GEOTECHNICAL ENGINEERING REPORT

PREPARED BY:

THE RILEY GROUP, INC.
17522 BOTHELL WAY NORTHEAST
BOTHELL, WASHINGTON 98011

PREPARED FOR:

MILESTONE NORTHWEST
227 BELLEVUE WAY NORTHEAST, SUITE 183
BELLEVUE, WASHINGTON 98004

RGI PROJECT NO. 2015-088

90TH AVENUE DEVELOPMENT
4845 90TH AVENUE SOUTHEAST
MERCER ISLAND, WASHINGTON 98040

JUNE 10, 2015

RILEYGROUP

June 10, 2015

Mr. Greg Arms
Milestone Northwest
227 Bellevue Way Northeast, Suite 183
Bellevue, Washington 98004

Subject: **Geotechnical Engineering Report**
90th Avenue Development
4845 90th Avenue Southeast
Mercer Island, Washington 98040
RGI Project No. 2015-088

Dear Mr. Arms:

As requested, The Riley Group, Inc. (RGI) has prepared this Geotechnical Engineering Report (GER) for the above-referenced site. Our services were completed in accordance with our proposal PRP2015-134 dated May 29, 2015 and authorized by you on June 1, 2015. The information in this GER is based on our understanding of the proposed construction, and the soil and groundwater conditions encountered in the test pits and borings completed by RGI at the site on June 4, 2015.

RGI recommends the project plans and specifications be submitted for a general review so that RGI may confirm that the recommendations in this GER are interpreted and implemented properly in the construction documents. RGI also recommends that a representative of our firm be present on site during portions of the project construction to confirm that the soil and groundwater conditions are consistent with those that form the basis for the engineering recommendations in this GER.

If you have any questions or require additional information, please contact us.

Respectfully submitted,

THE RILEY GROUP, INC.

RICKY RUNQI WANG
STATE OF WASHINGTON
35013
REGISTERED
PROFESSIONAL ENGINEER

6/10/15

Kristina M. Weller, PE
Senior Project Engineer

Ricky R. Wang, PhD, PE
Principal Engineer

Tacoma, Washington
Phone 253.565.0552

Corporate Office
17522 Bothell Way Northeast
Bothell, Washington 98011
Phone 425.415.0551 ♦ Fax 425.415.0311

Kennewick, Washington
Phone 509.586.4840

www.riley-group.com

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Executive Summary

This Executive Summary should be used in conjunction with the entire GER for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and this GER must be read in its entirety for a comprehensive understanding of the items contained herein. Section 7.0 should be read for an understanding of limitations.

RGI's geotechnical scope of work included the advancement of four test pits and two hand auger borings to depths up to 8 feet below ground surface (bgs).

Based on the information obtained from our subsurface exploration, the site is suitable for development of the proposed project. The following geotechnical considerations were identified.

Soil Conditions: The soils encountered in the north portion of the site include 1 to 6 feet of loose to medium dense silty sand over glacial till consisting of very dense silty sand with gravel. The soils in the south portion of the site include 4 feet of organic soil including forest duff and yard debris over native soil which is medium dense silty sand and glacial till.

Groundwater: Groundwater seepage was not encountered during our field exploration.

Foundations: Foundations for the proposed buildings (A, B, and C) can be supported on conventional continuous and spread footings bearing on dense native soil or new structural fill. Foundation for building D can be supported on firm native soil after the organic debris is removed. Alternatively, the foundation for building D can be supported on deep foundations to avoid disturbance to the slope surface.

Slab-on-grade: Slab-on-grade floors for the proposed building can be supported on dense native soil or new structural fill.

Pavements: The following pavement sections are recommended for driveways:

- **Flexible** : 2 inches of AC over 6 inches of CRB over compacted subgrade
- **Concrete**: 5 inches of concrete over 4 inches of CRB over compacted subgrade

1.0 Introduction

This Geotechnical Engineering Report (GER) presents the results of the geotechnical engineering services provided for the proposed 90th Avenue Development in Mercer Island, Washington. The purpose of this GER is to assess subsurface conditions and provide geotechnical recommendations for the construction of four single-family residences. Our scope of services included field explorations, laboratory testing, engineering analyses, and preparation of this GER.

The recommendations in the following sections of this GER are based upon our current understanding of the proposed site development as outlined below. If actual features vary or changes are made, RGI should review them in order to modify our recommendations as required. In addition, RGI requests to review the site grading plan, final design drawings and specifications when available to verify that our project understanding is correct and that our recommendations have been properly interpreted and incorporated into the project design and construction.

2.0 Project Description

The site is located at 4845 90th Avenue Southeast in Mercer Island, Washington. The approximate location of the site is shown on Figure 1. The site is currently occupied by a single-family residence on the north portion of the site.

RGI understands that the client plans to demolish the existing residence and develop it into four single-family residential lots. Our understanding of the project is based on the preliminary project plans prepared by Architecture Innovations dated April 3, 2015. Based on our experience with similar construction, RGI anticipates that the proposed buildings will be supported on perimeter walls with bearing loads of 2 to 3 kips per linear foot, and a series of columns with a maximum load up to 100 kips. Slab-on-grade floor loading of 250 pounds per square foot (psf) are expected. RGI also expects that significant site grading will be needed to reach the final grades.

3.0 Field Exploration and Laboratory Testing

3.1 Field Exploration

On June 4, 2015, RGI observed the excavation of four test pits and advanced two hand auger borings. Test pits TP-1 to TP-4 were excavated with a backhoe in the northern portion of the site. Boring B-1 and B-2 was drilled with a hand auger on the slope surface in the southern portion of the site. The approximate exploration locations are shown on Figure 2.

Field logs of each exploration were prepared by the geologist who continuously observed the drilling. These logs included visual classifications of the materials encountered during drilling as well as our interpretation of the subsurface conditions between samples. The boring logs included in Appendix A represent an interpretation of the field logs and include modifications based on laboratory observation and analysis of the samples.

3.2 LABORATORY TESTING

During the field investigation, a representative portion of each recovered sample was sealed in containers and transported to our laboratory for further visual and laboratory examination. Samples retrieved from the borings were tested for moisture content to aid in soil classification and provide input for the recommendations provided in this GER. The results and descriptions of the laboratory tests are enclosed in Appendix A.

4.0 Site Conditions

4.1 SURFACE

The site is a rectangular-shaped parcel of land approximately 1.1 acres in size. The site is bound to the north and south by existing residences, to the west by Island Crest Way, and to the east by 90th Avenue Southeast.

The north portion of the site is occupied by a single-family residence. There is a ravine in the south portion of the site with steep side slopes with gradients over 50 percent. The slopes on both sides of ravine are covered by trees and other vegetation.

4.2 GEOLOGY

Review of the *Geologic Map of the Mercer Island, Washington* by Kathy G. Troost, etc, (2006) indicates that the soil in the project vicinity is mapped as Vashon till (Map Unit Qvt) and the ravine area is mapped as Advance Outwash Deposits (Map Unit Qva). Vahson till consists of dense to very dense compact diamict of silt, sand, and subrounded to well-rounded gravel glacially transported and deposited under ice and advanced outwash is dense to very dense sand and gravel deposited by meltwater streams issuing from, and subsequently overrun by an advancing ice sheet. The native soils encountered below the site appears to be generally consistent with Vashon till described in the geology map.

4.3 SOILS

The soils encountered during our field exploration include 1 to 6 feet of loose to medium dense silty sand over glacial till consisting of very dense silty sand with gravel in the north portion of the site. The soils include 4 feet of organic debris over native soil consisting of medium dense silty and very dense glacial till in the south portion of the site.

More detailed descriptions of the subsurface conditions encountered are presented in the borings are included in Appendix A. Sieve analysis was performed on one selected soil sample. The grain-size distribution curve is included in Appendix A.

4.4 GROUNDWATER

Groundwater seepage was not encountered during our field exploration to a maximum depth of 8 feet bgs.

It should be recognized that fluctuations of the groundwater table will occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the explorations were performed. In addition, perched water can develop within seams and layers contained in fill soils or higher permeability soils overlying less permeable soils following periods of heavy or prolonged precipitation.

4.5 SEISMIC CONSIDERATIONS

Based on the 2012 International Building Code (IBC), RGI recommends the follow seismic parameters in Table 1 be used for design.

Table 1 IBC Seismic Parameters

2012 IBC Parameter	Value
Site Soil Class[1]	D[2]
Site Latitude	47.55875 N
Site Longitude	122.21994 W
Maximum considered earthquake spectral response acceleration parameters (g)	S_s =1.433, S_1 =0.550
Spectral response acceleration parameters adjusted for site class (g)	S_{ms} =1.433, S_{m1} =0.825
Design spectral response acceleration parameters (g)	S_{ds} =0.956, S_{d1} =0.550

1 Note: In general accordance with the USGS *2012 International Building Code*. IBC Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.

2 Note: The *2012 International Building Code* requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope of our services does not include the required 100 foot soil profile determination. Test borings extended to a maximum depth of 8 feet, and this seismic site class definition considers that stiff soil continues below the maximum depth of the subsurface exploration.

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 from a seismic event. Liquefaction mainly affects geologically recent deposits of fine-grained sands that are below 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 reducing or eliminating the soil's strength.

RGI reviewed the results of the field and laboratory testing and assessed the potential for liquefaction of the site's soil during an earthquake. Since the site is underlain by glacial till, RGI considers that the possibility of liquefaction during an earthquake is minimal.

4.6 GEOLOGIC HAZARD AREAS

RGI reviewed the City of Mercer Island Municipal Codes (19.07.060 and 19.16). The review indicates that the site is mapped as geologic hazard area due to site topography and soil conditions. The sloped areas of the site are subject to severe erosion and potential landslides when cleared.

4.6.1 SITE RECONNAISSANCE

On June 4, 2015, RGI performed a site reconnaissance to evaluate the stability of the site slopes. During our field observations, no indications of recent landslide activity were observed. No seeps or springs were observed on the slope face. Trees with curved trucks were observed that is consistent with surficial creep. Much of the slope is heavily vegetated with mature trees and undergrowth, reducing the potential of shallow debris flow failures.

We observed that the south slope surface was covered by organic waste and yard debris. Localized hummocky terrain was observed that may be indicative of past shallow debris flow failures on the slope surface. No signs or features indicating a major landslide or deep seated slope failure were observed.

4.6.2 SLOPE STABILITY ANALYSIS

To determine the stability of the slope a Cross Sections A-A' and B-B' (Figure 3) through the ravine were produced to model the existing slope and the effects of the proposed development in lot C and D. The slope profile was produced from the Boundary and Topography Survey prepared by Eastside Consultants, Inc. dated May 28, 2015. The profiles extend from the bottom of the ravine to the top of the street. Soil parameters were estimated from *Geotechnical Properties of Geologic Materials,* by John W. Koloski, et al. (1989).

Based on our analyses, safety factors of over 1.5 and 1.15 were obtained for the existing slope against deep-seated, rotational failures after construction under static conditions and seismic condition, respectively. These safety factors met the typical requirements used in the region. Similar analyses were performed for slope stability of post construction. The safety factors for section A-A' meet standard design requirements. The safety factors for section B-B' do not meet the standard requirement of post construction. In order to meet the standard requirements, the organic debris should be removed on the south slope. The safety factors of section B-B' listed in the appendix B represent the condition that the organic debris has been removed. The detailed analyses results are included in Appendix B.

5.0 Discussion and Recommendations

5.1 Geotechnical Considerations

Based on our observations, explorations and analysis, the site is suitable for the proposed construction from a geotechnical standpoint. RGI recommends that foundations for the proposed buildings (A to C) be supported on conventional spread footings bearing on dense native soil or new structural fill if needed. Slab-on-grade floors and pavement section can be similarly supported on dense native soil or structure fill.

The organic soil in the south portion of the site cannot support building foundations and needs to be removed under structural elements. The foundation of building D can be supported on dense native soil after the organic debris is removed. Alternatively, the buildings D can be supported on piles to minimize slope disturbance. RGI also recommends that the final site grading be limited to 5 feet of fill and 12 feet of cut on the existing slopes.

Detailed recommendations regarding the above issues and other geotechnical design considerations are provided in the following sections. These recommendations should be incorporated into the final design drawings and construction specifications.

5.1.1 Erosion and Sediment Control

Potential sources or causes of erosion and sedimentation depend on construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. The impacts on erosion-prone areas can be reduced by implementing an erosion and sedimentation control plan. The plan should be designed in accordance with applicable city and/or county standards.

RGI recommends the following erosion control Best Management Practices (BMPs):

- Scheduling site preparation and grading for the drier summer and early fall months and undertaking activities that expose soil during periods of little or no rainfall
- Establishing a quarry spall construction entrance
- Installing siltation control fencing or anchored straw or coir wattles on the downhill side of work areas
- Covering soil stockpiles with anchored plastic sheeting
- Revegetating or mulching exposed soils with a minimum 3-inch thickness of straw if surfaces will be left undisturbed for more than one day during wet weather or one week in dry weather

- Directing runoff away from exposed soils and slopes
- Minimizing the length and steepness of slopes with exposed soils and cover excavation surfaces with anchored plastic sheeting (Graded and disturbed slopes should be tracked in place with the equipment running perpendicular to the slope contours so that the track marks provide a texture to help resist erosion and channeling. Some sloughing and raveling of slopes with exposed or disturbed soil should be expected.)
- Decreasing runoff velocities with check dams, straw bales or coir wattles
- Confining sediment to the project site
- Inspecting and maintaining erosion and sediment control measures frequently (The contractor should be aware that inspection and maintenance of erosion control BMPs is critical toward their satisfactory performance. Repair and/or replacement of dysfunctional erosion control elements should be anticipated.)

Permanent erosion protection should be provided by reestablishing vegetation using hydroseeding and/or landscape planting. Until the permanent erosion protection is established, site monitoring should be performed by qualified personnel to evaluate the effectiveness of the erosion control measures. Provisions for modifications to the erosion control system based on monitoring observations should be included in the erosion and sedimentation control plan.

5.1.2 STRIPPING

Stripping efforts should include removal of pavements, vegetation, organic materials, and deleterious debris from areas slated for building, pavement, and utility construction. The test pits encountered 6 to 12 inches of topsoil and rootmass in the north portion of the site. Deeper areas of stripping and excavation up to 5 feet may be required to remove the organic debris on the south portion of the site.

5.1.3 EXCAVATIONS

All temporary cut slopes associated with the site and utility excavations should be adequately inclined to prevent sloughing and collapse. The site soils consist of sandy soils. Due to the steep slopes on site, we recommend limiting temporary cuts to 12 feet in height.

Accordingly, for excavations more than 4 feet but less than 12 feet in depth, the temporary side slopes should be laid back with a minimum slope inclination of 1H:1V (Horizontal:Vertical) in loose to medium dense native soil and 3/4H:1V in glacial till. If there is insufficient room to complete the excavations in this manner, or excavations greater than 12 feet in depth are planned, using temporary shoring to support the excavations should be considered. Shoring recommendations are provided in the following section of this GER.

