Report: Geotechnical Investigation

Fairfax Housing Development: Marinda Drive and Ridgeway Avenue Sites, Marin County, California

For Rothman Construction

by
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Introduction

This report presents the results of geotechnical and geological investigations conducted by William W. Moore, PE, GE and Phyllis E. Flack, PG, PE for a proposed multiple housing development located in Fairfax, California. The planned development is comprised of two sites: one off an existing fire road beyond the current end of Marinda Drive and one beyond the end of Ridgeway Avenue. The Marinda Drive location includes nine residential lots (eight approximately 10 acre lots and a one acre lot) and the Ridgeway Avenue property with one 14.6 acre lot.

All proposed residences would be designed to minimize environmental impacts. Specifically, each will be designed to collect, retain and use as much rainfall runoff as is reasonably possible. In addition, impervious paved or solid surface areas will be minimized to reduce runoff and permeable pavement and other “green” surfaces will be used instead.

The general locations of the proposed two sites are shown on Figure 1, Site Vicinity Map. Site topography and lot boundaries for the Marinda Drive and Ridgeway Avenue Lots are shown on Figure 2.

Purpose and Scope

The purpose of the investigation was to develop geotechnical recommendations for the project addressing: foundations, grading, slope stability, retaining walls, earthwork and seismic considerations.

Our scope of work consisted of reviewing readily available published geotechnical and geological data, site reconnaissance, and subsurface investigations. Fieldwork performed under this investigation consisted of drilling 15 test borings on the Marinda Drive property and 1 boring on the Ridgeway Drive property. Pitcher Drilling of East Palo Alto, CA drilled the borings using wheel mounted and track mounted drilling equipment. Drilling was completed during the week of July 4, 2016.

Summary

Ground conditions at all sites were found to be very good to excellent for supporting foundations for residential developments. Sound bedrock was encountered at shallow depths, generally less than 5 feet below ground surface (bgs) on the Marinda Drive sites and at 13.5 feet bgs at the Ridgeway Avenue Site. Soils overlying bedrock consist of dry loose silty soils with very little clay on the Marinda Drive Sites. Soils overlying bedrock at the Ridgway Avenue site consists of silty sand with some clay; strength of these soils increased with depth to very stiff to hard.

No significant geologic hazards, that might preclude development, were observed. Structures may generally be supported on shallow foundations. Surface soils are highly erodible, therefore establishing and maintaining good drainage will be important.

We recommend that Marin County hillside construction practices be followed to safely construct on these properties minimizing adverse impacts to surrounding slopes and vegetation and minimize obstruction of views or altering natural drainages.

Site Soils and Bedrock - Exploration Borings

Boring locations are shown on Figures 2. Borings were drilled to depths from 2 to 18 feet below ground surface (bgs) using a standard mud rotary drilling technique. Rock coring was initiated at or near the top of bedrock utilizing an HQ wireline core recovery system. Bedrock was encountered in our borings at depths ranging from 0.5 to 5 feet bgs on the Marinda Drive site and 14 feet bgs on the Ridgeway property

Boring coordinates and elevations and are provided on Table 1 below.

Table 1. Boring Locations and Elevations

Boring Number	Total Depth (ft BGS)	Lot Number	Location		
			Northing	Easting	Elevation
B-1A	8.0	Lot 1	2190846.0973	5959089.0248	331.93
B-1B	7.0	Lot 1			
B-2A	8.0	Lot 2	2191129.3099	5959017.5318	389.30
B-3A	8.0	Lot 1	2191068.4706	5958891.7168	360.86
B-4A	9.0	Lot 4	2191439.7946	5959180.2626	424.66
B-4B	8.0	Lot 4	2191490.0956	5959149.1611	423.77
B-5A	2.0	Lot 5			Est. 450
B-6A	10.0	Lot 5	2191824.6097	5959123.6858	460.70
B-6B	8.0	Lot 4	2191858.5598	5958961.4935	425.93
B-7A	11.0	Lot 6	2191802.3646	5959221.3869	472.49
B-7B	8.0	Lot 6	2191771.3735	5959260.6687	472.43
B-8A	11.5	Lot 7	2191824.5842	5959336.9196	492.32
B-8B	9.0	Lot 7	2191866.6545	5959366.4590	492.83
B-9A	10.0	Lot 8	2192012.4496	5959439.9989	510.99
B-9B	15.0	Lot 8	2191950.4906	5959421.4369	510.27
B-10	18.0	Lot 9			Est. 355

Source: Oberkamper & Associates Civil Engineers, Inc., Novato, CA, August 2016.

Boring information is summarized in Table 2. Detailed descriptions of the materials encountered in borings are presented in the boring logs in Appendix A.

Table 2. Summary of Boring Information

Boring Number	Total Depth (ft BGS)	Soil Depth (ft bgs)	USCS Soil Description	Top of Bedrock (ft bgs)	Description	Date Drilled
B-1A	8.0	0-3.5	SM	3.5	Sandstone	7/7/16
B-1B	7.0	0-3.5	ML	3.5	Sandstone	7/7/16
B-2A	8.0	0-4.0	SM/GW	4.0	Sandstone	7/7/16
B-3A	8.0	0-1.5	ML	1.5	Sandstone	7/6/16
B-4A	9.0	0-2.0	SM/GW	2.0	Sandstone	7/6/16
B-4B	8.0	0-5.0	ML/SM	5.0	Sandstone	7/6/16
B-5A	2.0	0-0.5	SM/ML	0.5	Sandstone	7/6/16
B-6A	10.0	0-3.5	ML/GW	3.5	Sandstone	7/5/16
B-6B	8.0	0-2.5	ML	2.5	Sandstone	7/6/16
B-7A	11.0	0-3.0	SM/GW	3.0	Sandstone	7/6/16
B-7B	8.0	0-2.0	SM/GW	2.0	Sandstone	7/6/16
B-8A	11.5	0-3.0	ML/GW	3.0	Sandstone	7/5/16
B-8B	9.0	0-3.5	ML/GW	3.5	Sandstone	7/5/16
B-9A	10.0	0-3.0	SM/GW	3.0	Sandstone	7/5/16
B-9B	15.0	0-6.0	SM	6.0	Sandstone	7/5/16
B-10	18.0	0-13.5	SM/CL/ML/SC	13.5	Sandstone/Shale	7/7/16

Local Geology

The Marinda Drive and Ridgeway properties are situated within the Coast Ranges geomorphic province, which is characterized by northwest trending mountain ranges and intervening valleys controlled by folds and faults that resulted from the collision of the Farallon and North American tectonic plates, and subsequent translational shear along the San Andreas Fault system. Uplift occurred in the coastal ranges from 2 million to 16 million years ago (Quaternary to Miocene Geologic Time Periods). Bedrock in the region consists primarily of the Franciscan Complex, a diverse assemblage of sandstone, shale, greenstone, chert and mélange, with lesser amounts of conglomerate, serpentine, calc-silicate rock, schist and other metamorphic rocks. Franciscan Sandstone was the predominant bedrock material encountered in site borings at the Marinda Drive site and interbedded Franciscan Sandstone and shale at the Ridgeway site. Outcrops observed at the site were predominantly Franciscan Sandstone. The Franciscan Formation/Complex materials are generally overlain by shallow soils and surficial silt to silty sand deposits.

Geologic Hazards

Primary geologic hazards for these sites are listed below and detailed in the sections that follow:

- Earthquakes and Seismicity (severe shaking)
- Drainage/Erosion
- Surficial landslides/debris flows on steep slopes
- Expansive soils

Other low risk geologic hazards considered include: seismic induced surface ruptures, liquefaction, differential compaction, settlement, flooding and deep-seated landslides. These hazards were not considered to significantly impact the proposed development.

