in the area will further inundate his property. Snohomish County is repairing a slide area and drainage facitities in the 7300 block.

When the recent development of the Morgan Brothers Garden Tracts, east of the trail embankment, blocked the culvert, the water no longer drained, but flooded his property in heavy rains.

What We Found...Site Visit On: 1/28/1997 **Investigator:** Nat Washington

INVESTIGATION BY ARMY CORPS OF ENGINEERS: 1/28/97

East ditch is clogged with vines and the culvert under the trail is 3/4 full of sediment.

INVESTIGATION BY NAT WASHINGTON: 4/22/97 & 7/7/97

Runoff from the west side of South Machias Rd crosses over to the complainant's property through a 12" concrete culvert. The water flows west across open pasture in a ditch to the east toe of the road bed for the former Burlington Northern Railroad track, now an easement for the Centennial Trail maintained by the Snohomish County Parks and Recreation Department. Water is backing up at this point, and flooding the complainant's property, due to a partially plugged 36" concrete culvert that conveys the runoff to the east side of the old railroad track bed.

It is not evident that the culvert was plugged due to construction related to the recent development of the Morgan Brothers Garden Tracts.

Conclusions/Recommendations:

INVESTIGATION BY ARMY CORPS OF ENGINEERS: 1/28/97

Blocked drain is causing flooding, clean the drain under the trail, and clear the ditch on the east side of the trail. Due to the low gradient of the east ditch, siltation in the ditch and the culvert will be a chronic problem. flooding is restricted to Gerry's Field (pasture) Contact Parks for this work.

INVESTIGATION BY NAT WASHINGTON: 4/22/97 & 7/7/97

7/8/97, I contacted Marc Krandel of the Parks and Recreation Department at (425) 339-1208. He said that he was not aware of the problem, and that he would see to it that the pipe was unplugged and maintained.

Drainage Rehabilitation and Investigation Service Request Record

SWM Number:	20120256	Scot Roetcisoender	
First Contact Date:	10/30/2012	SnoCo R/M (65xx Machias Rd.)	
Researched Date:	10/30/2012	, WA	
DRI Staff Review Date:		**Completed:**	7/23/2013

Problem (as you told us):

There is a new slope drain that flows from the west to a Type II catch basin adjacent to South Machias Road. The water then flows through some 4" to 8" spalls and I am not sure where the water should go, but I am concerned that it may flow over the road. There is a cross culvert identified in the Road Maintenance inventory, but I have been unable to find it. I think the slope drain was installed by the City of Snohomish.

What We Found...Site Visit On: **Investigator:** Nathan Diaz

In 2012, the City of Snohomish installed a drainage improvement project located within Snohomish County road right-of-way near the 6500 block of South Machias Road. The project included a new slope drain from the Stone Ridge subdivision and an energy dissipation manhole. The energy dissipation manhole has a "jailhouse window" that is the outlet for the system. According to the design of construction drawings for the system, the energy dissipation manhole was to be placed a minimum of 10-feet from the edge of the asphalt road. The quarry spall splash pad and drainage ditch were to be placed a minimum of six-feet from the edge of asphalt and with a minimum depth of 12-inches.

From my observation on site, the energy dissipation manhole was placed approximately eight-feet from the edge of the asphalt road and the flowline of the roadside ditch was placed approximately 2-feet from the edge of the asphalt. During rain events, water from the system spills out dangerously close to the travel lanes of the road.

Conclusions/Recommendations:

This issue is being pursued with the City of Snohomish by Gary Millar, the Snohomish County Planning and Development Services site inspector for this project, and Own Carter, the Snohomish County Engineer.

If you have any questions or comments about this investigation feel free to contact the investigator, Nathan Diaz, at 425-388-3464, extension 4675 and reference file number 20120256.

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APPENDIX D2

PHOTOS

Site Planning
Civil Engineering
Landscape Architecture
Land Use Consulting
Project Management

Photo#1 and 2: Roadside ditch and culvert system along the western frontage of the project site, east side of Terrace Avenue.

Photo#3: Where runoff enters the closed underground drainage system near the intersection of Terrace Avenue and 16th Street.

Photo#5: Looking north, roadside ditch along the west side of Machias Road. The steep slopes of the project site are seen on the left side of the photo. Standing water was observed in the ditch.

Photo#6: The end of the roadside ditch, where flow is conveyed east under Machias Road.

Photo#7: Standing water observed in the closed depression between the east side of Machias Road and the Centennial Trail, where runoff from the project site ultimately discharges.