For open cuts at the site, RGI recommends:

- No traffic, construction equipment, stockpiles or building supplies are allowed at the top of cut slopes within a distance of at least 5 feet from the top of the cut
- Exposed soil along the slope is protected from surface erosion using waterproof tarps and/or plastic sheeting
- Construction activities are scheduled so that the length of time the temporary cut is left open is minimized
- Surface water is diverted away from the excavation
- The general condition of slopes should be observed periodically by a geotechnical engineer to confirm adequate stability and erosion control measures

In all cases, however, appropriate inclinations will depend on the actual soil and groundwater conditions encountered during earthwork. Ultimately, the site contractor must be responsible for maintaining safe excavation slopes that comply with applicable OSHA or WISHA guidelines.

5.2 SHORING RECOMMENDATIONS

RGI anticipates that excavations ranging up to 12 feet deep will be needed at the site to reach the final foundation grade for buildings C and D. Our geotechnical comments and recommendations concerning site excavations are presented below.

5.2.1 SOIL CONDITIONS

Based on our explorations, RGI anticipates that the on-site excavation will encounter primarily loose to medium dense silty sand. These soils can be readily excavated with conventional earthworking equipment, in our estimation, but extra effort will be needed if hard silt or glacial till is encountered at depth. Although our explorations did not reveal rubble within the fill soils or boulders within the native soils, such obstacles could be present at random locations within these deposits.

5.2.2 GROUNDWATER CONDITIONS

Our explorations did not encountered groundwater seepage to a depth of 8 feet bgs. Groundwater seepage is not expected if the site excavation is performed in the summer months.

5.2.3 SOLDIER PILES

In our opinion, soldier piles can be used in a cantilevered configuration for shoring the proposed excavation sidewalls at the site. The following geotechnical comments and recommendations are provided concerning soldier piles.

Soldier Pile Embedment

All soldier piles must have sufficient embedment below the final excavation level to provide adequate kick-out resistance to horizontal loads, as calculated by the design engineer. For cantilevered soldier piles, RGI recommends the embedment depth not be less than the exposed wall height or a minimum of 10 feet below the excavation base directly in front of each pile, whichever is more.

Drilling Conditions

Our subsurface explorations revealed that the site is underlain by layers of loose to very dense sands and stiff to hard silts. These soils can likely be drilled with a conventional auger, but the very dense and hard layers will undoubtedly yield slow drilling rates. Although none of our explorations encountered cobbles or boulders, it should be realized that such obstructions could exist at random locations within these deposits. Groundwater seepage should be expected at various depths throughout each borehole.

Applied Loads

All soldier piles at the subject site should be designed to resist the various lateral loads applied to them. For a temporary shoring wall, RGI expects that these lateral loads will consist of active or at-rest pressures and possibly traffic surcharge or structural surcharge pressures, depending on the specific wall location. For a shoring wall that has adequate drainage, RGI does not expect that hydrostatic pressures will need to be considered. Our recommended design pressures are presented graphically on Figure 4 and are discussed in the following paragraphs.

- Active Earth Pressures: Cantilevered walls and tied-back walls that have only one row of tiebacks can be designed using active earth pressures modeled as the equivalent fluid densities shown on Figure 4. From the backslope level to the foreslope level, these active pressures should be applied over the soldier pile spacing; below the foreslope level, the pressures need be applied over just one pile diameter.

- Structural Surcharge Pressures: Lateral earth pressures acting on the soldier piles should be increased to account for any structural loads located within a horizontal distance equal to half the wall height. If existing footings or other structural loads are found to exist within this distance, RGI should be contacted to calculate the appropriate surcharge pressures.

- Traffic Surcharge Pressures: Lateral earth pressures acting on the soldier piles should be increased to account for traffic, construction equipment, material stockpiles, or other temporary loads located within a horizontal distance equal to half the wall height. The alleyway located adjacent to the eastern site boundary will result in a traffic surcharge. For light to moderately heavy vehicles, this traffic surcharge can be modeled as a uniform lateral pressure of 75 psf acting over the upper 8 feet of wall; or heavy vehicles, such as concrete trucks, a value of 150 psf would be more appropriate.

- Hydrostatic Pressures: If groundwater is allowed to collect behind the shoring wall, a net hydrostatic pressure of 45 pcf would act against the portion of wall above the foreslope level and below the saturation level. However, if adequate drainage is provided behind the shoring wall, we expect that hydrostatic pressures will not develop.
- Resisting Forces: Lateral resistance can be computed by using an appropriate passive earth pressure acting over the embedded portion of each soldier pile, neglecting the upper 2 feet. This passive pressure should be applied over a lateral distance equal to the pile spacing or twice the pile diameter, whichever is less. For a level foreslope (measured perpendicular to the wall face), RGI recommends using a maximum allowable passive pressure modeled as an equivalent fluid density of 400 pounds per cubic foot (pcf), based on a safety factor of 1.5 or more.
- Pile Deflections: Lateral deflections for a soldier pile can be calculated from the horizontal modulus of subgrade reaction, which generally increases with depth. As a reasonable approximation, however, a uniform modulus of 250 kips per cubic foot (kcf) or 145 pounds per cubic inch (pci) can be used.

5.2.4 LAGGING

RGI recommends that lagging be installed between all adjacent soldier piles to reduce the potential for soil caving, backslope subsidence, and hazardous working conditions. Our geotechnical comments and recommendations about lagging are presented below.

Lagging Materials

In our opinion, either conventional wooden timbers or reinforced shotcrete panels could be utilized as lagging at the site, but the former would likely be much less expensive. For permanent shoring wall applications, RGI typically recommends that all wooden timber lagging be pressure-treated. However, because the on-site shoring wall serves only a temporary function, pressure-treated wooden lagging is not necessary.

Lateral Pressures

Due to soil arching effects, temporary lagging that spans 8 feet or less need be designed for only 50 percent of the lateral earth pressure previously recommended for soldier pile design. Permanent lagging, on the other hand, should be designed for 75 percent of this same lateral earth pressure. In both cases, these values assume that adequate drainage is provided behind the lagging, as discussed below.

Lagging Backfill

RGI recommends that any voids behind the lagging be backfilled with a material sufficiently pervious to allow groundwater flow and prevent a build-up of hydrostatic pressure. For this reason, permeable materials such as granular excavation spoils, clean sand, or pea gravel are suitable as backfill material, whereas silty soils, cement grout, controlled-density fill, or other less-permeable materials are not suitable.

Drainage System

RGI recommends that all lagging backfill material connect to a continuous horizontal drain located in front of the wall. This can be accomplished either by extending gravel under the lagging or by providing gaps between the lagging boards. If concrete or shotcrete walls are to be placed against wooden lagging, prefabricated vertical drainage strips (such as MiraDRAIN 6000®) should be attached to each lagging bay.

5.2.5 CONSTRUCTION MONITORING

Because shoring requires specialized installation and earthwork techniques to maintain stable conditions during and after construction, RGI strongly recommends that an RGI representative be retained to continuously monitor all construction activities. This would include observation and documentation of installation procedures, construction materials, drilling conditions, and load testing.

5.2.6 SURVEY MONITORING

A monitoring program must be implemented to verify the performance of the shoring system and possible excavation effects on neighboring buildings and existing alley. The first step in this program should consist of surveying building feature elevations and documenting the condition of the existing properties, alley and adjacent buildings. This documentation should include a photographic record. Monitoring points should be set by a licensed surveyor on the adjacent streets and structures at a maximum of 25 foot intervals with a minimum of two on each side of the excavation.

Monitoring of the shoring system should occur two times per week as the excavation proceeds and then once every two weeks once the excavation is completed. A registered land surveyor should be retained to establish the baseline data and obtain the bi-weekly readings. Monitoring data can be obtained by the project contractor. Monitoring should continue until the permanent new lower walls are adequately braced and should include surveying the vertical and horizontal alignment of the top of every other soldier pile or at 15 foot intervals on the soil nail wall. The project’s structural and geotechnical engineers should review the monitoring data weekly.

5.3 EARTHWORK

After completion of the temporary cuts or shoring and removal of the soils to subgrade elevation, the site earthwork is expected to consist of excavating foundations, installing under slab utilities and preparing the slab subgrade. The earthwork should take place in the dry season (June through September).

5.3.1 SITE PREPARATION

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to reveal firm, non-yielding, non-organic soils and backfilled with compacted structural fill. If earthwork is completed during the wet season (typically November through May) it will be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork will require additional mitigative measures beyond that which would be expected during the drier summer and fall months.

5.3.2 STRUCTURAL FILL

RGI recommends fill below the foundation and floor slab, behind retaining walls, and below pavement and hardscape surfaces be placed in accordance with the following recommendations for structural fill.

The suitability of excavated site soils and import soils for compacted structural fill use will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the U.S. No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Soils containing more than about 5 percent fines cannot be consistently compacted to a dense, non-yielding condition when the moisture content is more than 2 percent above or below optimum. Optimum moisture content is that moisture that results in the greatest compacted dry density with a specified compactive effort.

Organic debris excavated in the south portion of the site is not suitable to be used as structural fill. Non-organic site soils are only considered suitable for structural fill provided that their moisture content is within about 2 percent of the optimum moisture level as determined by ASTM D1557. Excavated site soils may not be suitable for re-use as structural fill depending on the moisture content and weather conditions at the time of construction. If soils are stockpiled for future reuse and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored.

Even during dry weather, moisture conditioning (such as, windrowing and drying) of site soils to be reused as structural fill may be required. Even during the summer, delays in grading can occur due to excessively high moisture conditions of the soils or due to precipitation. If wet weather occurs, the upper wetted portion of the site soils may need to be scarified and allowed to dry prior to further earthwork, or may need to be wasted from the site.

If on-site soils are or become unusable, it may become necessary to import clean, granular soils to complete site work that meet the grading requirements listed in Table 2 to be used as structural fill.

Table 2 Structural Fill Gradation

U.S. Sieve Size	Percent Passing
3 inches	100
No. 4 sieve	75 percent
No. 200 sieve	5 percent *

*Based on minus 3/4 inch fraction.

Prior to use, an RGI representative should observe and test all materials imported to the site for use as structural fill. Structural fill materials should be placed in uniform loose layers not exceeding 12 inches and compacted as specified in Table 3. The soil's maximum density and optimum moisture should be determined by American Society of Testing and Materials D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (ASTM D1557).

Table 3 Structural Fill Compaction ASTM D1557

Location	Material Type	Minimum Compaction Percentage	Moisture Content Range	
Foundations	On-site granular or approved imported fill soils:	95	+2	-2
Retaining Wall Backfill	On-site granular or approved imported fill soils:	92	+2	-2
Slab-on-grade	On-site granular or approved imported fill soils:	95	+2	-2
General Fill (non-structural areas)	On-site soils or approved imported fill soils:	90	+3	-2
Pavement – Subgrade and Base Course	On-site granular or approved imported fill soils:	95	+2	-2

Placement and compaction of structural fill should be observed by RGI. A representative number of in-place density tests should be performed as the fill is being placed to confirm that the recommended level of compaction is achieved.

5.3.3 WET WEATHER CONSTRUCTION CONSIDERATIONS

RGI recommends that preparation for site grading and construction include procedures intended to drain ponded water, control surface water runoff, and to collect shallow subsurface seepage zones in excavations where encountered. It will not be possible to successfully compact the subgrade or utilize on-site soils as structural fill if accumulated water is not drained prior to grading or if drainage is not controlled during construction. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use, increase the amount of select import fill materials required, and ultimately increase the cost of the earthwork phases of the project. Free water should not be allowed to pond on the subgrade soils. RGI anticipates that the use of berms and shallow drainage ditches, with sumps and pumps in utility trenches, will be required for surface water control during wet weather and/or wet site conditions.

5.4 FOUNDATIONS

5.4.1 SHALLOW FOUNDATION

Following site preparation and grading, the proposed building foundations (A to C) can be supported on conventional spread footings bearing on medium dense native soil or new structural fill. Building D may also be supported on spread footings after the surface debris being removed. The foundations (building C and D) on slope surface should be supported at least 3 feet below the existing ground surface due to the steep slopes at the site. Where loose existing fill soils or other unsuitable soils are encountered in the proposed building footprint, they should be overexcavated and backfilled with structural fill.

Table 4 Foundation Design

Design Parameter	Value
Allowable Bearing Capacity - Structural Fill Dense native soils	2,500 psf[1] 4,000 psf
Friction Coefficient	0.30
Passive pressure (equivalent fluid pressure)	250 pcf[2]
Minimum foundation dimensions	Columns: 24 inches Walls: 16 inches

1. psf = pounds per square foot
2. pcf = pounds per cubic foot

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. For short-term loads, such as wind and seismic, a 1/3 increase in this allowable capacity may be used. At perimeter locations, RGI recommends not including the upper 12 inches of soil in the computation of passive pressures because it can be affected by weather or disturbed by future grading activity. The passive pressure value assumes the foundation will be constructed neat against competent soil or backfilled with structural fill as described in Section 5.3.2. The recommended base friction and passive resistance value includes a safety factor of about 1.5.

With spread-footing foundations designed in accordance with the recommendations in this section, maximum total and differential post-construction settlements of 1 inch and 1/2 inch, respectively, should be expected.

5.4.2 PILE FOUNDATION

Driven Piles

To avoid major excavation and shoring in steep slope area, the building D may be supported on driven piles bearing on dense native soil below loose surface soil. If this option is selected, RGI recommends that a test pile be installed before construction. The test pile will provide the necessary information for pile capacity and pile depth.

RGI expects 4- to 6- inch-diameter steel pipe piles may be used for supporting the proposed building foundation. The piles should be driven to refusal in glacial till below surface debris. Based on our experience with similar projects, the pile capacities listed in Table 5 can be used for project planning and preliminary structural design. Based on the soil information, RGI expects that the pile termination depth will be from 10 feet to 15 feet. The actual pile depth will be determined in the field based on actual driving condition.

Table 5 Driven Pile Capacities (kips)

Pile Type	Pile Diameter (inches)	Compression	Uplift	Lateral*
Steel Pipe	6	30	14	3
Steel Pipe	4	20	14	2

*Lateral load assumes 1” top deflection and uplift can be achieved by the pile couplers.

Augercast Piles

As an alternative, the proposed building can be supported on augercast pile foundations. Augercast piles are constructed using a hollow stem auger advanced in the ground to a predetermined tip elevation. When the bearing depth is reached, cement grout is injected under pressure through the stem of the auger, and the auger is slowly extracted from the ground. Reinforcing steel, as required, is then set into the completed grout column. Table 6 lists recommended allowable axial and lateral capacities for the most common 12 and 18-inch diameter auger cast pile used in the area.

The soil profile was based on the soil information obtained from test boring. RGI recommends that the minimum pile depth be 15 feet bgs. The augercast piles can be designed and constructed using the following pile capacities detailed in Table 6.

Table 6 Augercast Pile Capacities (kips)

Pile Type	Pile Diameter (inches)	Compression	Uplift	Lateral*
Augercast	18	35	20	3.5
Augercast	12	20	15	2

*Lateral load assumes 1" top deflection.

Full single pile capacities can be used, provided that pile spacing is at least three pile diameters. For closer spacing, there will be a slight reduction in the allowable single pile capacity due to group effects. The amount of this reduction will depend on the number of piles in the grouping and their spacing. We can provide this information, if required. The lateral load capacity assumes 1-inch deflection on the top of the pile.