Earthquakes and Seismicity

The properties are located within the seismically active San Andreas Fault system within the San Francisco Bay region. The US Geologic Survey estimates that within 30 years, there is up to a 70 percent probability of one or more large (magnitude 7 or 8) earthquakes occurring in the San Francisco Bay region due to faults in the region. For our site locations in Fairfax, two faults are of primary importance: San Andreas (about 6 miles to the west) and the Hayward Fault (about 9 miles to the east). Figure 3 shows the identified fault locations and the proposed development areas. No active faults are known to exist on the properties based on identified faults included in the Alquist-Priolo Earthquake Fault Zoning Act of 1972.

Designs will need to accommodate seismic conditions. The very competent soils and bedrock underlying these sites will readily transmit strong earthquake motions and result in high accelerations (shaking) to structures. According to the California Geologic Survey, structures founded on bedrock or very dense soils, present at both the Marinda Drive and Ridgeway Avenue sites, generally withstand earthquakes far better than structures founded on softer soils, fill or bay mud.

While no active or potentially active faults have been identified in the immediate vicinity of the planned developments, severe ground shaking from earthquakes is likely to occur. Specific motion characteristics will depend on the characteristics of the fault generating motions, and the distance to the released energy as well as the magnitude of the earthquake and site-specific geology.

The following information was derived from USGS web site providing seismic design information and tools. Seismic Design Criteria for the Marinda Drive and Ridgeway Avenue sites are summarized below:

Marinda Drive Lots

- USGS Site Class B – Rock
- Seismic Design Category D

Ridgeway Avenue Lot

- USGS Site Class C – Very Dense Soil and Soft Rock

- Seismic Design Category D

Summary and Detailed USGS Reports using USGS on-line software are provided in Appendix B.

Drainage and Erosion

Surface soils throughout both sites have a high silt content resulting in a high susceptibility to erosion. Controlling and directing surface runoff in order to minimize erosion will be very important. Surface drainage within building sites, as well as above and below the site should be designed to keep surface water away from building areas and minimize runoff flows toward steep slopes. All runoff should be directed into existing natural drainages, roadside ditches or culverts. Interceptor drainage ditches should be constructed near the top and bottom of existing and new cut slopes. Specific recommendations for house sites are provided in subsequent sections and on Figures 4 and 5.

Surficial Landslides and Debris Flows

The steep slopes in the area have potential for localized debris flows (mud flows). The use of well engineered slopes, swales, V-ditches, waddles, seeding, and other erosion control practices should be used to minimize concentrated runoff flows and erosion.

The Marinda Drive sites generally face south-southwest. No indications of deep-seated slope instability were observed at either the Marinda Drive or Ridgeway sites. Surficial expressions of localized areas of slope instability (shallow scarps and debris flows) were observed upslope of the current end of pavement at Marinda Drive. A local resident reported that mudflows/debris flows have occurred in the past; with a significant debris flow occurring about two years ago following a heavy rainfall. No slope or surface instability areas were identified at the Ridgeway Avenue site.

Expansive Soils

The silty soils present throughout most of the development the area are not considered to be expansive. Based on field observation and classification, some of clay soils may have significant expansive characteristics. Clayey soils encountered on Ridgeway Avenue Lot were tested found to have expansive characteristics. When building layouts are determined additional soil testing within building footprints may be appropriate. At the Ridgeway Avenue site some additional exploration may be needed to evaluate the expansion potential of underlying clayey soils. It is possible that other areas within the Marinda Drive lots may also have zones of expansive soils. The potential for encountering expansive soils should be considered when planning developments. Expansive soils are not considered to be as critical as the other geologic hazards described previously.

Groundwater

Groundwater was not observed in the test borings during our investigation. No springs, seeps or vegetation indicating the presence of high ground water were identified at either site. Groundwater conditions vary with the seasons and annual fluctuations in weather. Below average rainfalls have occurred within the last few years; it is expected that a general rise in groundwater would occur after average or above average rainfall years, which will increase flows in all drainage pathways and could affect basements and foundations.

Foundations Conditions

Excellent foundation materials were found at both the Marinda Drive and Ridgeway Avenue proposed building sites. Sound bedrock was encountered at shallow depths (generally less than 5 feet bgs) on Marinda Drive sites. Soils consist of loose, dry silty soils and overlying weathered bedrock. Bedrock on the Ridgeway site was encountered at a depth of 13.5 feet (bgs). Overlying soils at the Ridgeway Avenue site are silty sand with some clay grading to stiff to hard strength at about 3 feet depth (bgs).

Three lots (6, 7 and 8) of the nine Marinda Drive sites contain areas that were graded previously (about 50 years ago) for home sites. The remaining sites (designated in this study as Lots 1, 2, 3, 4, 5 and 10) have not been graded; they are moderately steep (slopes 15 to 20 degrees) and will require significant cutting and filling to create building sites.

The Ridgeway Avenue site (Lot 9) is located on the top of a broad east-west aligned ridge, which has not been graded. Moderate cutting and filling will be necessary to create a building site.

Building Codes and Regulations

All design and construction activities should be conducted in full compliance with all applicable laws and regulations, including recent updates. The following represents a partial tabulation of key regulatory documents.

- California 2013 Building Code, Volume 2; Special attention to Chapter 16 and 16A Structural Design; Chapter 18 and 18A Soils and Foundations and Appendix J.
- Marin County "Stormwater Quality Manual for Development Projects in Marin County" and Bay area Stormwater Management Agencies Association guidance should be the basis for Stormwater runoff control designs and construction. Ref. BASMAA (Bay Area Stormwater Management Agencies Association) ref. Stormwater Control Plan for Small Projects/Single-Family Homes.

- Town of Fairfax: Guide Papers on the Planning Process, Zoning and especially important "Hill Area Residential Development (HRD) Overlay Ordinance.

Foundation Design Recommendations

The following foundation design recommendations were made based on soils and bedrock encountered in drilled borings. The lot sizes are large and irregularly shaped; and any plan to design a home outside of the footprint containing drilled borings will require additional geotechnical evaluation. Ten home sites were investigated and 4 basic types of foundation conditions were encountered. The table below summarizes the site types.

Site Type	Home Site Numbers	Foundation Materials
Previously Graded	Marinda Lots 2, 6, 7 and 8	Bedrock at or near ground surface
Ungraded Sloping Sites	Marinda Lots 1, 3, 4 and 10	Sloping site with bedrock at or near ground surface
Ungraded Heavily Wooded Knoll	Marinda Lot 5	Hard Rock Knoll
Ungraded on broad ridge line	Ridgeway Avenue Lot 9	Very Stiff to Hard Silty Sand/Sandy Silt

Previously Graded Sites

For previously graded sites, shallow foundations bearing directly on the bedrock are recommended. Foundations may be slab-on-grade, stem walls or spread footings. For foundations bearing on bedrock a design bearing pressure of 4,000 pounds per square foot (psf) may be used. For lateral loads, passive pressure in the bedrock may be calculated using an equivalent fluid density of 400 psf, neglecting the upper eight inches. A foundation bottom friction factor of 45percent may be used.

Slab foundations should be deepened at the perimeter. The minimum slab thickness should be 8 inches, with the perimeter deepened to 16 inches below the nearest adjacent grade.

If the bearing surfaces, after excavation, are variable, then all foundation elements should be tied together by grade beams or as a slab.

Foundations founded on clean sound bedrock are expected to experience minimal settlement.

Ungraded Sloped Sites

For ungraded sloped sites, a level building pad may be created by cutting back into the hillside, allowing shallow foundations to bear directly on bedrock. Under this scenario the recommendations stated previously for the graded sites may be used. Alternatively, piers may be drilled into the bedrock. Piers should extend a minimum of 5 feet into sound bedrock, with an 18-inch minimum diameter and appropriate vertical and spiral/stirrup steel reinforcement. Piers may be designed for skin friction of 800 psf from one foot below the top of rock. All piers should be tied together with a grid of grade beams. Settlement for this construction is expected to be minimal.