The pressure used to inject the grout and construct the pile column will compress the soils immediately adjacent to the pile. As a result, the amount of grout needed to form the pile will be greater than the computed grout volume. For estimating purposes, a volume increase of 25 percent should be used. Also, the installation sequence should be such that piles are constructed at a minimum spacing of five diameters. Once the grout has achieved its initial set, usually in 24 hours, installation between these locations can be completed.

The auger should be extracted slowly and uniformly below a sufficient and consistent head of grout. If the auger is extracted too quickly, the pile may neck down and soil may collapse into the pile, reducing its structural integrity. At an accessible and easily read location along the inject line, the piling contractor should install a pressure gauge to monitor the grout pressure during construction. The amount of grout used in forming the pile should also be determined. This can be accomplished by calibrating the grout pump and determining the volume of grout pumped per piston stroke.

5.5 RETAINING WALL

If retaining walls are needed for the basements, RGI recommends cast-in-place concrete walls be used. The magnitude of earth pressure development on retaining walls will partly depend on the quality of the wall backfill. RGI recommends placing and compacting wall backfill as structural fill. Wall drainage will be needed behind the wall face. A typical retaining wall drainage detail is shown on Figure 5 for backfilled walls and on Figure 6 for walls formed against shoring.

With wall backfill placed and compacted as recommended, and drainage properly installed, RGI recommends using the values in the following table for design.

Table 7 Retaining Wall Design

Design Parameter	Value
Allowable Bearing Capacity – Dense native soils	4,000 psf
Active Earth Pressure (unrestrained walls)	35 pcf
At-rest Earth Pressure (restrained walls)	50 pcf

For seismic design, an additional uniform load of 7 times the wall height (H) for unrestrained walls and 14H for restrained walls should be applied to the wall surface. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 5.4.

5.6 SLAB-ON-GRADE CONSTRUCTION

Once site preparation has been completed as described in Section 5.3, suitable support for slab-on-grade construction should be provided.

Immediately below the floor slab, RGI recommends placing a 4-inch-thick capillary break layer of clean, free-draining pea gravel, washed rock, or crushed rock that has less than 5 percent passing the U.S. 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. Where moisture by vapor transmission is undesirable, an 8- to 10-millimeter-thick plastic membrane should be placed on a 4-inch-thick layer of clean gravel or rock. For the anticipated floor slab loading, we estimate post-construction floor settlements of ¼- to ½-inch.

5.7 DRAINAGE

5.7.1 SURFACE

Final exterior grades should promote free and positive drainage away from the building area. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building area. For non-pavement locations, RGI recommends providing a minimum drainage gradient of 3 percent for a minimum distance of 10 feet from the building perimeter. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structure.

5.7.2 Subsurface

RGI recommends installing perimeter foundation or retaining wall drains, details shown on Figures 5, 6 and 7. The foundation or retaining wall drains and roof downspouts should be tightlined separately to an approved discharge facility. Subsurface drains must be laid with a gradient sufficient to promote positive flow to a controlled point of approved discharge.

5.8 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) specifications. For site utilities located within the right-of-ways, bedding and backfill should be completed in accordance with City of Mercer Island specifications. At a minimum, trench backfill should be placed and compacted as structural fill, as described in Section 5.3.2. Where utilities occur below unimproved areas, the degree of compaction can be reduced to a minimum of 90 percent of the soil's maximum density as determined by ASTM D1557. The onsite excavated soil may be suitable for re-use as structural fill depending on time of the construction. If the construction occurs in winter, imported structural fill may be required for trench backfill as recommended Table 2.

5.9 Pavements

Pavement subgrades should be prepared as described in Section 5.3 of this GER and as discussed below. Regardless of the relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. This condition should be verified by proofrolling with heavy construction equipment or hand probe by inspector.

With the pavement subgrade prepared as described above, RGI recommends the following pavement sections for parking and drive areas paved with flexible asphalt concrete surfacing.

- **For driveway areas**: 2 inches of asphalt concrete (AC) over 6 inches of crushed rock base (CRB) over compacted subgrade

The asphalt paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for Hot Mix Asphalt Class 1/2 inch and CRB surfacing. If concrete drive way is preferred, the following section can be used.

- **For driveway area**: 5 inches of concrete over 4 inches of CRB over compacted subgrade

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability.

For optimum pavement performance, surface drainage gradients of no less than two percent are recommended. Also, 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.

6.0 Additional Services

RGI is available to provide further geotechnical consultation throughout the design phase of the project. RGI should review the final design and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and incorporated into project design and construction.

RGI is also available to provide geotechnical engineering and construction monitoring services during construction. The integrity of the earthwork and construction depends on proper site preparation and procedures. In addition, engineering decisions may arise in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this scope of work. If these services are desired, please let us know and we will prepare a proposal.

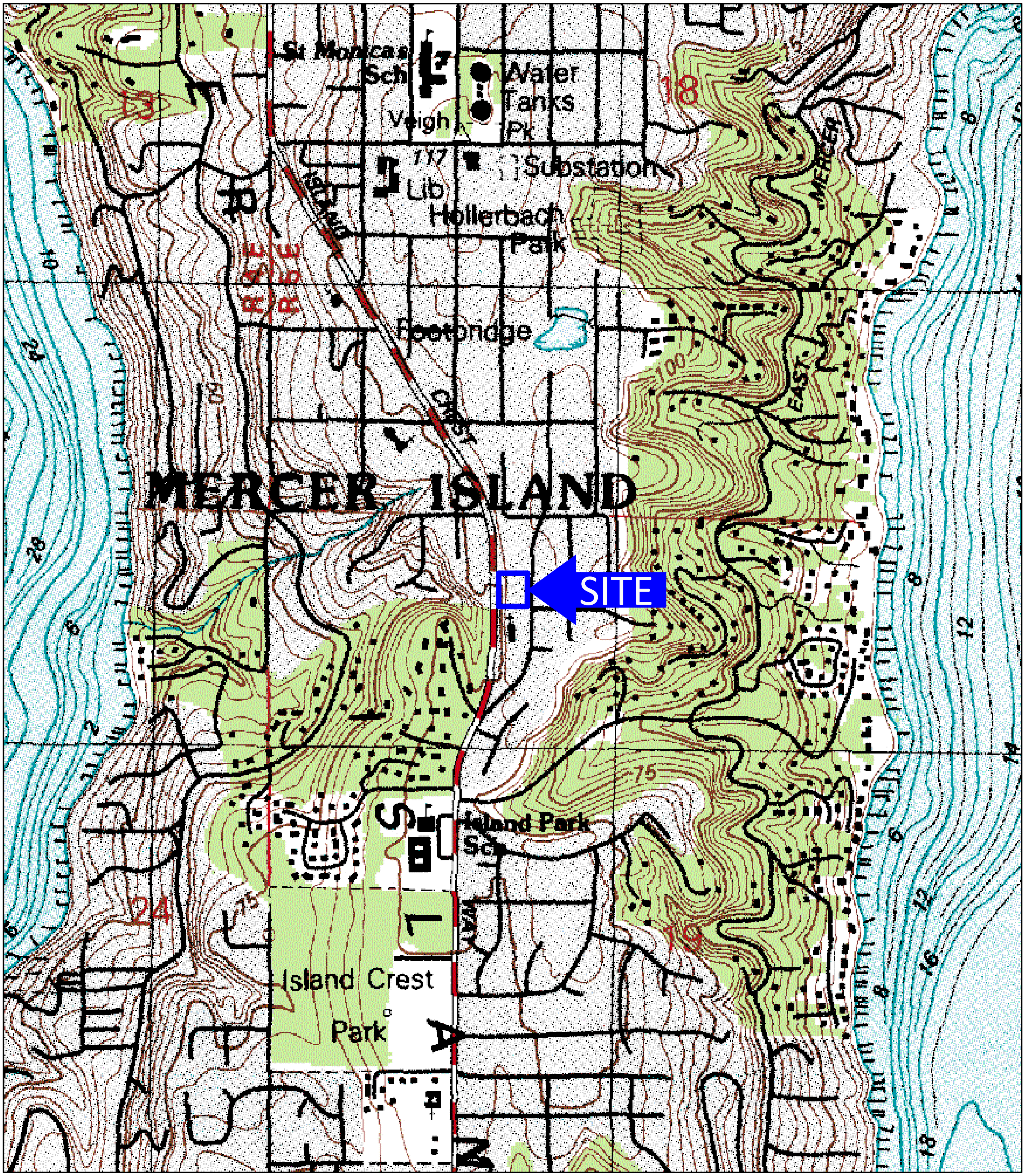
7.0 Limitations

This GER is the property of RGI, Milestone Northwest, and their designated agents. Within the limits of the scope and budget, this GER was prepared in accordance with generally accepted geotechnical engineering practices in the area at the time this report was issued. This GER is intended for specific application to the 90th Avenue Development project at 4845 90th Avenue Southeast in Mercer Island, Washington, and for the exclusive use of Milestone Northwest and their authorized representatives. No other warranty, expressed or implied, is made. Site safety, excavation support, and dewatering requirements are the responsibility of others.

The scope of services for this project does not include either specifically or by implication any environmental or biological (for example, mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, we can provide a proposal for these services.

The analyses and recommendations presented in this GER are based upon data obtained from the test exploration performed on site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, RGI should be requested to reevaluate the recommendations in this GER prior to proceeding with construction.

It is client's responsibility to see that all parties to the project, including the designers, contractors, subcontractors, are made aware of this GER in its entirety. The use of information contained in this GER for bidding purposes should be done at the contractor's option and risk.



USGS, 1983, Bellevue South, Washington
7.5-Minute Quadrangle

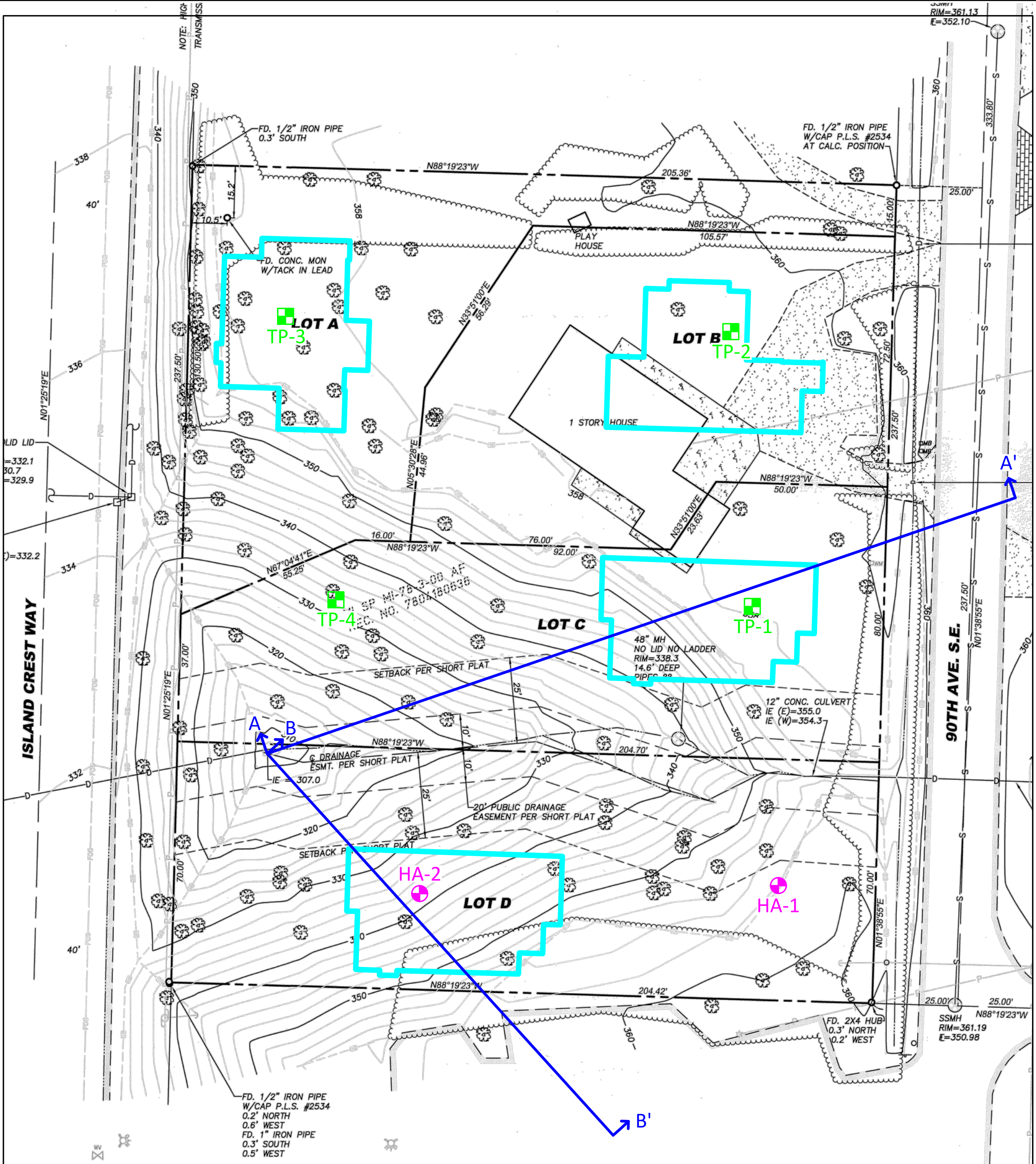
Approximate Scale: 1"=1000'

0 500 1000 2000

N

RILEYGROUP
Corporate Office
17522 Bothell Way Northeast
Bothell, Washington 98011
Phone: 425.415.0551
Fax: 425.415.0311

90th Avenue Development		Figure 1
RGI Project Number 2015-088	Site Vicinity Map	Date Drawn: 06/2015
Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040		



= Cross Section

= Test Pit Location by RGI on 06/04/15

= Hand Auger Location by RGI on 06/04/15

= (in light blue) Proposed Building Location

Drawn from Eastside Consultants, Inc., Boundary & Topography Survey, 05/2015.