These two types of foundations may be combined, that is one part of the house on rock cut (with a slab foundation) and one part of the house on drilled piers. While minimal settlement is expected from either foundation system, there may be small differential movements between the two types of foundations. The house structure should be designed to accommodate such movements. One method to practically eliminate differential movements/settlements is to support the home structure on robust grade beams supported on rock surfaces at the up-hill side and on piers on the downhill side. Piers and grade beams should be rigidly tied together.

Ungraded Heavily Wooded Knoll Site

The ungraded heavily wooded knoll site should be cleared and graded over a limited area. For foundation support we recommend a grid of grade beams cut into the rock and extending laterally beyond the knoll to accommodate the building footprint desired. Depending on the footprint of the house, some piers may be used on slopes to support some of the beams beyond the central graded area. This concept can support many different home footprints. Design parameters described previously for either slab or pier foundations may be used.

Ridgeway Avenue Site

The ungraded ridgeline site at Ridgeway Avenue will have foundations in very stiff to hard soils. We recommend either a grid of grade beams or a slab-on-grade foundation with deepened perimeter areas. Alternatively spread-footing foundations may be used where the entire footing is excavated in to very stiff to hard soils. To minimize differential movements, all foundation elements should be rigidly tied together. Settlements are expected to be minimal. The potential for expansive soils should be considered during foundation design.

Slab on Grade

A slab-on-grade foundation may be used on all sites subject to some constraints. The most suitable sites are those previously graded where sound bedrock is very near the surface. Sloped sites can accommodate slabs, provided the slab is entirely supported on cut rock surfaces. Marinda Lot 6 may be constrained by the limited area on top of the knoll (in the vicinity of boring 5A). The Ridgeway site will accommodate a slab because the near surface soils are very stiff to hard silty soils with variable clay content that are much easier to cut, grade than the rocky Marinda Drive sites.

Where slabs are used, we recommend structural slabs of an 8-inch minimum thickness reinforced by layers of steel rebar at the top and bottom. We do not recommend the use of thin slabs (on the order of 3'' to 5" thickness), because they nearly always crack and sealing them against water intrusion is not usually successful. Placing any slab on a variable subgrade, such as cut and fill, will result in uneven settlement and cracking.

All slabs should be underlain by a prepared, graded subgrade with gravity drainage pathways routed to points or collection areas well outside the building footprint. A layer of compacted free draining material such as clean, crushed drain rock (1-inch minus), at least, 4" thick should be placed under the slab area and in the drainage pathways. This free draining crushed rock or similar material should be compacted with vibratory plate type compaction equipment.

An impermeable layer of 80 mil HDPE or similar should be placed over the compacted free draining material to form a water and moisture stop. Care will be required to minimize risks of penetrating this layer either by the compacted material below or whatever material is placed above. For living areas it is recommended that a waterproofing expert be consulted.

Additional controls may be required for the Ridgeway Drive site to address potentially expansive soils, if the presence of these materials are confirmed within the building design footprint.

Retaining Walls (up to 8 feet, base to top)

Retaining walls should be founded on the same sound bedrock (for the Marinda Lots) or very stiff/hard soils (for the Ridgeway Avenue Lot) as building foundations. Design bearing pressure should be 4,000 psf. For free standing retaining walls, it is recommended that they be designed to slope back into the slope by approximately 5 degrees. For level backfills, design for lateral soil pressure of equivalent fluid density of 50 pounds per cubic foot (pcf). For uphill-sloped (<20%)backfill of natural soils/rocks use an equivalent fluid density of 65 pcf. Bottom friction of 45% may be used for clean rock surfaces to resist lateral soil pressures. Passive soil resistance may be calculated with an equivalent fluid density of 400 pcf, neglecting the upper 6 inches of sound material. A minimum factor of safety of 1.5 should be used against overturning or lateral sliding. If additional lateral resistance is needed, intermittent 1.5 foot deep keyways may be incorporated.

For retaining walls connected to structures or otherwise restrained at the top, an equivalent fluid density of 75 pcf for level backfill and 85 pcf for 2H:1V (horizontal to vertical) uphill-sloped backfill.

All retaining walls should extend above backfill level by 6 inches for level backfill and one foot for uphill-sloped backfill.

For earthquake loads, an additional uniform lateral load of 16H (where H is the height of the wall in feet) equivalent fluid density is recommended. The Factor of Safety should be at least 1.2 for this transient loading condition. Design soil/rock bearing pressures may b increased by 1/3 during transient loading (seismic & wind).

All retaining walls must have full back drains, except for the top 6 inches that should be compacted soil of low permeability. The drainage material should consist of clean, very permeable rock or gravel, for at least 8 inches immediately behind the wall and drain to a 4-inch diameter or larger perforated pipe at the bottom. Drainage material and pipe should be fully enclosed by non-woven geotextile filter fabric. See Figure 4.

The drainpipe should slope downward at about 2 percent minimum grade and have cleanout access. The perforated drainpipe may be connected to solid drainpipe to combine with other collected runoff from roof gutters. A bentonite seal should be placed just upstream of the connection between perforated and solid pipe.

Earthwork

All earthworks should be performed in full compliance with the California Code of Regulations - Sections on Soils and Foundations. Earthwork, both cutting and filling, should be minimized to reduce impacts on the natural hillside environment. Similarly, all changes to natural drainage patterns should be minimized while providing proper drainage of building sites, foundations and retaining walls.

Marinda Drive Sites

Excavation of the silty surface soils will be relatively easy. Excavation of the underlying rock will be difficult and should be minimized. It will require ripping hard to very hard rock and extensive work to create level building sites.

Ridgeway Avenue Site

Excavation of the stiff to hard soils will be easier than the Marinda Drive rocky sites. The stiff to hard soils will stand vertically for shallow temporary cuts, under 5 feet during dry conditions. Soil strength will increase with increased depth.

Cut Slopes

The rocky material underlying the silty surface soils will be stable for brief periods - without rainfall. It is recommended that cuts in the rock be sloped back into the hillside with slopes similar to the nearby long standing rock faces; about 1H:1V, or flatter.

Fills

All fill should be started on an essentially level surface. Fills should be compacted in 8-inch (maximum) horizontal lifts. Any fill sections more than 3 feet thick should have a back drains incorporated in the design.

Fill Materials

Soil and rock materials on both sites will be suitable for general fill purposes provided it is properly conditioned. Large rock fragments should be broken up (pieces no larger than 4-inches in maximum dimension) and mixed with available silty/sandy soils. A representative bulk sample of site fill materials should be tested by a soil-testing laboratory (per ASTM D-1557) to determine maximum dry density and optimum moisture content. Fill materials should be moisture conditioned to within a few percent of optimum prior to placement and compaction.

General Fill

General fill- not to support slabs, foundations or pavements – may consist of prepared on-site materials. Fill materials should be moisture conditioned to within 2% of optimum, placed in horizontal lifts less than 8 inches thickness and compacted to 90% of maximum dry density.

Select Fill

Select fill may also consist of prepared on-site materials, moisture conditioned to within 2% of optimum, placed in thin horizontal lifts – less than 6 inches- and compacted to 95% of maximum dry density.

Utility Trench Backfill

Utility trenches backfilled with permeable materials, i.e. sand and gravel, can become conduits routing drainage under foundations and to other undesirable locations. We recommend that utility trenches for branches or laterals off main utility lines be sealed with a compacted bentonite and soil mixture to prevent drainage flowing to homes. This seal should be placed in the trench for the lateral, surrounding the pipe, at the location where the lateral joins the main line. Also, the upper 6-inches of backfill over utility trenches should consist of compacted impermeable material.

Drainage Considerations

These recommendations apply to the geotechnical aspect of the drainage as they affect the stability of the construction lots and nearby slopes. They do not include area drainage, which is within the design responsibility of project civil engineers and landscape professionals. Storm water runoff minimization and control and should be designed to follow best management practices of the California State Water Resources Control Board Phase II NPDES Permit for Small Municipal Storm Sewer Systems and other applicable requirements and regulations.

Positive surface drainage should be provided adjacent to buildings to direct surface water away from the foundations into closed pipes that discharge downslope of proposed buildings (see Figure 4). V-ditches and debris diversion structures as shown in Figure 5 are recommended to intercept and divert rainfall runoff and route rock/soil debris flows around houses.

Surface water and rainwater collected on the roof of the buildings should be transported through gutters, downspouts and closed pipes and routed to suitable discharge facilities or could be stored in tanks on site for later use. Ponding of surface water should not be allowed in any areas adjacent to the structures. To prevent erosion or weakening of the slopes, concentrated flows of water should not be allowed across site slopes. The stormwater runoff dissipation structures, trenches or bioretention structures may also provide appropriate drainage controls. Use of Pervious pavements is recommended to further reduce stormwater runoff flows.

SLOPE STABILITY HAZARD ASSESSMENT FOR DEVELOPMENT

The following information and assessments are provided primarily to assist the project Civil Engineer in evaluating the area hydrology and formulating appropriate measures to minimize the risk of flooding and/or debris flows from occurring.

Plans should be developed to minimize slope instability that could result in slope failures. No evidence of deep-seated slope failures was observed in the area; however shallow, surficial debris flows have been reported in the recent past and will likely continue after site development occurs. It is not expected that the development plans will exacerbate the existing slope instabilities, and careful planning and implementation of runoff controls may reduce the risk and severity of these historic, predevelopment debris flows.

Naturally occurring slope instability results from the type of soils blanketing the surface of the site, depth to bedrock, steep slopes, ground cover and the frequency and intensity of storms and runoff. The following section presents an evaluation completed for potential building sites within the proximity of drilled borings. Typically slope instability in this area develops during or immediately after rainstorm events. Our assessments are therefore closely related to likely stormwater running onto a building site or running off from a building site on to potentially unstable slopes.

Our assessment started at the top of the Marinda Drive development area and proceeded down to the entrance (current end of pavement at Marinda Drive).

Lot 8 (Borings 9A and 9B)

This building site is located near the top of the Marinda Drive Fire Road. This is a graded site, with moderately steep (approximately 30 degrees) rocky up-slope on the north side. The slope is stable but will yield silty debris flows under heavy rainfall conditions. Runoff coming from this site will flow primarily east toward a steep, heavily wooded slope with good grassy ground cover. While this slope appears stable, runoff from the site should be dissipated near the top of the slope or routed to existing natural drainages.

The west side of the site is bounded by the fire road cut. The slope is well vegetated with several trees. Site runoff should be directed into a roadside culvert/drainage ditch (to be constructed when the access road is paved.

The south side of this building site consists of a steep (40 to 50 degree rocky slope). Site drainage should be directed to either east or west side; flow down the south rocky slope should be minimized.

Provided care is taken to control and/or dissipate site runoff to the east, we assess the slope hazards, due to development to be moderate.

Lot 7 (Borings 8A and 8B)

This building site is immediately south of Lot 8. This site is a graded site similar to Lot 8; and stormwater run-on will come only from the rocky up-slope with some grass cover. While the slope is essentially stable, rainfall can cause some silty debris material to wash down onto the site. Site runoff should be directed primarily to the east down-slope (similar to Lot 8 above). Runoff should be dissipated or routed to existing developed drainages. The west side of this site is also bounded by the fire road and a short, moderately steep down-slope with minimal visible rock out crops and some brush ground cover and a few trees. Runoff toward the east and south should be directed to roadside ditches or culverts.

Slope hazards for the east side are rated as moderate, provided drainage is routed to existing drainages and/or dissipation structures.

Lot 5 (Borings 6A and 5A)

Two possible building sites were examined: an upper building site by boring 6A and a building site by 5A.

The 6A site is ungraded on a moderately steep slope west of the Fire road. A road cut runs to the west down the hill to Lot 4 (6B). The 6A site is on an east-west trending ridgeline sloping down to the west. This site will require significant grading to create a level building site. Primary runoff flows will bifurcate to the west, with about one-third flowing into a large deep valley to the north and two thirds flowing to a large deep valley on the south side. This runoff will likely carry silty debris. The north side slope is heavily wooded with thick vegetation. The south side surface cover is a mixture of well-established grass with numerous clumps of trees. The areas north and south of the sites are large, deep, well established valleys.

The area surrounding boring 5A consists of a knoll close to the west side of the Fire road. There is no drainage onto the knoll. Runoff, depending on development will be very small relative to the drainage areas north, west and south of this possible

building site. Depending on final building footprint, there may be some modest volume of runoff on to Lot 4 near borings 4A and 4B.
Because the sites are relatively small (compared to the sizes of the valleys), the volume of additional site runoff after development should be small compared to the sizes of the existing drainages; therefore slope instability hazards related to development of these sites is assessed as relatively low.

Lot 4 (Borings 4A, 4B and 6B)

There are numerous rock outcrops visible along the main Fire Road and the road/track running west to Lot 4 (by boring 6B) from Lot 5, boring 6A. Provided that the Fire road grading and drainage are maintained, there should be essentially no runoff entering the Lot 4 area from the east.

Again, because the likely development area is very small compared to the sizes of the adjacent drainage basins, the impact of development on possible slope hazards is small.

Lot 4 in the vicinity of borings 4A and 4B is graded, adjacent to the Fire Road on the east side and part of the south side. On the north side is predominantly rock cut slope of about 40 degrees. This slope is immediately south of the part of Lot 5 surrounding boring 5A. While there will be runoff from the north it is likely to be primarily silty debris type flow, with no deep slope failures in the bedrock.

The west side of this site is a moderately steep, heavily wooded and densely vegetated. The drainage down-slope to the west is well established. It is estimated that 35% of runoff from this site may flow to the west.

Because stormwater running onto the site from the north and Fire Road, with drainage ditches to the east and south, only a modest volume of runoff is likely to flow down the west slope. We assess the hazard of development creating an impact of the west slope as slight.

Lot 2 (Boring 2A)

The boring 2A site is located on a nose facing south. It is relatively level, but a portion slopes slightly to the east. Based on where the site is situated, there is practically no potential for stormwater to flow onto the site. The Fire Road runs along the west and south sides. The road cuts range from a few feet up to approximately 25 feet high on the south side. The rock outcrops appear stable, however rainfall may cause silty debris flows. Down-slope residents have confirmed that major rainfalls caused silty debris flows down the Fire Road track on to the paved road (Marinda Drive).

We assess the likelihood of significant debris flows on the east, south sides as high. However, the increment caused by runoff from the contributing area of the site development is a relatively small proportion of the total. As in the past, uncontrolled debris flows running down existing cut slopes on to the Fire Road may continue to be problem.

Additionally, we observed a potential problem area on the west side of the Fire Road (opposite side from Boring 2A Site) where loose soil and some debris have been pushed off the road. This area of loose debris is about 20 feet wide by approximately 30 feet long (down the slope) and it may be very unstable when rainfall commences. At a minimum, the Fire road should be graded into the slope, such that runoff will flow to and along the inside (cut side) of the road, to minimize potential for discharges onto the down slope and potential resulting instability.