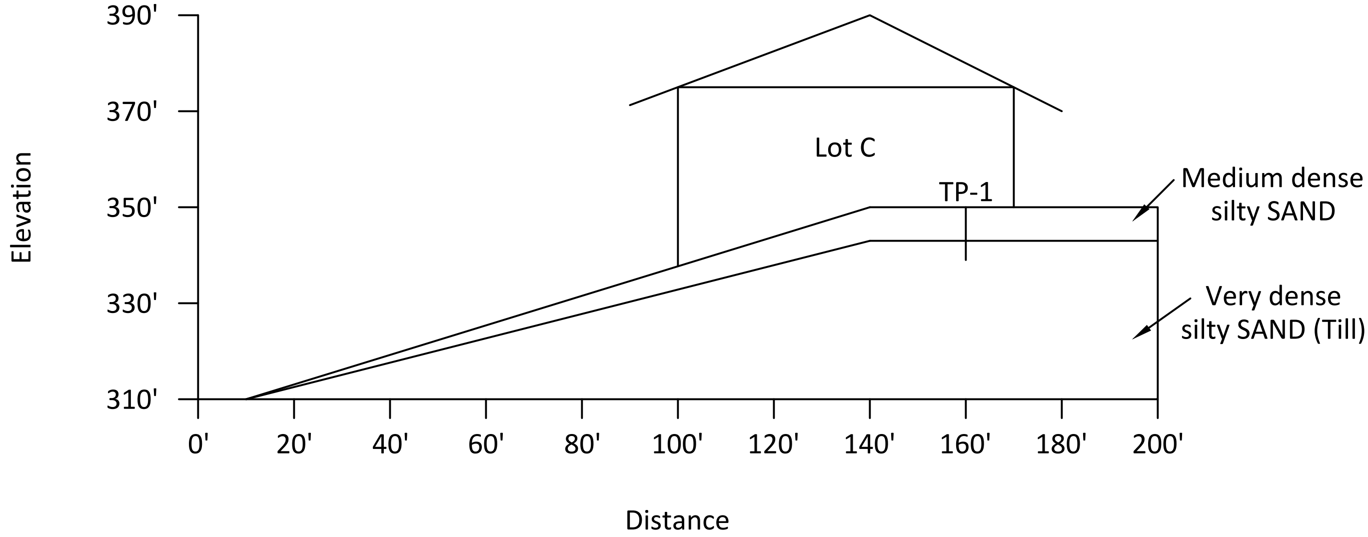
Approximate Scale: 1"=40'

0 20 40 80

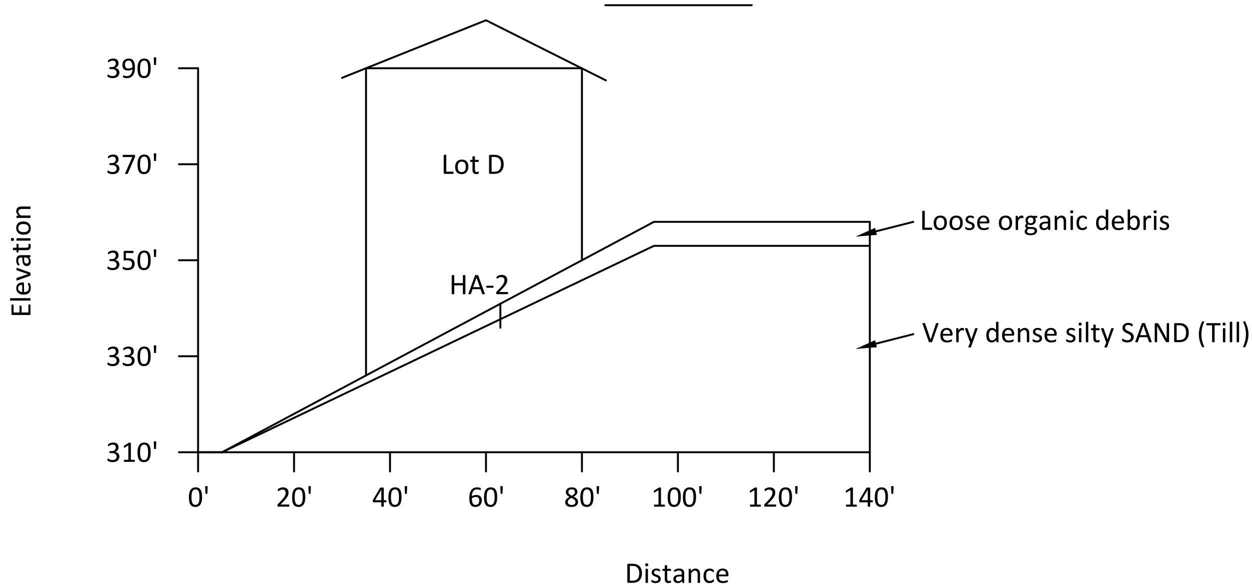
N

Corporate Office 17522 Bothell Way Northeast Bothell, Washington 98011 Phone: 425.415.0551 Fax: 425.415.0311	90th Avenue Development	Figure 2
	RGI Project Number 2015-088 — Geotechnical Exploration Plan	Date Drawn: 06/2015
	Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040	

Section A-A'



Section B-B'



Approximate Scale: 1"=40'

0 20 40 80

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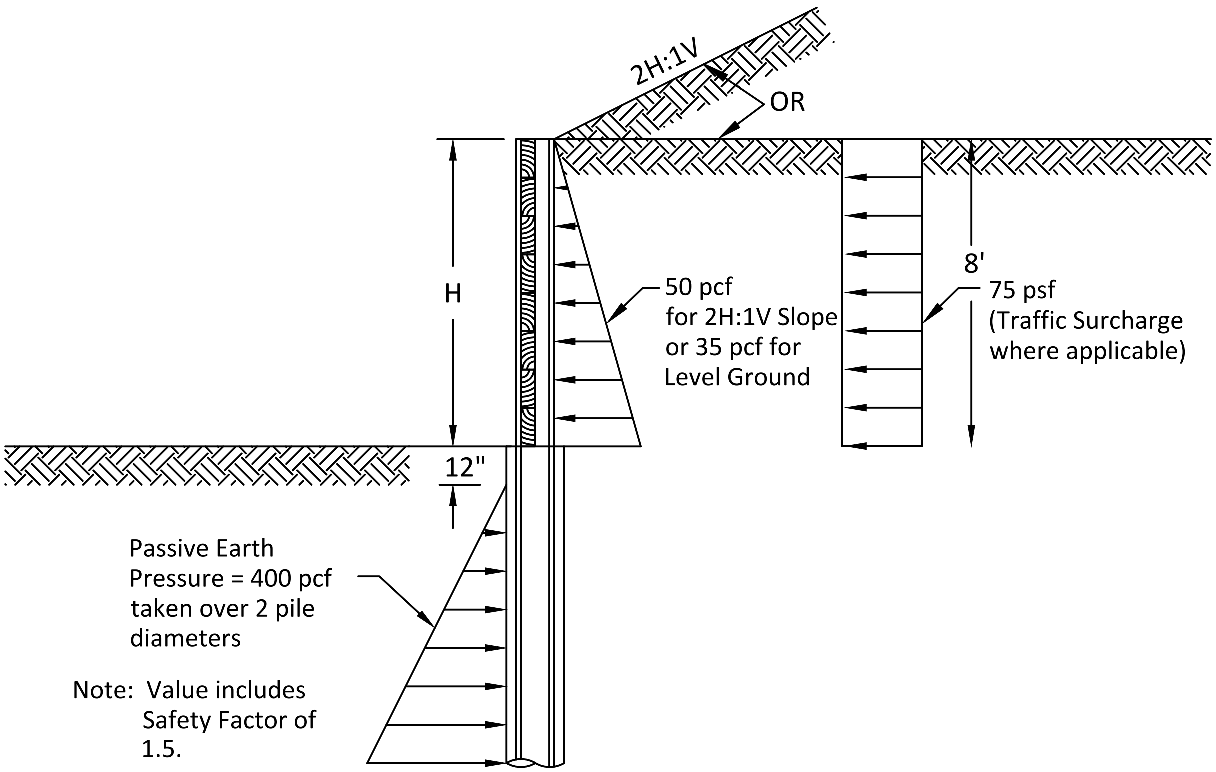
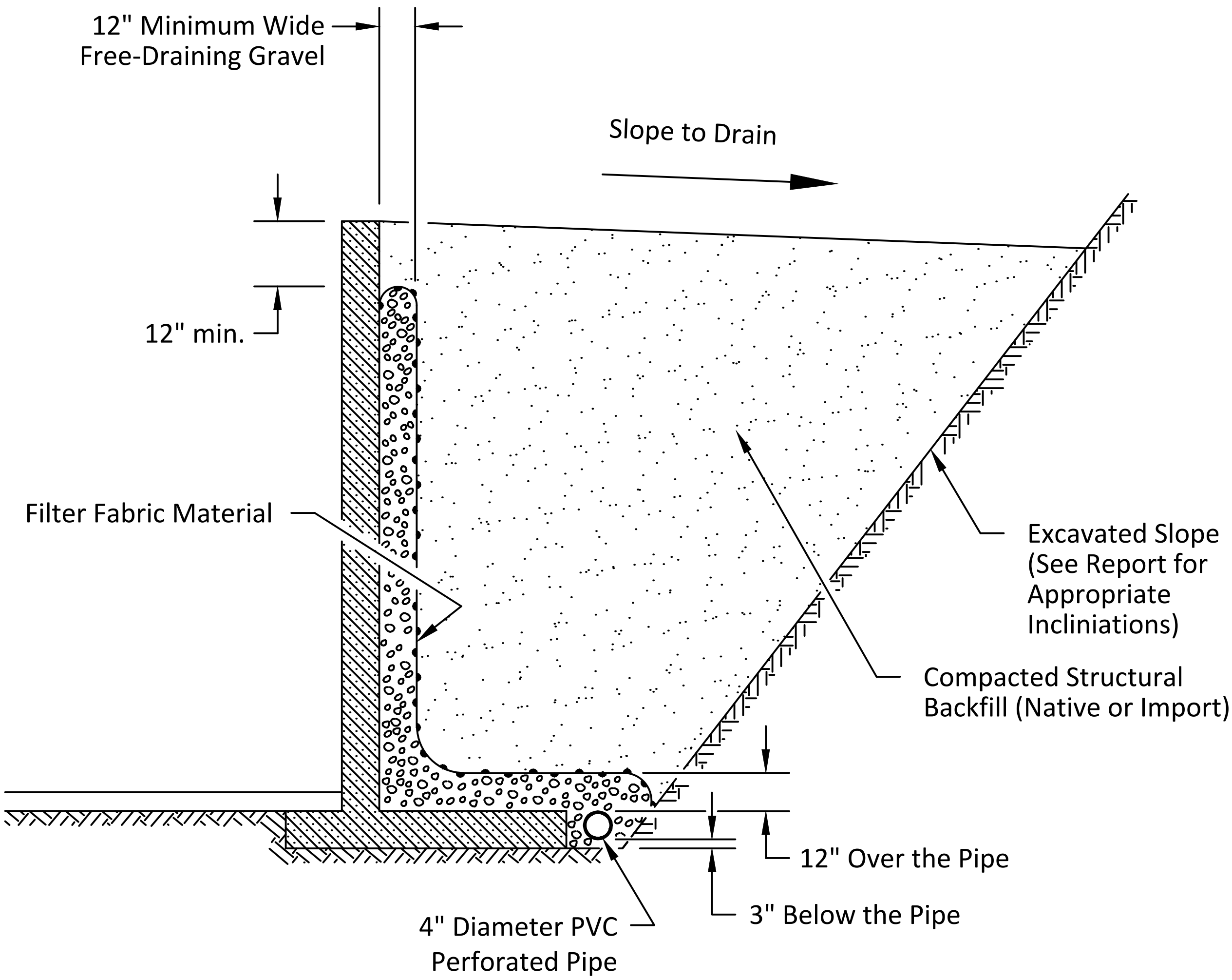
90th Avenue Development		Figure 3
RGI Project Number 2015-088	Cross Sections	Date Drawn: 06/2015
Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040		

EARTH PRESSURE DESIGN PARAMETERS
FOR SOLDIER PILE CANTILEVER WALL



NOT TO SCALE

RILEYGROUP Corporate Office 17522 Bothell Way Northeast Bothell, Washington 98011 Phone: 425.415.0551 Fax: 425.415.0311	90th Avenue Development	Figure 4
	RGI Project Number 2015-088 / Soldier Pile Pressure Diagram	Date Drawn: 06/2015
	Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040	



Not to Scale

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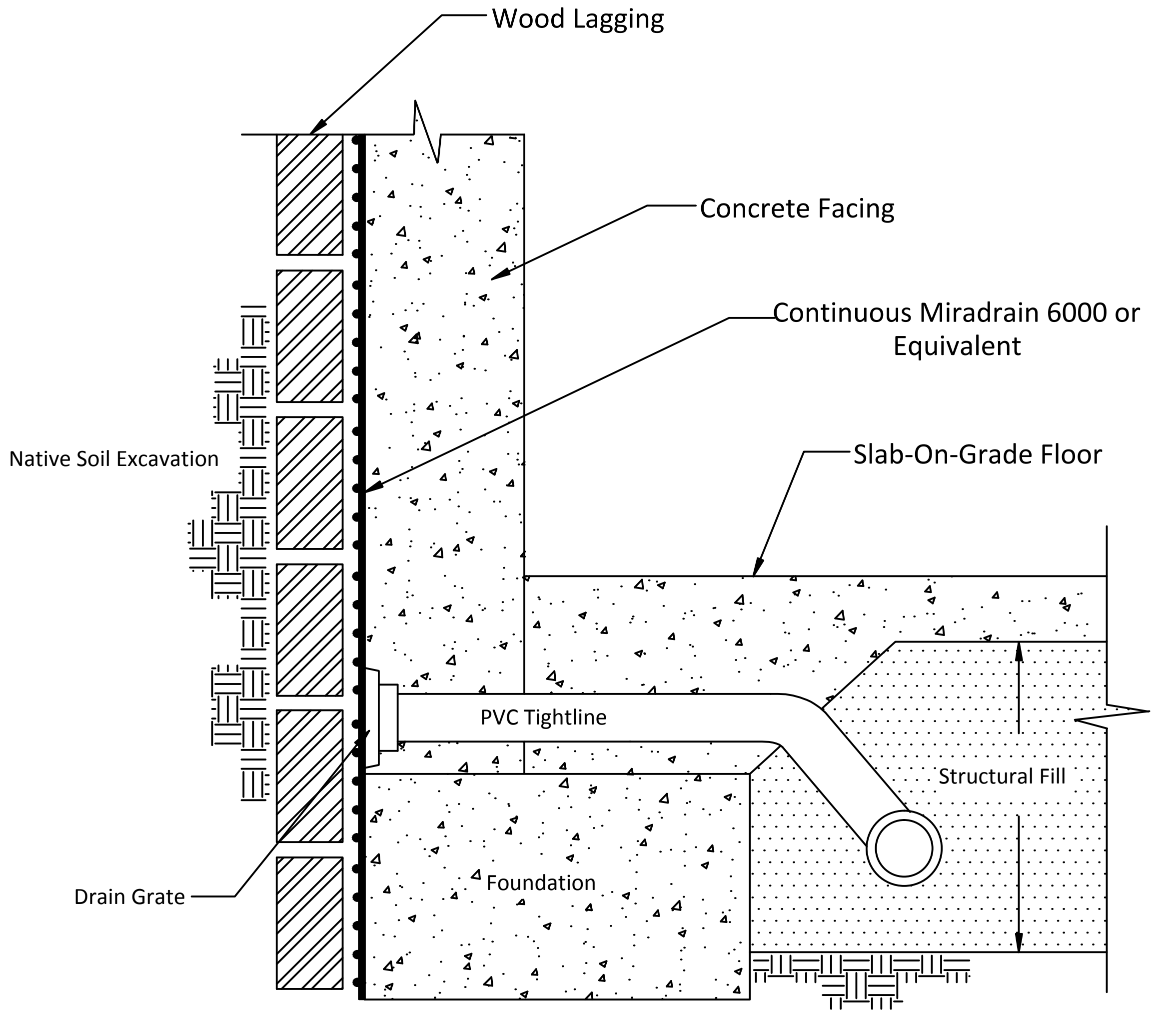
90th Avenue Development		Figure 5
RGI Project Number 2015-088	Retaining Wall Drainage Detail	Date Drawn: 06/2015
Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040		

Basement Wall Drainage Behind Shoring



Note: Drain Though Wall Should be Installed at Middle of Lagging.

Not to Scale

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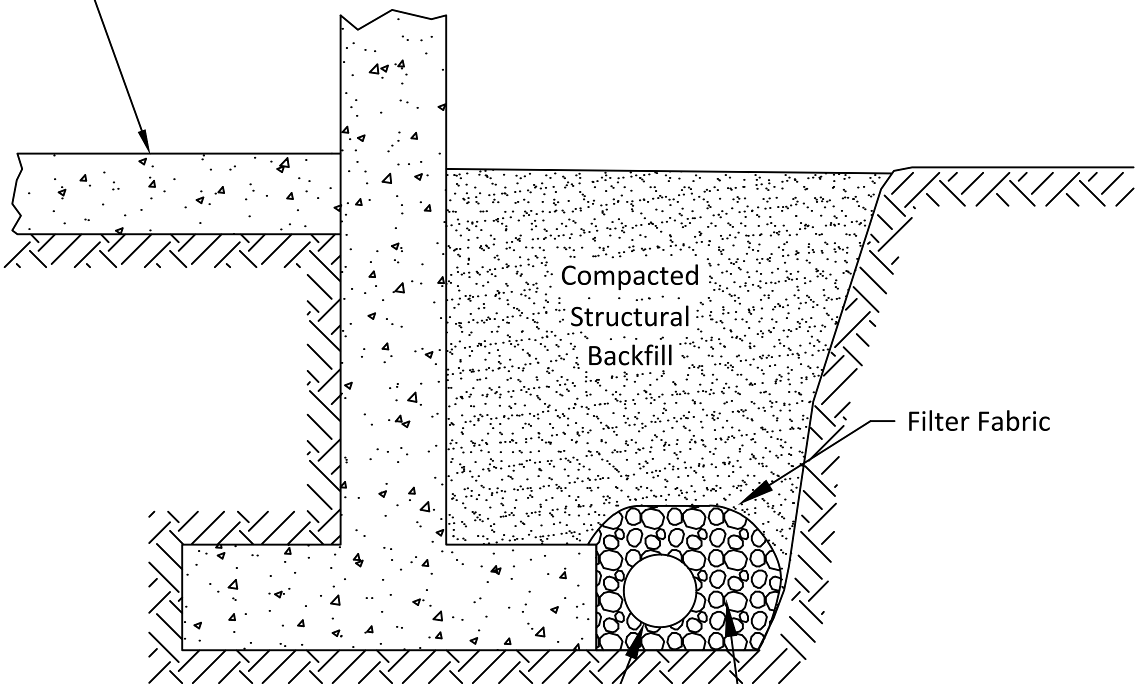
90th Avenue Development		Figure 6
RGI Project Number 2015-088	Basement Wall Drainage Detail	Date Drawn: 06/2015
Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040		



Not to Scale

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Fax: 425.415.0311

90th Avenue Development

Figure 7

RGI Project Number
2015-088

Typical Footing Drain Detail

Date Drawn:
06/2015

Address: 4845 90th Avenue Southeast, Mercer Island, Washington 98040

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

On June 4, 2015, RGI explored the subsurface soil conditions at the site by observing the excavation of four test pits to a depth of 12 feet bgs and advanced two hand auger borings. The test boring locations are shown on Figure 2. The test boring locations were approximately determined by measurements from existing property lines and paved roads.

A geologist from our office conducted the field exploration and classified the soil conditions encountered, maintained a log of each test exploration, obtained representative soil samples, and observed pertinent site features. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS).

Representative soil samples obtained from the explorations were placed in closed containers and taken to our laboratory for further examination and testing. As a part of the laboratory testing program, the soil samples were classified in our in house laboratory based on visual observation, texture, and the limited laboratory testing described below.

Moisture Content Determinations

Moisture content determinations were performed in accordance with the American Society of Testing and Materials D2216-10 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216) on representative samples obtained from the exploration in order to aid in identification and correlation of soil types. The moisture content of typical sample was measured and is reported on the test boring logs.

Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses for the greater than 75 micrometer portion of the samples were performed in accordance with American Society of Testing and Materials D422 Standard Test Method for Particle-Size Analysis of Soils (ASTM D422) on one of the samples, the results of which are attached in Appendix A.

Project Name: **90th Avenue Development**	**Test Pit No.: TP-1**
Project Number: **2015-088**	**Sheet 1 of 1**
Client: **Milestone NW**	

Date(s) Excavated: **6/4/15**	Logged By **CM**	Surface Conditions: **Grass**
Excavation Method: **Excavator**	Bucket Size: **18"**	Total Depth of Excavation: **8**
Excavator Type: **Track-mounted**	Excavating Contractor:	Approximate Surface Elevation **358**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Grab**	Compaction Method **Excavator Bucket**
Test Pit Backfill: **Cuttings**	Location **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
358	0			SM		Tan silty SAND, moist, medium dense	
						Becomes brown, loose to medium dense	
			TP1-1				19% Moisture
						Becomes reddish brown, trace gravel	
						Becomes dense, some gravel	
353	5		TP1-4.5				18% Moisture
				SM		Gray silty SAND with gravel (Till), moist, very dense, iron oxidation	
			TP1-7				17% Moisture
			TP1-8				10% Moisture
						Test pit terminated at 8 feet bgs.	
348	10						
343	15						

Project Name: **90th Avenue Development**
Project Number: **2015-088**
Client: **Milestone NW**

RILEYGROUP

Test Pit No.: TP-2

Sheet 1 of 1

Date(s) Excavated: **6/4/15**	Logged By **CM**	Surface Conditions: **Grass**
Excavation Method: **Excavator**	Bucket Size: **18"**	Total Depth of Excavation: **4.5**
Excavator Type: **Track-mounted**	Excavating Contractor:	Approximate Surface Elevation **360**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Grab**	Compaction Method **Excavator Bucket**
Test Pit Backfill: **Cuttings**	Location **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
360	0			Fill		Dark brown organic topsoil	
				SM		Reddish brown silty SAND, moist, loose to medium dense	
			TP2-1				15% Moisture
						Gray brown silty SAND with some gravel, moist, medium dense to dense	
			TP2-3				11% Moisture
						Gray silty SAND with gravel (Till), moist, very dense, iron oxidation	
			TP2-4.5				27% Moisture
						Test pit terminated at 4.5 feet bgs.	
355	5						
350	10						
345	15						

Project Name: **90th Avenue Development**	**Test Pit No.: TP-3**
Project Number: **2015-088**	**Sheet 1 of 1**
Client: **Milestone NW**	RILEYGROUP

Date(s) Excavated: **6/4/15**	Logged By **CM**	Surface Conditions: **Grass**
Excavation Method: **Excavator**	Bucket Size: **18"**	Total Depth of Excavation: **4.5**
Excavator Type: **Track-mounted**	Excavating Contractor:	Approximate Surface Elevation **358**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Grab**	Compaction Method **Excavator Bucket**
Test Pit Backfill: **Cuttings**	Location **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
358	0			SM		Reddish brown silty SAND with trace gravel, moist, loose to medium dense	
			TP3-0.5				13% Moisture
				SM		Gray silty SAND with gravel (Till), moist, very dense, iron oxidation	
			TP3-2				13% Moisture
						Abandoned, unmarked concrete pipe with pea gravel bedding encountered	
						Test pit terminated at 4.5 feet bgs.	
353	5						
348	10						
343	15						

Project Name: **90th Avenue Development**
Project Number: **2015-088**
Client: **Milestone NW**

RILEYGROUP

Test Pit No.: TP-4

Sheet 1 of 1

Date(s) Excavated: **6/4/15**	Logged By **CM**	Surface Conditions: **Grass**
Excavation Method: **Excavator**	Bucket Size: **18"**	Total Depth of Excavation: **6**
Excavator Type: **Track-mounted**	Excavating Contractor:	Approximate Surface Elevation **350**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Grab**	Compaction Method **Excavator Bucket**
Test Pit Backfill: **Cuttings**	Location **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
350	0			SM		Brown silty SAND with some gravel, moist, loose to medium dense	
			TP4-1				12% Moisture
			TP4-4			Gray brown silty SAND with gravel (Till), dense to very dense, trace iron oxidation	10% Moisture
345	5						
			TP4-6			Becomes very dense	10% Moisture
						Test pit terminated at 6 feet bgs.	
340	10						
335	15						

Project Name: **90th Avenue Development**	Hand Auger: **HA-1**
Project Number: **2015-088**	**Sheet 1 of 1**
Client: **Milestone NW**	RILEYGROUP

Date(s) Drilled: **6/4/15**	Logged By: **CM**	Surface Conditions: **Grass**
Drilling Method(s): **Excavator**	Drill Bit Size/Type: **18"**	Total Depth of Borehole: **4**
Drill Rig Type: **Track-mounted**	Drilling Contractor: **Riley Group**	Approximate Surface Elevation: **360**
Groundwater Level and Date Measured: **Not encountered**	Sampling Method(s): **Grab**	Hammer Data : **Excavator Bucket**
Borehole Backfill: **Cuttings**	Location: **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

PID Reading, ppm	Sample ID	Sample Type	Sampling Resistance, blows/ft	GW Depth	Depth (feet)	MATERIAL DESCRIPTION	USCS Symbol	Graphic Log
					0	Reddish brown silty SAND, moist, loose to medium dense	SM	
	HA1-0.5					10% Moisture		
	HA1-3					Becomes gray brown, medium dense, more silt content, 23% Moisture		
						Hand auger till refusal at 4 feet bgs.		
					5			
					10			

Project Name: **90th Avenue Development**	Hand Auger: **HA-2**
Project Number: **2015-088**	**Sheet 1 of 1**
Client: **Milestone NW**	RILEYGROUP

Date(s) Drilled: **6/4/15**	Logged By: **CM**	Surface Conditions: **Grass**
Drilling Method(s): **Excavator**	Drill Bit Size/Type: **18"**	Total Depth of Borehole: **2.5**
Drill Rig Type: **Track-mounted**	Drilling Contractor: **Riley Group**	Approximate Surface Elevation: **344**
Groundwater Level and Date Measured: **Not encountered**	Sampling Method(s): **Grab**	Hammer Data : **Excavator Bucket**
Borehole Backfill: **Cuttings**	Location: **4845 90th Avenue Southeast, Mercer Island, Washington 98040**	

PID Reading, ppm	Sample ID	Sample Type	Sampling Resistance, blows/ft	GW Depth	Depth (feet)	MATERIAL DESCRIPTION	USCS Symbol	Graphic Log
					0	Organic materials, roots, pine needles, moist, very loose	Fill	
	HA2-2.5					Dark brown organic soil, moist, loose, 61% Moisture	Fill	
						Hand auger till refusal at 3.5 feet bgs.		
					5			
					10			

Project Name: **90th Avenue Development** Project Number: **2015-088** Client: **Milestone NW**	RILEYGROUP **Boring Log Key** **Sheet 1 of 1**

PID Reading, ppm	Sample ID	Sample Type	Sampling Resistance, blows/ft	GW Depth	Depth (feet)	MATERIAL DESCRIPTION	USCS Symbol	Graphic Log
1	2	3	4	5	6	7	8	9

COLUMN DESCRIPTIONS

1. PID Reading, ppm: The reading from a photo-ionization detector, in parts per million.
2. Sample ID: Sample identification number.
3. Sample Type: Type of soil sample collected at the depth interval shown.
4. Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
5. GW Depth: Groundwater depth in feet below the ground surface.
6. Depth (feet): Depth in feet below the ground surface.
7. MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
8. USCS Symbol: USCS symbol of the subsurface material.
9. Graphic Log: Graphic depiction of the subsurface material encountered.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

AF

Silty SAND (SM)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
CME Sampler
Pitcher Sample
Bulk Sample
Grab Sample
2-inch-OD unlined split spoon (SPT)
3-inch-OD California w/ brass rings
2.5-inch-OD Modified California w/ brass liners
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
?— Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

THE RILEY GROUP, INC.
17522 Bothell Way NE
Bothell, WA 98011

PHONE: (425) 415-0551
FAX: (425) 415-0311

GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	90th Avenue Development	SAMPLE ID/TYPE	TP-1
PROJECT NO.	2015-088	SAMPLE DEPTH	4.5'
TECH/TEST DATE	CM 6/4/2015	DATE RECEIVED	6/4/2015

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	278.3
Wt Dry Soil & Tare (gm)	(w2)	237.3
Weight of Tare (gm)	(w3)	9.0
Weight of Water (gm)	(w4=w1-w2)	41.0
Weight of Dry Soil (gm)	(w5=w2-w3)	228.3
Moisture Content (%)	(w4/w5)*100	18

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

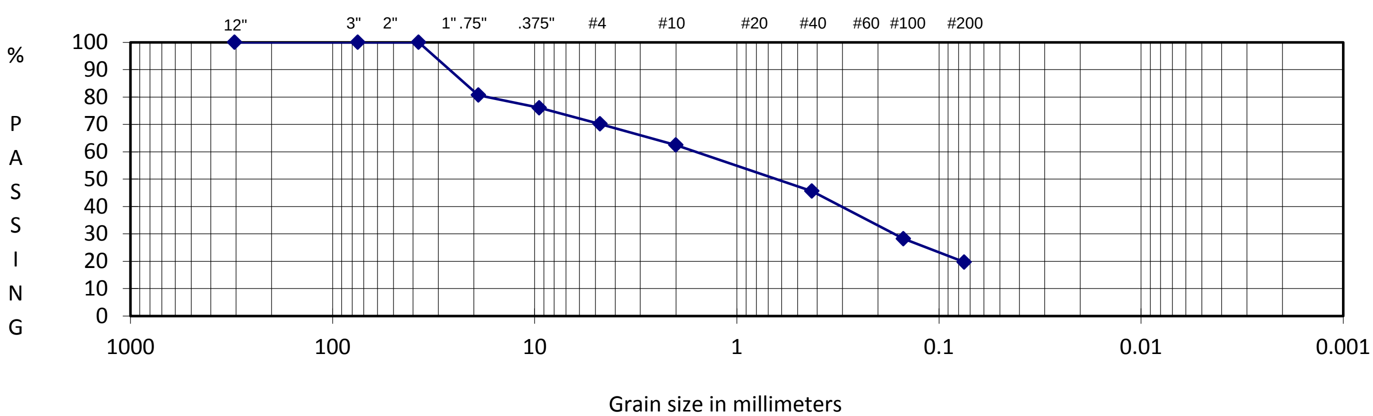
	Weight Of Sample (gm)	237.3
	Tare Weight (gm)	9.0
(W6)	Total Dry Weight (gm)	228.3

SIEVE ANALYSIS

% COBBLES	0.0
% C GRAVEL	19.3
% F GRAVEL	10.5
% C SAND	7.8
% M SAND	16.8
% F SAND	25.9
% FINES	19.7
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	9.0	0.00	0.00	100.00	cobbles
3.0"	9.0	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	9.0	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	53.0	44.00	19.27	80.73	fine gravel
0.50"					fine gravel
0.375"	63.5	54.50	23.87	76.13	fine gravel
#4	77.0	68.00	29.79	70.21	coarse sand
#10	94.7	85.70	37.54	62.46	medium sand
#20					medium sand
#40	133.1	124.10	54.36	45.64	fine sand
#60					fine sand
#100	172.8	163.80	71.75	28.25	fine sand
#200	192.3	183.30	80.29	19.71	fines
PAN	237.5	228.50	100.09	-0.09	silt/clay