Lot 2 also includes a large drainage valley just above the current end of the Marinda Drive paved road. This area has been unstable in the past and produced major debris flows that have repeatedly flooded, engulfed the upper portion of Marinda Drive. The most recent example of this occurrence was about 2 years ago (according to a local resident).

Four of the possible building sites located on the east side of the Fire Road (Lots 2, 6, 7 and 8) will contribute some runoff to this slope. Because the lower portion of the basin is currently unstable, even a small increase in runoff, caused by development of these sites will add a very small increment slope instability.

It is suggested that a debris wall could be constructed at the bottom of the drainage, adjacent to Marinda Drive to contain or greatly reduce debris flows. Design of this structure would require detailed drainage, runoff and stability design studies – beyond the scope of our investigation.

Lot 1 (Borings 1A, 2A and 3A)

The boring 3A site is located on the south edge of the Fire Road at the top of a moderately steep grassy slope (35 to 45 degrees), with scattered clumps of trees. The rock is relatively shallow (visible on the road bed cut). Provided the road grade is maintained such that no runoff may flow onto this site, then the south and eastern slopes appear stable. Because the site is well vegetated (with grasses, bushes and some trees) and the runoff volume is low (from this site only – no run-on from the road above), it is anticipated that the impacts from development will be modest. Drainage ditches and diversions to protect this as well as existing downslope properties and houses will be required. Slope instability hazard potential is assessed as low to moderate.

Slope instability hazard associated with the boring 1A site is very similar to conditions surrounding boring 3A. No runoff should be allowed from the Fire Road above.

The area surrounding 1B is about 100 feet south of the Fire Road on a 25 to 30 percent grassy slope with scattered clumps of trees. The slope faces south and becomes steeper below the site. There are established homes about 80 feet further down slope.

There will be runoff flow onto this site from the above slope. Some collection/diversion ditch or wall may be needed as shown in Figure 5. The slope is roughly uniform on the east and west sides and there will be minimal flow on to the site. Because the slope below the site extends to the fence line of existing houses, some collection/diversion of any runoff that occurs is needed. All collected runoff should be routed to the east by south east to existing drainages.

Presently there is loose exposed soil along a track created for drill rig access from the Fire Road to the drill site 1B. These areas of loose, highly erodible soil should be protected with waddles, seeding or other corrective actions before the wet weather season.

The hazard of negative impacts on slope stability from development of this site is high without implementing the drainage collection, improvements described above. With these improvements the slope stability hazard may be reduced to moderate.

Lot 9 (Boring 10)

This site is on a broad knoll near the end of Ridgeway Avenue, with no stormwater runoff entering the site. The north side is heavily wooded and moderately sloped with an abandoned road cut about 150 feet from the site. Runoff contributions from areas to the north will be small compared to the size of the whole hillside. Similarly, the east side consists of a gentle slope (or dip) followed by a slight up-slope to a ridgeline running north, up the hill. A minimal slope instability hazard to the north and east is anticipated related to development of this site.

The west side down-slope steepens with distance from the site. It is also heavily wooded with trees and brush. Runoff from this site to the west will be quite small relative to the size of the western hillside; consequently, only slight slope instability hazard is indicated.

The south side slope consists of a fairly open, grassy moderate slope with a wooded area about 200 feet down slope. Again, because runoff from the site will be small compared to the hillside, minimal slope instability hazard related to development is indicated.

Inspections / Technical Supervision

It is recommended that all grading, earthwork (cuts, fills, backfills) and foundation construction be conducted under the technical supervision of a qualified Civil or Geotechncial Engineer. This designated Engineer should have the authority to review construction plans and approve or modify plans to accommodate specific on-site circumstances. He/She should also confirm that construction work is performed pursuant to the recommendations provided in this report. These inspections should include at least following:

- Grading and cut slopes
- Filling and compaction (including approval of fill materials, moisture conditioning, compaction methods)
- Foundation excavations, including piers – before placement of rebar and pouring of concrete.
- Drainage ditches and other drainage features including placement of filter fabric and drainrock and inspect all drainage discharge points to off site natural drainage courses including review and approval of drainage materials.
- Retaining wall drainage and construction

Future Maintenance

Because of the highly erodible soils present at both sites, a qualified Civil or Geotechncial Engineer should perform periodic inspections of individual sites and area drainages. We recommend inspections be performed at least annually and immediately following major rainstorms (e.g. 2 inches or more within 3 to 4 days).

In addition sites with adjacent upslopes, and/or retaining walls or debris bearers, should also be inspected periodically and after major rainstorms.

It is likely that natural debris (silt, sand, and rocks) will accumulate against walls, debris barriers and in drainage ditches and should be removed in order to minimize possible overtopping of the walls and clogging of drainage paths.

Additional Engineering Services

A qualified Civil or Geotechnical Engineer should work closely with project engineers and architects to review site plans for conformance with the intent of the recommendations presented in this report, and provide inspections and testing as necessary during project construction to assure compliance, and provide a certification of construction compliance at the conclusion of the project.

Limitations on the Use of This Report

The recommendations made in this report are based on the assumption that soil and groundwater conditions do not deviate appreciably from those encountered in the exploratory borings drilled at the two sites. If any variations or undesirable conditions are encountered during future exploration or construction, the effects of these conditions on the recommendations presented herein should be evaluated and modified or supplemented as appropriate.

William W. Moore and Phyllis E. Flack complied with the standards of care and skill ordinarily exercised by members of our profession currently practicing in the same or similar localities in performing our professional services. No other warranty, either expressed or implied, is made or intended in connection with the work we performed.

Prepared by:

William W. Moore, GE	Phyllis E. Flack, PG, PE
WILLIAM WEBBER MOORE No. GE-615 Exp. 06-30-17	PHYLLIS E. FLACK No. 4507 exp. 11/30/17
Geotechnical Engineer #615, exp. 6/30/17 Civil Engineer #18340, exp 6/30/17	Professional Geologist #4507, exp. 11/30/17 Civil Engineer #67169, exp 9/30/18

Fairfax, California

Figure 1. Site Vicinity Map

Source: Apple Maps Application, Apple Inc. 2016

Figure 2. Lot Layout and Boring Location Map

NO.	DATE	REVISION	APP.
1			
2			
3			
4			

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PROJECT-ADDRESS&APN
LANDS OF ROTHMAN
PRELIMINARY LAYOUT ~ GEOLOGY
FAIRFAX MARIN CALIFORNIA

Scale: 1"=200'
Drawn by: HJS
Designed by: LEO
Checked by: LEO
Date: SEPTEMBER 2016