DESCRIPTION	Silty SAND with some gravel
USCS	SM

Prepared For:
Windward Real Estate Services Inc

Reviewed By: KMW

RILEYGROUP

THE RILEY GROUP, INC.
17522 Bothell Way NE
Bothell, WA 98011

PHONE: (425) 415-0551
FAX: (425) 415-0311

GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	90th Avenue Development	SAMPLE ID/TYPE	TP-2
PROJECT NO.	2015-088	SAMPLE DEPTH	3'
TECH/TEST DATE	CM 6/4/2015	DATE RECEIVED	6/4/2015

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	265.6
Wt Dry Soil & Tare (gm)	(w2)	240.3
Weight of Tare (gm)	(w3)	8.4
Weight of Water (gm)	(w4=w1-w2)	25.3
Weight of Dry Soil (gm)	(w5=w2-w3)	231.9
Moisture Content (%)	(w4/w5)*100	11

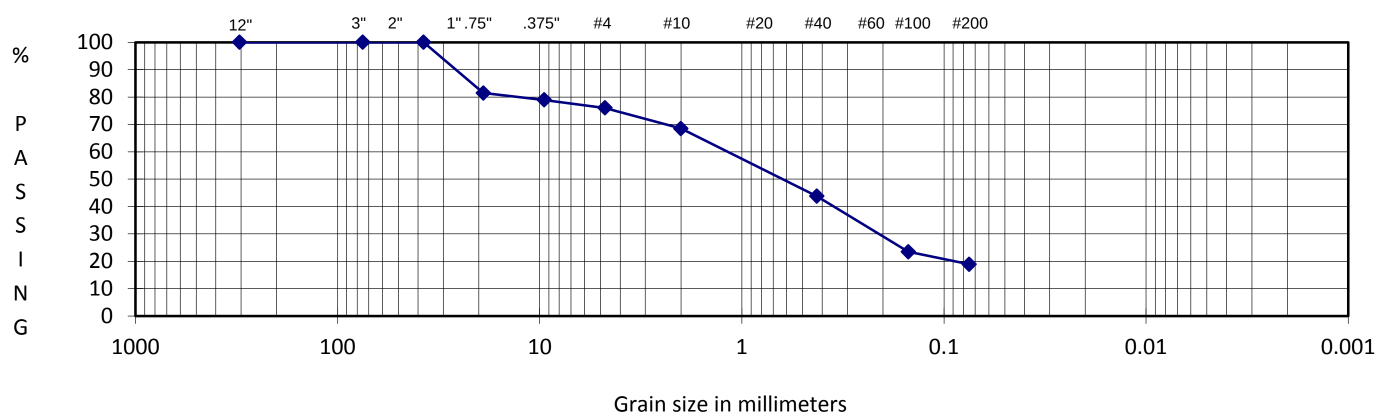
Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	240.3
	Tare Weight (gm)	8.4
(W6)	Total Dry Weight (gm)	231.9

SIEVE ANALYSIS

% COBBLES	0.0	
% C GRAVEL	18.5	
% F GRAVEL	5.5	
% C SAND	7.5	
% M SAND	24.8	
% F SAND	24.9	
% FINES	18.9	
% TOTAL	100.0	
D10 (mm)		
D30 (mm)		
D60 (mm)		
Cu		
Cc		

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	8.4	0.00	0.00	100.00	cobbles
3.0"	8.4	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	8.4	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	51.3	42.90	18.50	81.50	fine gravel
0.50"					fine gravel
0.375"	57.1	48.70	21.00	79.00	fine gravel
#4	64.0	55.60	23.98	76.02	coarse sand
#10	81.4	73.00	31.48	68.52	medium sand
#20					medium sand
#40	138.8	130.40	56.23	43.77	fine sand
#60					fine sand
#100	185.9	177.50	76.54	23.46	fine sand
#200	196.5	188.10	81.11	18.89	fines
PAN	240.3	231.90	100.00	0.00	silt/clay



DESCRIPTION	Silty SAND with some gravel
USCS	SM

Prepared For:
Windward Real Estate Services Inc

Reviewed By: KMW

RILEYGROUP

THE RILEY GROUP, INC.
17522 Bothell Way NE
Bothell, WA 98011

PHONE: (425) 415-0551
FAX: (425) 415-0311

GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	90th Avenue Development	SAMPLE ID/TYPE	TP-3
PROJECT NO.	2015-088	SAMPLE DEPTH	0.5'
TECH/TEST DATE	CM 6/4/2015	DATE RECEIVED	6/4/2015

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	212.4
Wt Dry Soil & Tare (gm)	(w2)	189.6
Weight of Tare (gm)	(w3)	8.5
Weight of Water (gm)	(w4=w1-w2)	22.8
Weight of Dry Soil (gm)	(w5=w2-w3)	181.1
Moisture Content (%)	(w4/w5)*100	13

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

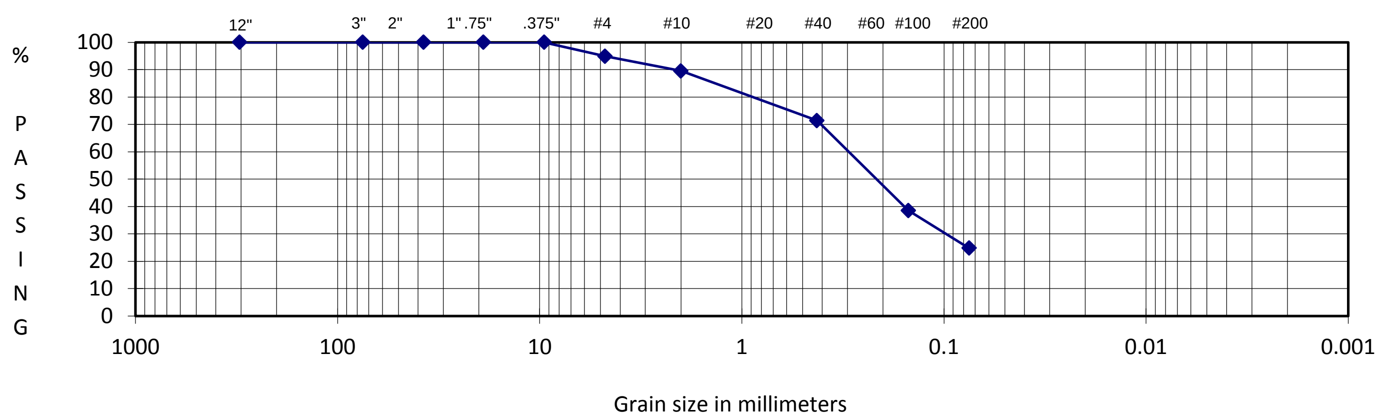
	Weight Of Sample (gm)	189.6
	Tare Weight (gm)	8.5
(W6)	Total Dry Weight (gm)	181.1

% COBBLES	0.0
% C GRAVEL	0.0
% F GRAVEL	5.1
% C SAND	5.4
% M SAND	18.1
% F SAND	46.7
% FINES	24.8
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

SIEVE ANALYSIS

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	8.5	0.00	0.00	100.00	cobbles
3.0"	8.5	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	8.5	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	8.5	0.00	0.00	100.00	fine gravel
0.50"					fine gravel
0.375"	8.5	0.00	0.00	100.00	fine gravel
#4	17.7	9.20	5.08	94.92	coarse sand
#10	27.4	18.90	10.44	89.56	medium sand
#20					medium sand
#40	60.2	51.70	28.55	71.45	fine sand
#60					fine sand
#100	119.8	111.30	61.46	38.54	fine sand
#200	144.7	136.20	75.21	24.79	fines
PAN	189.6	181.10	100.00	0.00	silt/clay



DESCRIPTION	Silty SAND with trace gravel
USCS	SM

Prepared For:
Windward Real Estate Services Inc

Reviewed By: KMW

RILEYGROUP

THE RILEY GROUP, INC.
17522 Bothell Way NE
Bothell, WA 98011

PHONE: (425) 415-0551
FAX: (425) 415-0311

GRAIN SIZE ANALYSIS
ASTM D421, D422, D1140, D2487, D6913

PROJECT TITLE	90th Avenue Development	SAMPLE ID/TYPE	TP-4
PROJECT NO.	2015-088	SAMPLE DEPTH	1'
TECH/TEST DATE	CM 6/4/2015	DATE RECEIVED	6/4/2015

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	247.1
Wt Dry Soil & Tare (gm)	(w2)	220.9
Weight of Tare (gm)	(w3)	8.6
Weight of Water (gm)	(w4=w1-w2)	26.2
Weight of Dry Soil (gm)	(w5=w2-w3)	212.3
Moisture Content (%)	(w4/w5)*100	12

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

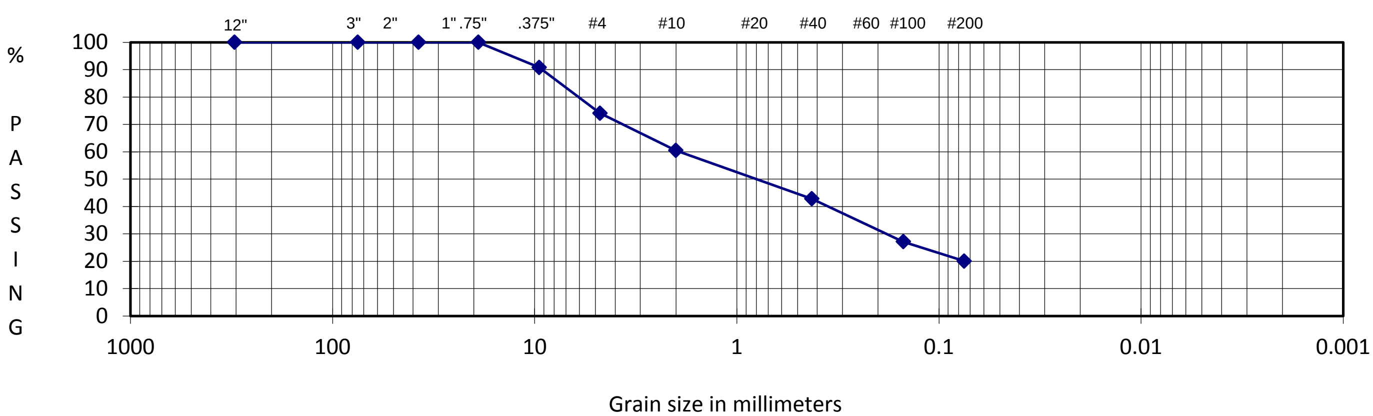
	Weight Of Sample (gm)	220.9
	Tare Weight (gm)	8.6
(W6)	Total Dry Weight (gm)	212.3

% COBBLES	0.0
% C GRAVEL	0.0
% F GRAVEL	25.9
% C SAND	13.6
% M SAND	17.7
% F SAND	22.8
% FINES	20.1
% TOTAL	100.0

D10 (mm)	
D30 (mm)	
D60 (mm)	
Cu	
Cc	

SIEVE ANALYSIS

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	
12.0"	8.6	0.00	0.00	100.00	cobbles
3.0"	8.6	0.00	0.00	100.00	coarse gravel
2.5"					coarse gravel
2.0"					coarse gravel
1.5"	8.6	0.00	0.00	100.00	coarse gravel
1.0"					coarse gravel
0.75"	8.6	0.00	0.00	100.00	fine gravel
0.50"					fine gravel
0.375"	28.0	19.40	9.14	90.86	fine gravel
#4	63.6	55.00	25.91	74.09	coarse sand
#10	92.5	83.90	39.52	60.48	medium sand
#20					medium sand
#40	130.0	121.40	57.18	42.82	fine sand
#60					fine sand
#100	163.3	154.70	72.87	27.13	fine sand
#200	178.3	169.70	79.93	20.07	fines
PAN	220.9	212.30	100.00	0.00	silt/clay



DESCRIPTION	Silty SAND with some gravel
USCS	SM

Prepared For:
Milestone NW

Reviewed By: KMW

RILEYGROUP

APPENDIX B
SLOPE STABILITY ANALYSIS

RGI performed the slope stability analysis by using a computer program, Slide version 6.0, which was developed by rocscience. The slope data is based on the Boundary and Toporgaphy Survey prepared by Eastside Consultants, Inc. dated May 28, 2015. The slope profiles and soil parameters used for the analysis are shown on the Cross Sections A-A' in the middle of the site.

Results of Slope Stability Analyses

Soils	Color	Unit Weight (pcf)	Cohesion (pcf)	Phi angle (degrees)
Debris Fill	Dark Brown	60	200	10
Silty Sand	Brown	120	100	34
Glacial Till	Gray	130	250	36

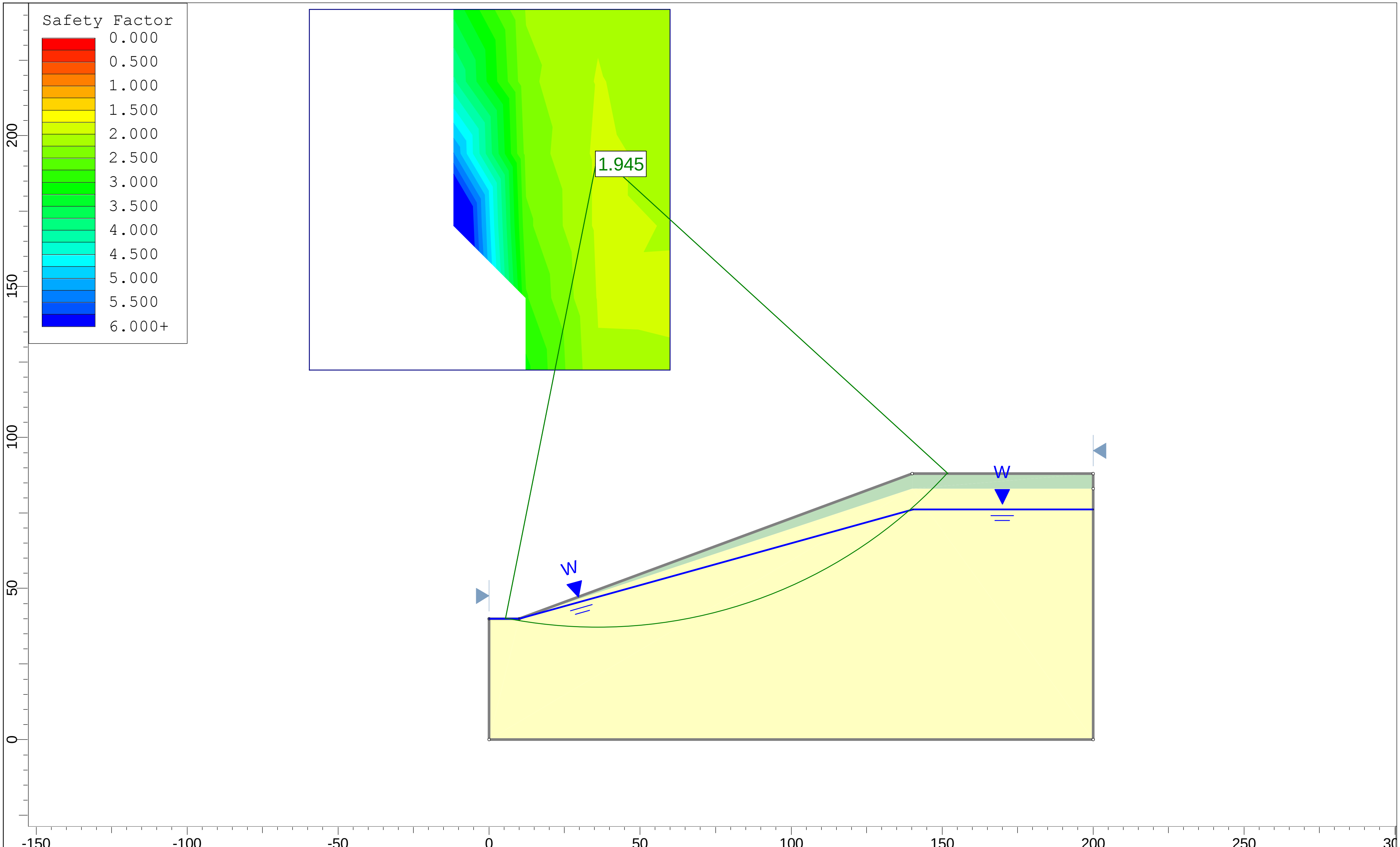
The safety factor for the critical surfaces was calculated by the Bishop Method. The analyses were performed for the natural slope, and post-construction under the static and seismic loading condition. The safety factors (SF) for most critical surfaces are shown in the table below.

Results of Slope Stability Analyses

Condition	Section A-A'	Section B-B'	Design Requirements
Existing Slope	Static SF =1.95 Seismic SF = 1.30	Static SF =1.6 Seismic SF = 1.2	1.5 1.15
Post-Construction	Static SF =1.64 Seismic SF = 1.29	Static SF =1.63 Seismic SF = 1.21	1.5 1.15

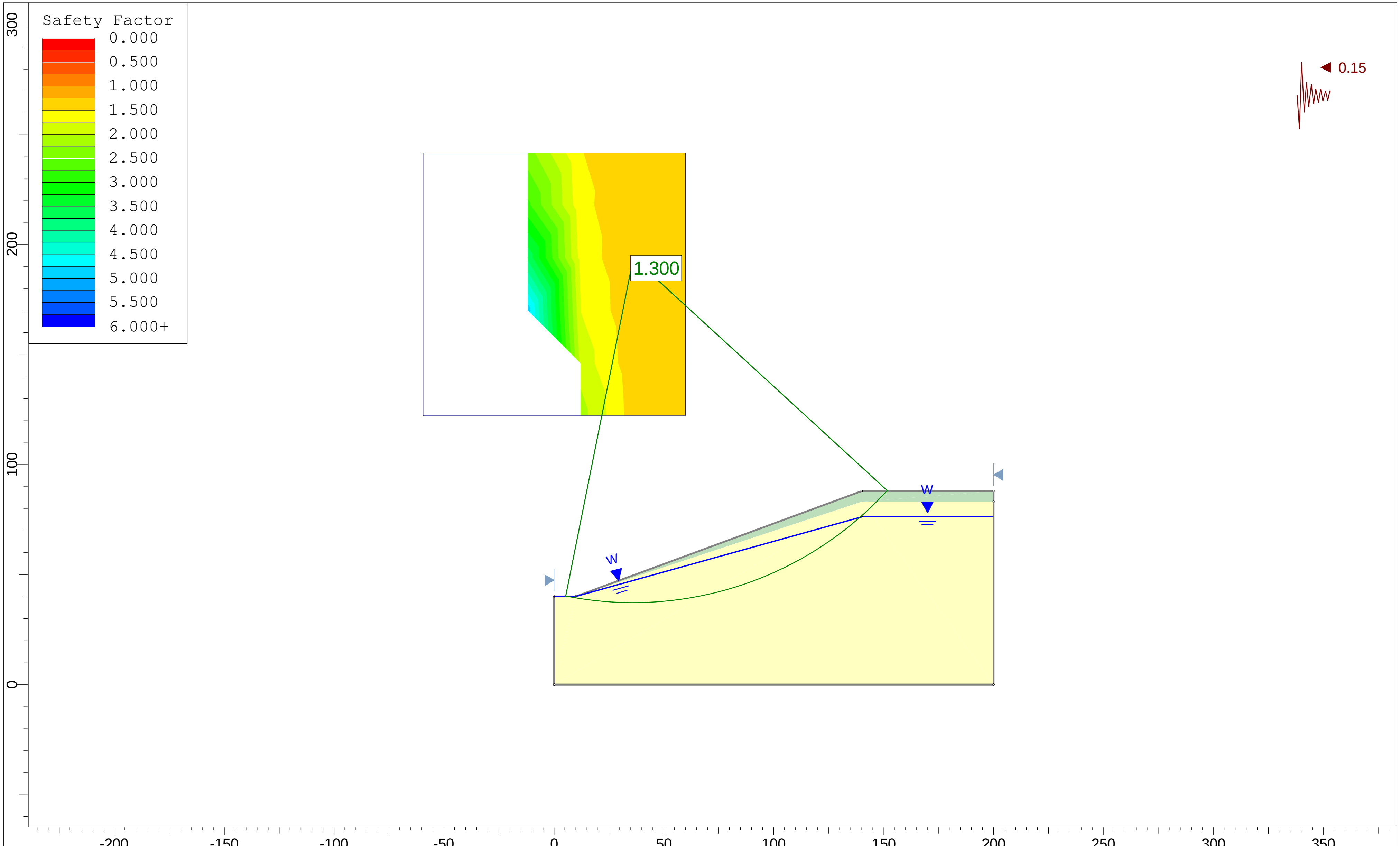
The safety factors for section A-A' meet standard design requirements before and after construction. The safety factors for section B-B' meet the standard requirements before construction and do not meet the standard requirement of post construction. In order to meet the post construction requirements, the organic debris must be removed on the south slope surface. After the organic debris is removed, the safety factors for section B-B' will meet standard design requirements. More detailed recommendation shown in the report sections.

Based on the analyses, the slope is currently stable condition and will remain stable after construction if the geotechnical recommendations are incorporated in the development.



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:528	Company
Date	6/4/2015, 11:00:54 AM	File Name	90th Avenue Section A-A' Static.slim

SLIDEINTERPRET 6.009



SLIDEINTERPRET 6.009	*Project* SLIDE - An Interactive Slope Stability Program		
	Analysis Description		
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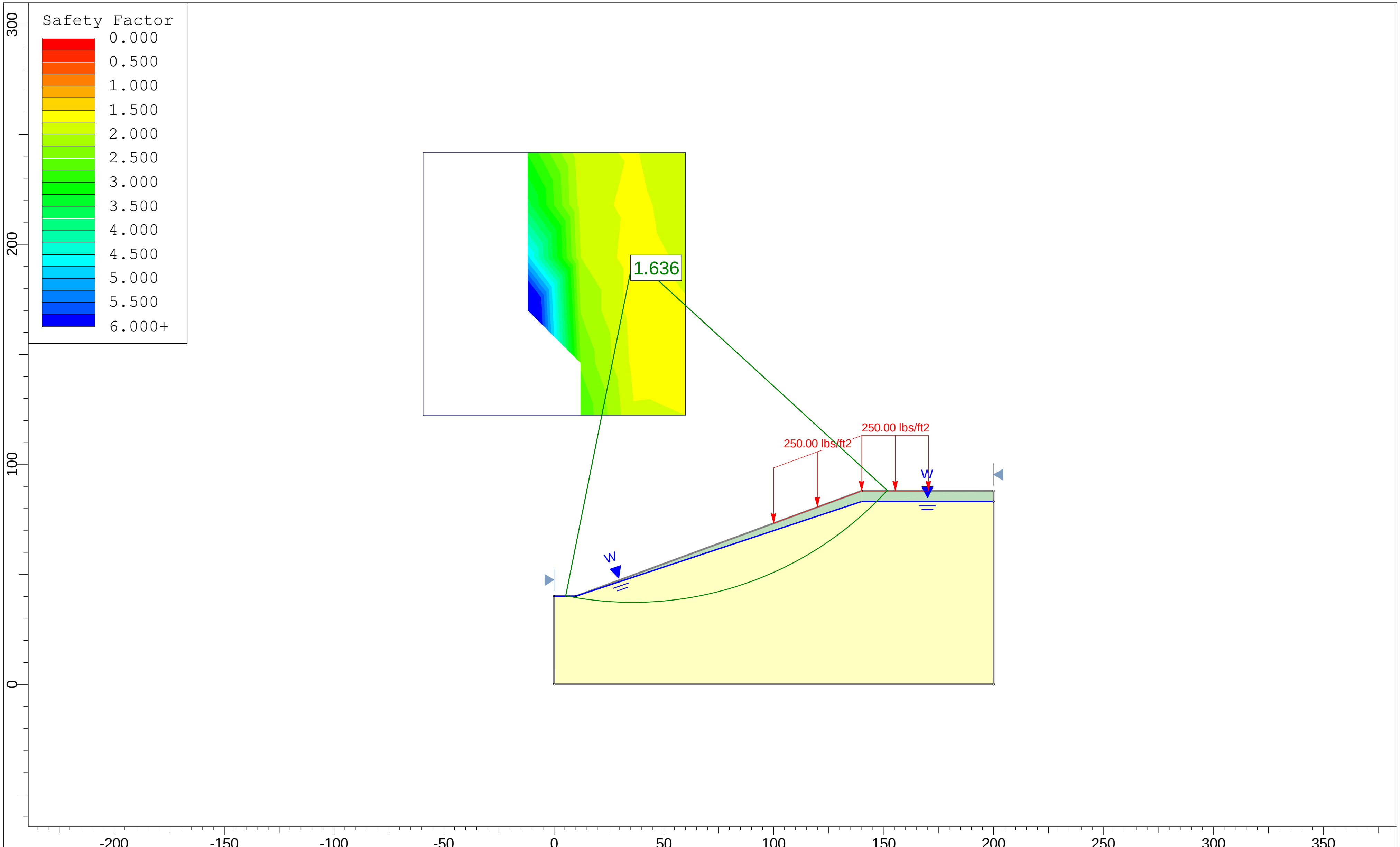