SHEET
C1
OF 1
15-163

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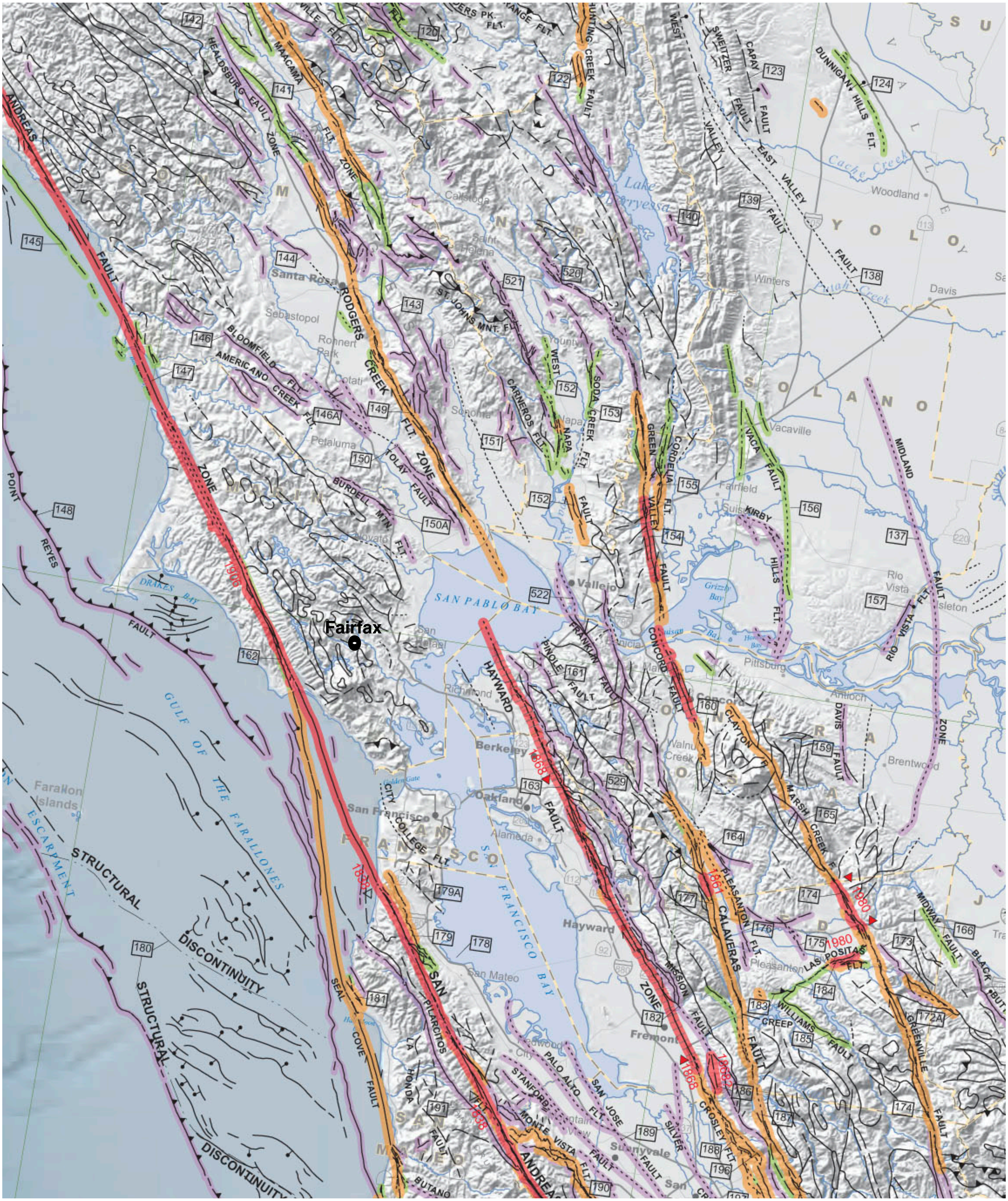

http://www.conservation.ca.gov/cgs/cgs_history/PublishingImages/FAM_750k_ReleaseStatement_SAMPLE.jpg

Figure 3. Fault Location Map

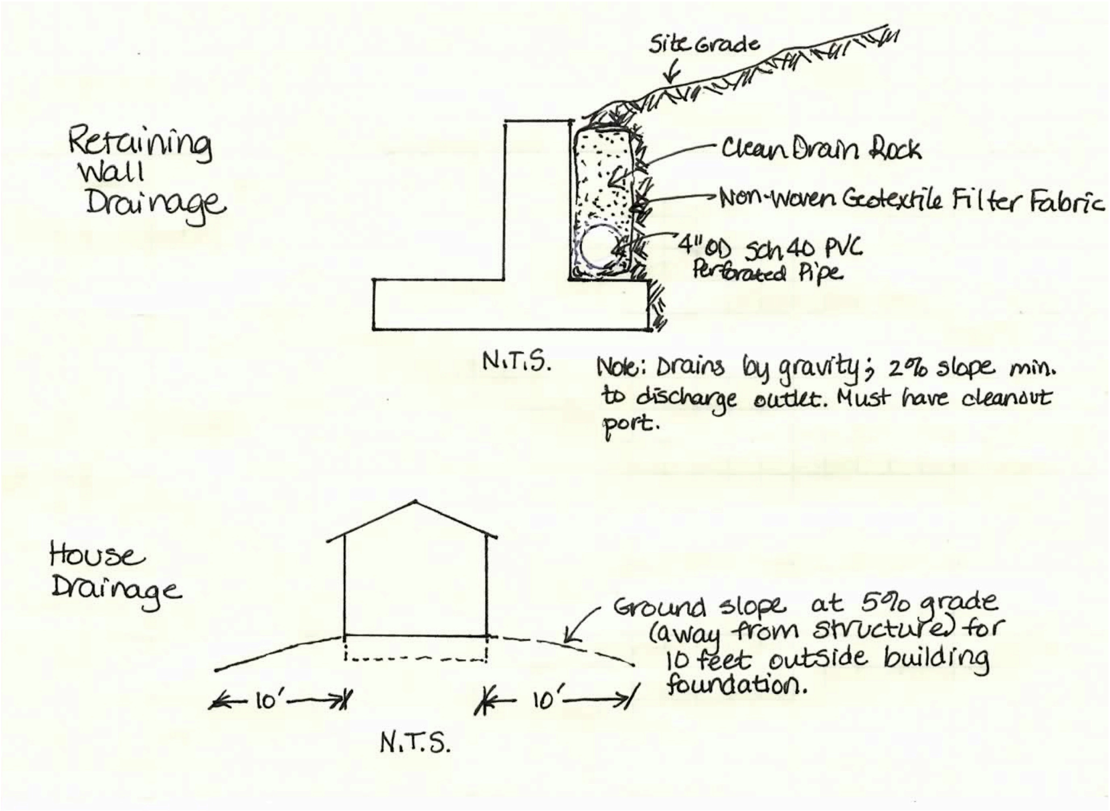

Figure 4. Drainage Details

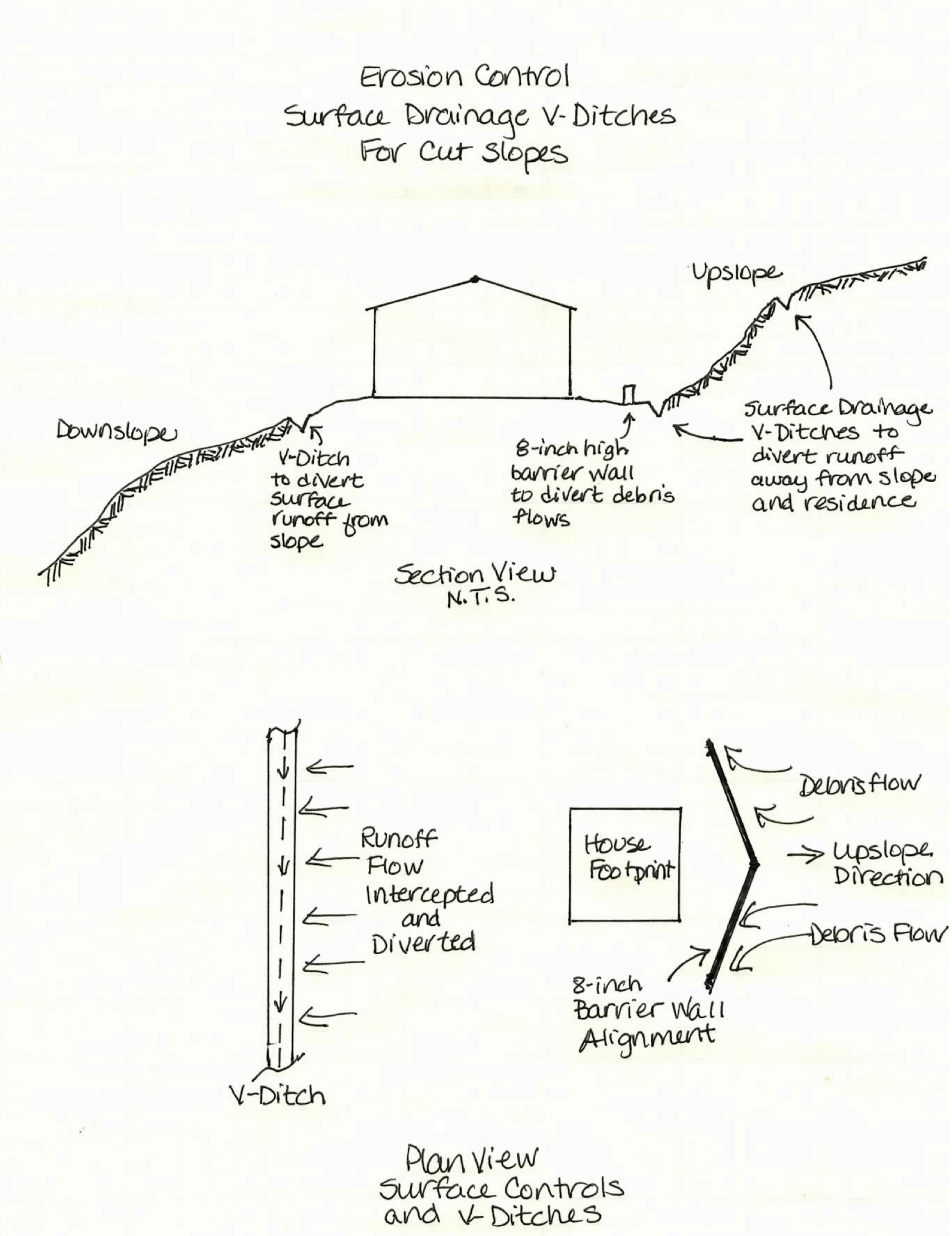

Figure 5. Cut Slope Drainage Details

Appendix A. Boring Logs

UNIFIED SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3 inches and basing fractions on estimated weights)						Group Symbols	TYPICAL NAMES
Coarse-grained Soils More Than Half of Material Is Larger Than No. 200 Sieve Size	The No. 200 U.S. Standard Sieve Is About The Smallest Particle Visible To The Naked Eye	**Gravels** More Than Half of Coarse Fraction Is Larger Than No. 4 Sieve Size	For Visual Classification, The 1/4" Size May Be Used As Equivalent To The No. 4 Sieve Size	**Clean Gravels** (Little or No Fines)	Wide range in grain size and substantial amounts of intermediate particle sizes	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
					Predominately one size or a range of sizes w/some intermediate sizes missing	GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
				Gravels with Fines (Appreciable Amount of Fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty gravels, gravel-sand-silt mixtures
					Plastic fines (for identification procedures see CL below)	GC	Clayey gravels, gravel-sand-clay mixtures
		Sands More Than Half of Coarse Fraction Is Smaller Than No. 4 Sieve Size		**Clean Sands** (Little or No Fines)	Wide range in grain size and substantial amounts of intermediate particle sizes	SW	Well-graded sand or gravelly sands, little or no fines
					Predominately one size or a range of sizes w/some intermediate sizes missing	SP	Poorly-graded sands or gravelly sands, little or no fines
				Sands with Fines (Appreciable Amount of Fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty sands, sand-silt mixtures
					Plastic fines (for identification procedures see CL below)	SC	Clayey sands, sand-clay mixtures

Less than 5% - SW, SP, GW, GP
More than 12% - SM, SC, GM, GC
5%-12% - Borderline cases requiring use of dual symbols

		ID Procedures on Fraction Smaller Than No. 40 Sieve Size					
			Dry Strength (Crushing Characteristics)	**Dilatancy** (Reaction to Shaking)	**Toughness** (Consistency Near Plastic Limit)		
Fine-Grained Soils More Than Half of Material Is Smaller Than No. 200 Sieve Size	The No. 200 U.S. Standard Sieve Is About The Smallest Particle Visible To The Naked Eye	**Silts & Clays** Liquid Limit Less Than 50	None to low	Rapid to slow	None	ML	Inorganic silts, very fine sands, rock flour; silty or clayey fine sands with slight plasticity
			Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			Low to medium	Slow	Low	OL	Organic silts and organic silt-clays of low plasticity
		Silts & Clays Liquid Limit Greater Than 50	Low to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts
			High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
			Medium to high	None to very slow	Low to medium	OH	Organic clays of medium to high plasticity, organic silts
Highly Organic Soils			Readily identified by color, odor, spongy feel and frequently by fibrous texture			PT	Peat and other highly organic soils

SOIL CLASSIFICATION

Must Include

1. Group Symbol
2. Color (Field Moisture Condition)
3. Group Name
4. Particle Size Range
5. Consistency (Soft, Hard, etc.)
6. Moisture content (Dry, Moist, Wet)
7. Structure (Stratified, Laminated, Fissured)
8. Geologic Origin
9. Additional comments indicating soil characteristics which might affect engineering properties (organics, root holes, mica, gypsum, caving, sloughing, loss of drilling water, contamination, etc.)

May Include

10. Percentage of Boulders, Cobbles, Gravel, Sand or Fines
11. Particle Angularity (angular, rounded, etc.)
12. Particle Shape (if appropriate)
13. Maximum Particle Size
14. Hardness of Coarse Particles
15. Cementation (if present)
16. Odor (if Organic or unusual)
17. Local Name (if known)
18. Plasticity of Fines
19. Dilatancy
20. Toughness
21. Reaction with Acid

Example: SM DARK GRAY SILTY FINE SAND with trace of dark gray silty clay (wet) (loose) [FILL] (caving of borehole sides)

Clay Consistency	Thumb Penetration	SPT, N Blows/ft.	Undrained Shear Strength c (PSF)	Unconfined Compressive Strength q_u (PSF)
			TORVANE	POCKET PENETROMETER
Very Soft	Easily penetrated several inches by thumb. Exudes between thumb and fingers when squeezed in hand.	<2	250	500
Soft	Easily penetrated one inch by thumb. Molded by light finger pressure.	2-4	250-500	500-1000
Medium stiff	Can be penetrated over 1/4 inch by thumb with moderate effort. Molded by strong finger pressure.	4-8	500-1000	1000-2000
Stiff	Indented about 1/4 inch by thumb but penetrated only with great effort.	8-15	1000-2000	2000-4000
Very stiff	Readily indented by thumbnail.	15-30	2000-4000	4000-8000
Hard	Indented with difficulty by thumbnail.	>30	>4000	>8000

VARIATIONS IN SOIL STRATIGRAPHY

Descriptive Term	Thickness or Configuration
Parting	- 0 to 1/16 inch thickness
Seam	- 1/16 to 1/2 inch thickness
Layer	- 1/2 to 12 inch thickness
Stratum	- Greater than 12 inch thickness
Pocket	- Small, erratic deposit, usually less than 1 foot
Varved Clay	- Alternating seams or layers of sand, silt & clay (laminated)
Occasional	- One or less per foot of thickness
Frequent	- More than one per foot of thickness
With	- 5 to 15 percent
Trace	- Less than 5 percent

CRITERIA FOR DESCRIBING STRUCTURE

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 1/4 inch thick; note thickness.
Laminated	Alternating layers of varying material or color with the layers less than 1/4 millimeter thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

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Criteria for Describing Angularity of Coarse-grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but having rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width and thickness refer to the greatest, intermediate and least dimensions of a particle, respectively

Flat	Particles with width/thickness >3
Elongated	Particles with length/width >3
Flat & Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Moisture Content

Description	Criteria
Dry	Absence of moisture, dusty, dry to touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb & a hard surface
Very High	The dry specimen cannot be broken between the thumb & a hard surface