SLIDEINTERPRET 6.009

Project
SLIDE - An Interactive Slope Stability Program

Analysis Description

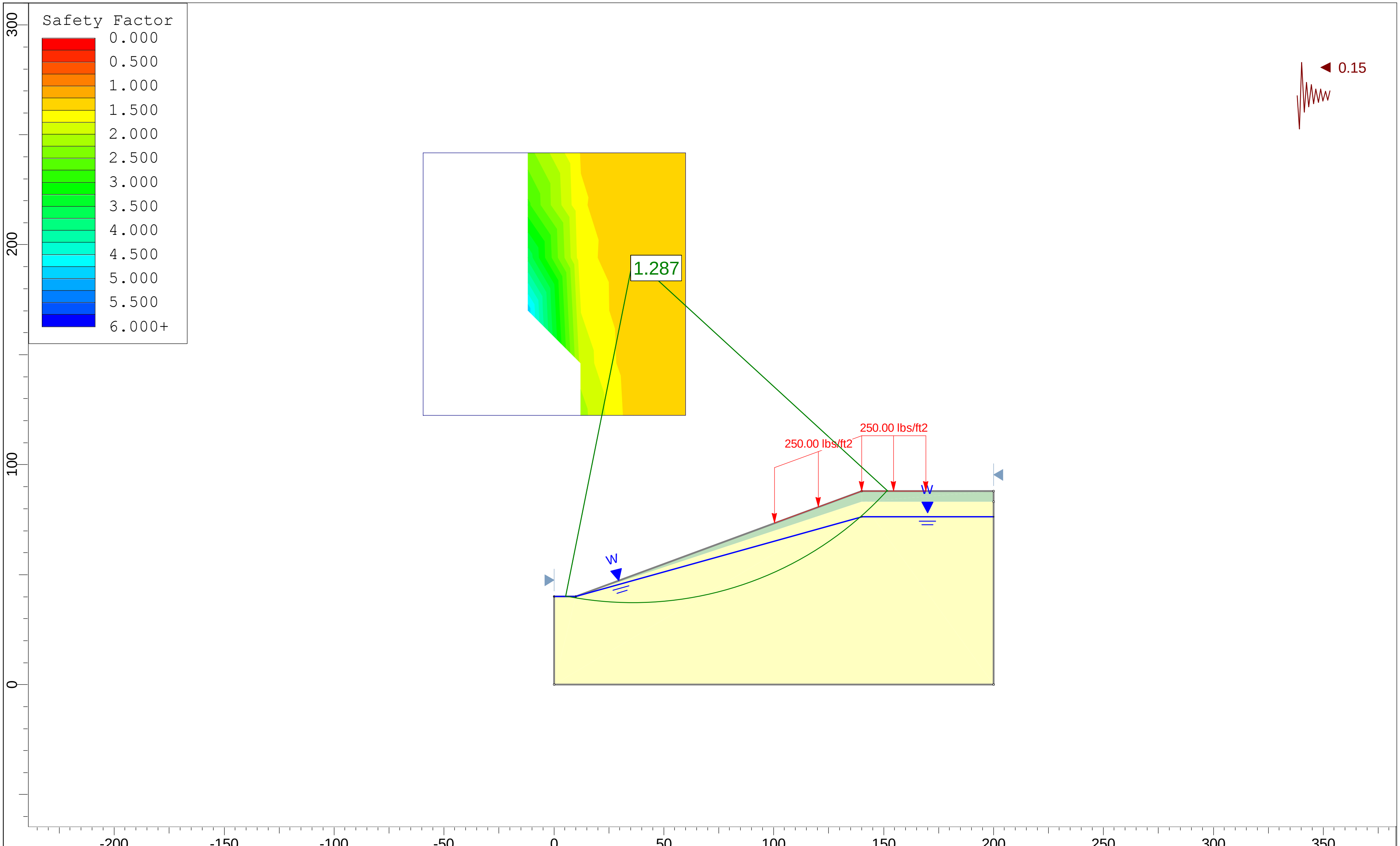
Drawn By

Scale 1:725

Company

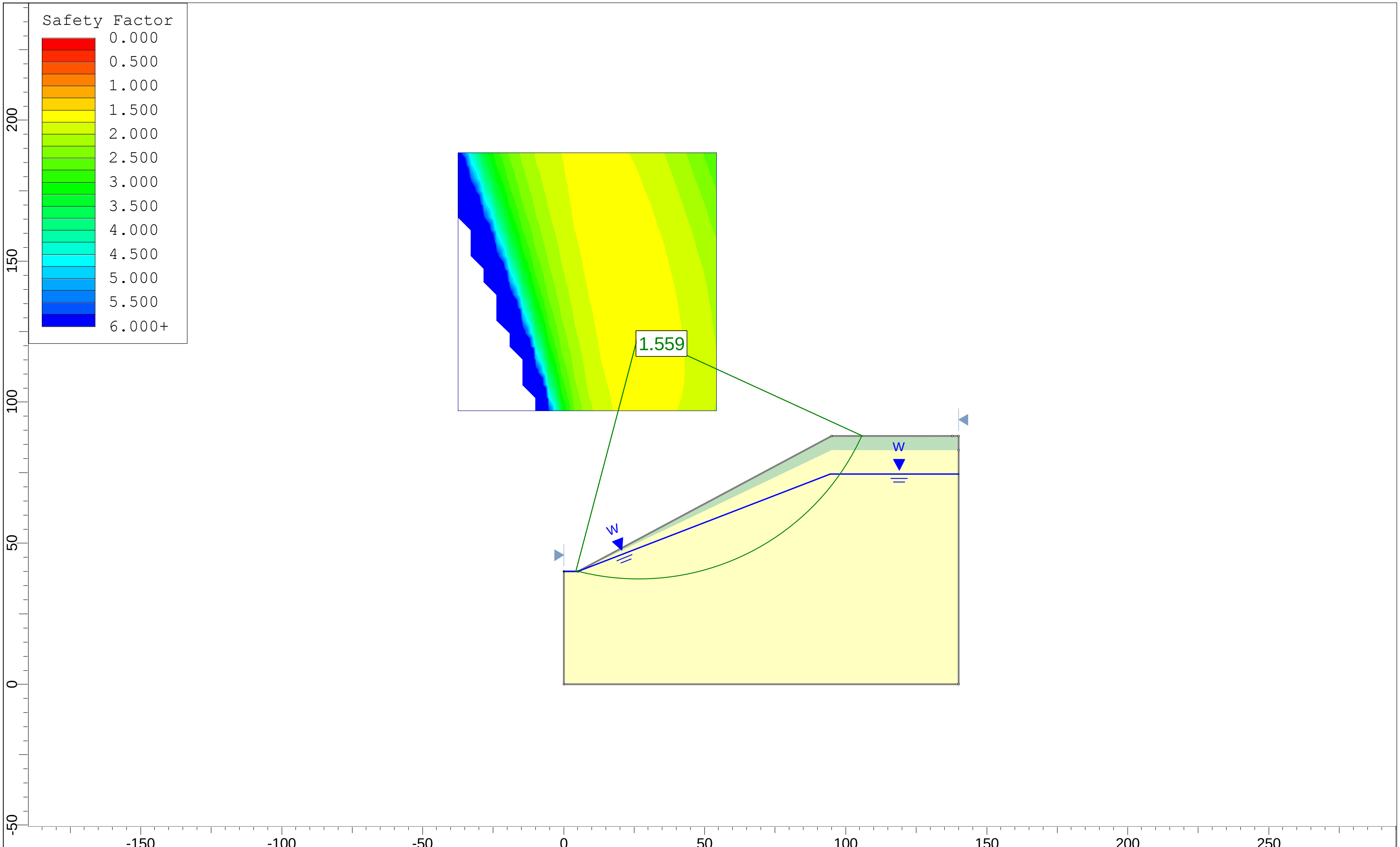
Date 6/4/2015, 11:00:54 AM

File Name 90th Avenue Section A-A' Static Post Construction.slim



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:725	*Company*
Date 6/4/2015, 11:00:54 AM		*File Name* 90th Avenue Section A-A' Seismic Post Construction.slim	

SLIDEINTERPRET 6.009



SLIDEINTERPRET 6.009	*Project* SLIDE - An Interactive Slope Stability Program		
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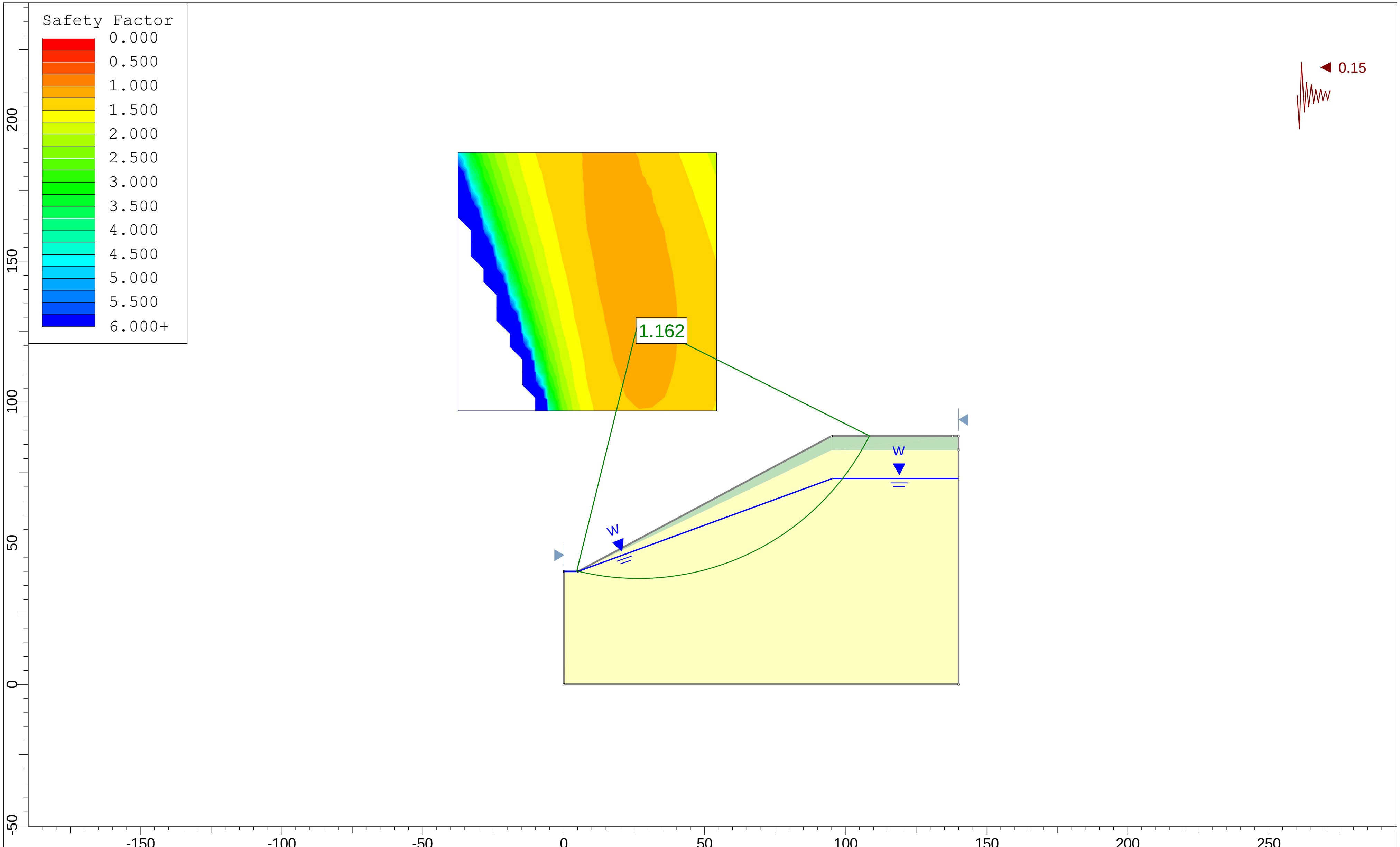
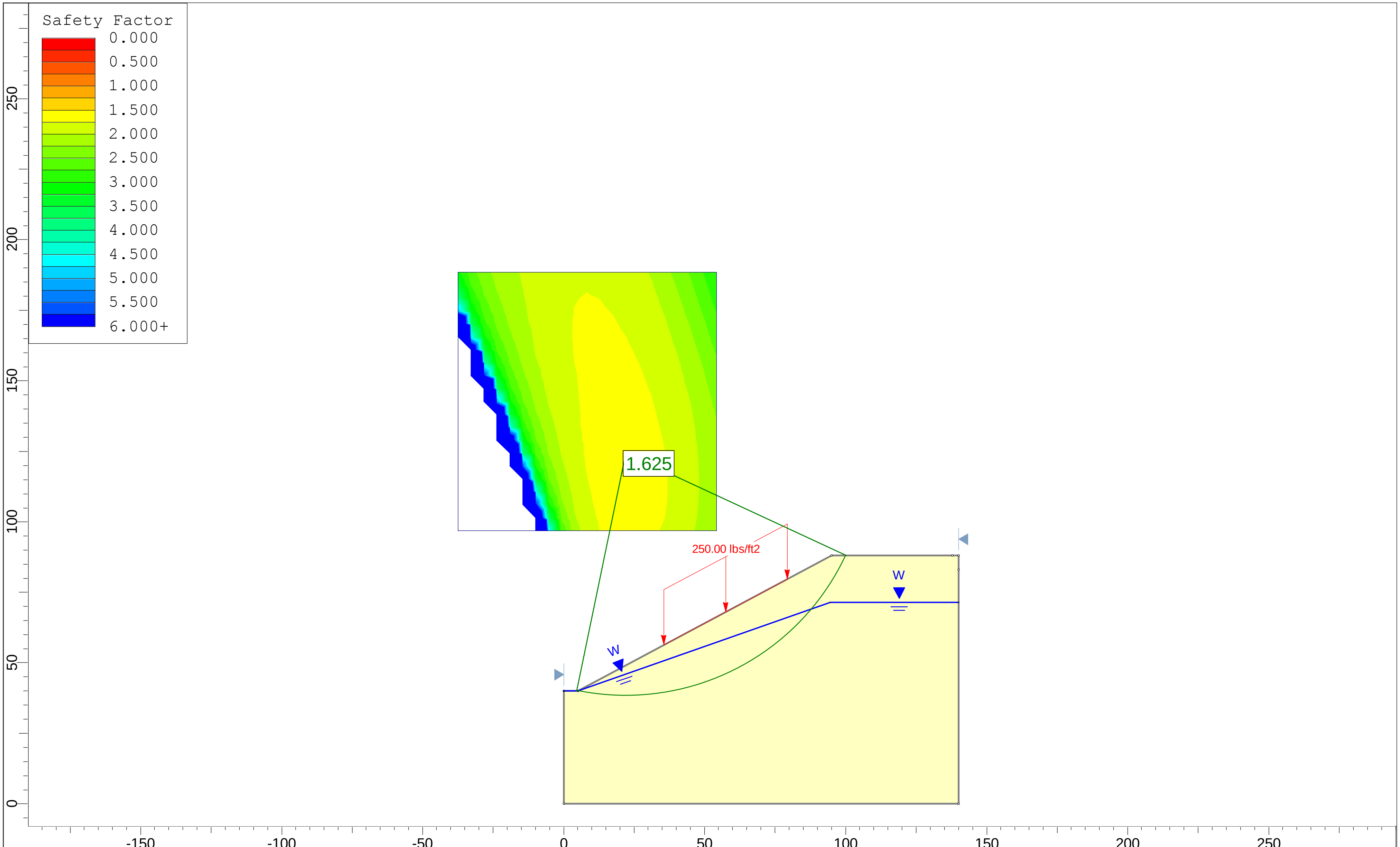
	Date 6/4/2015, 11:00:54 AM		*File Name* 90th Avenue Section B-B' Static Existing Slope.slim



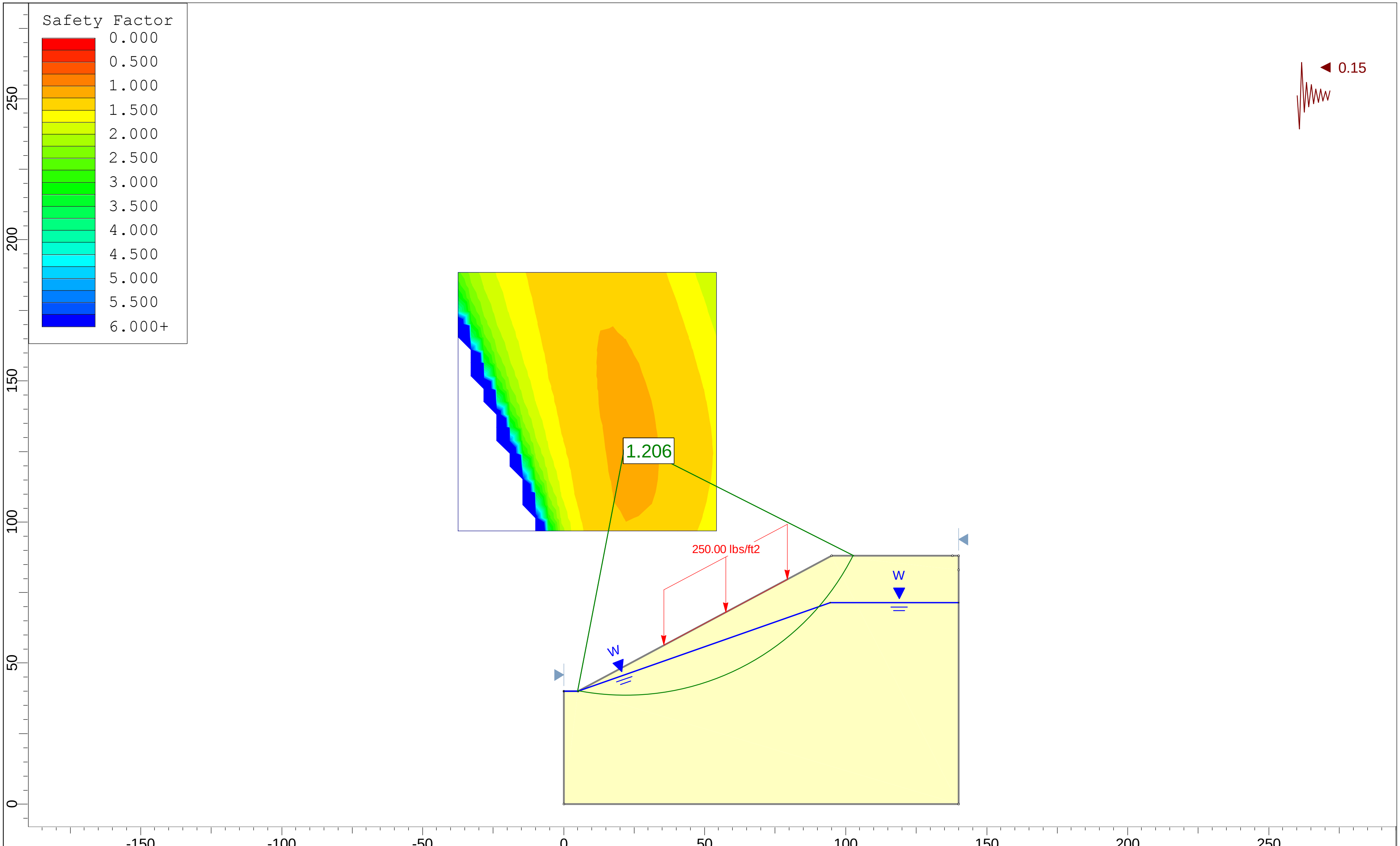
Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By	*Scale* 1:565	*Company*	
Date 6/4/2015, 11:00:54 AM		*File Name* 90th Avenue Section B-B' Seismic Existing Slope.slim	

SLIDEINTERPRET 6.009



Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:565	Company
Date 6/4/2015, 11:00:54 AM		File Name 90th Avenue Section B-B' Static Post Construction.slim	

SLIDEINTERPRET 6.009



SLIDEINTERPRET 6.009

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	*Scale* 1:565
Company	
Date 6/4/2015, 11:00:54 AM	*File Name* 90th Avenue Section B-B' Seismic Post Construction.slim