Criteria for Describing Dilatancy

Description	Criteria
None	No visible changes in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

Criteria for Describing Toughness

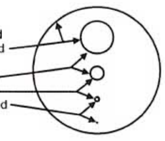
Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to rol l he thread to near the plastic limit. The thread and the lump have medium thickness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbing when drier than the plastic limit

Soil Type	SPT, N blows/ft	Relative Density, %	Field Test
Very loose sand	4	0-15	Easily penetrated with 1/2-in. reinforcing rod pushed by hand
Loose sand	4-10	15-35	Easily penetrated with 1/2-in. reinforcing rod pushed by hand
Medium dense sand	10-30	35-65	Penetrated a foot with 1/2-in. reinforcing rod driven with a 5-lb hammer
Dense sand	30-50	65-85	Penetrated a foot with 1/2-in. reinforcing rod driven with a 5-lb hammer
Very dense sand	50	85-100	Penetrated a few inches with 1/2-in. reinforcing rod driven with a 5-lb hammer

Material	Fraction	Sieve Size	Grain Size	Approximate Scale Size
Boulders		12 inches +	12 inches +	Larger than basketball
Cobbles		3 in to 12 in.	3 in. to 12 in.	Fist-sized to basketball
Gravel	Coarse	3/4 in. to 3 in.	3/4 in. to 3 in.	Thumb-sized to fist-sized
	Fine	No. 4 to 3/4 in.	0.19 in. to 0.75 in.	Pea-sized to thumb-sized
Sand	Coarse	No. 10 to No.4	0.079 in. to 0.19 in.	Rock Salt to pea-sized
	Medium	No. 40 to No. 10	0.017 in. to 0.079 in.	Sugar-sized to rock salt
	Fine	No. 200 to No. 40	0.0029 in. to 0.017 in.	Flour-sized to sugar-sized
Fines (silt/clay)		Passing No. 200	0.0029. in.	Flour-sized and smaller



Source: URS, 1995

Figure A-1. USCS Classification Key

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer blows if crystaline
Very Slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rings under hammer blows if crystaline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 inch. Joints may contain clay. In granite rocks, some occasional feldspar crystals are dull and discolored. Crystaline rock rings under hammer blows.
Moderate	Significant portions of rock show discoloration and weathering effects. In granite rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer blows and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granite rocks, all feldspars dull and discolored and manority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes 'clunk" when struck
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in srength to strong soil. In some granite rocks, all feldspar kaolinized to some extent. Some fragments of strong rock usually remain.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but rock mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers.

Source: After Civil Consulting Group, Inc., 2014

STRENGTH

Very Strong	Resists breakage from hammer blows; but will yield dust and small chips.
Strong	Withstands a few hammer blows; but will yield large fragments.
Moderately Strong	Withstands a few firm hammer blows.
Weak	Crumbles with light hammer blows.
Friable	Can be broken down with hand and finger pressure.

ROCK QUALITY DESIGNATION

RQD	Rock Mass Quality
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
0-25	Very Poor

HARDNESS

Very Hard	Cannot be scratched with a knife; metal powder left on sample
Hard	Scratched with knife with difficulty; trace of metal powder left on samples; scratch faintly visible.
Moderately Hard	Readily scratched with knife, scratch leaves heavy trace of dust and is readily visible.
Low Hardness	Gouged or grooved to 1/16 inch by firm pressure on knife; scratches with penny.
Soft	Gouged or grooved readily with knife; small thin pieces can be broken by finger pressure.
Very Soft	Carves with knife; scratched by fingernail.

Rock Quality Designation (RQD) is the ratio of the total length of core segments longer than 4 inches to the total length of the core run, expressed as a percentage. Mechanical breaks are ignored in the calculation of total length of segments greater than 4 inches long. RQD will always be equal to or less than percent recovery.

Percent Recovery is the ratio of the total length of core recovered to the total length of the core run, expressed as a percentage.

ROUGHNESS OF DISCONTINUITY SURFACES

Smooth	Appears smooth and essentially smooth to the touch. May be slickensided.
Slightly Rough	Asperities on surfaces are visible and distinct.
Medium Rough	Asperities are clearly visible and surface feels abrasive.
Rough	Large angular asperities can be seen. Some ridge and high side angle steps are evident.
Very Rough	Near vertical steps and ridges occur on surfaces.

DISCONTINUITY SPACING

Joints	Bedding, Cleavage, Foliation	Spacing
Very Close	Very thin	Less than 2 inches
Close	Thin	2 inches to 1 foot
Moderately Close	Medium	1 foot to 3 feet
Wide	Thick	3 feet to 10 feet
Very Wide	Very thick	Greater than 10 feet

Figure A-2. Rock Mass Description Key

Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt	**Client:** M. Rothman	B-1A **Sheet** 1 **of** 1
Date(s) Drilled: 7/7/16	**Logged By:** WWM	**Checked By:**	
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Carbide Core Bit	**Total Depth Drilled (m):** 8.0'	
Drilling Rig Type: Fraste- Track Mount	**Drilling Contractor:** Pitcher	**Relative Level:** m	
Groundwater Depth: n/a	**Location:** 37°59'36"N -122°35'28"W mN mE	**Inclination from Horizontal/Bearing:** Vertical 0 deg	
Borehole Backfill: Cement Grout	**Sampler Type:** SPT/ HQ Core Barrel	**Hammer Data:** 140# Automatic	

Relative Level (m RL)	ROCK CORE Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
										FILL - Road Cut Mat'l.						
								1	SM	1.0-2.3 Silt to Siltstone, Lt. Tan, Low strength, hard, dry, low plasticity		5 35 52/4"	87+	10/16 63%	n/a	
								2								
								3		Cleanout						
										- Rock Core sandstone, dk gray, hard, v. slight to fresh weathering, fractures v. close, trace clay infilling along longitudinal cracks						
	1	1	47/48		13"/47"	4'/40min.		4	Franciscan Fm.							
								5								
								6								
								7								
								8		TD 8.0'						
								9								
								10								
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt	**Client:** M. Rothman	B-1B **Sheet** 1 **of** 1

Date(s) Drilled: 7/7/2016 to	**Logged By:** WWM	**Checked By:**
Drilling Method: mud Rotary	**Drill Bit Size/Type:** Carbide Rock Core Bit	**Total Depth Drilled (m):** 7.0
Drilling Rig Type: Fraste-Track mtd.	**Drilling Contractor:** Pitcher	**Relative Level:** m
Groundwater Depth: n/a	**Location:** mN mE	**Inclination from Horizontal/Bearing:** Vertical 0 deg
Borehole Backfill: Cement Grout	**Sampler Type:** HQ Wireline System, SPT	**Hammer Data:** 140# / Automatic

Relative Level (m RL)	ROCK CORE Run No.	Box No.	TCR (%)	Fracture Spacing (I_f)	RQD (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								1		Fill, Loose - pushed up to construct level pad for drilling.						Steep Slope, Grass cover; ≈20° slope.
								2 3	ML	sandy SILT, trace clay, med. brown, v. Stiff, low plasticity, dry.		5 9 12	21	9/18 50%	n/a	
	1	1	40"/42" 95%	1" to 7"	11"/42" 26%	-	-	4 5 6	Franciscan Fm	ROCK CORE Sandstone, med. brown to dk. gray; moderately strong to strong, low to moderately hard, fractures common, F's 20-45°; slight to fresh weathering.						
								7 8 9 10 11 12		TD 7.0'						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt.

Client: M. Rothman

B-2A

Sheet 1 **of** 1

Date(s) Drilled: 7/6/16 to

Logged By: pef

Checked By:

Drilling Method: Mud Rotary

Drill Bit Size/Type: Bucket Auger, TriCone, Carbide Core Bit

Total Depth Drilled (m): 8'

Drilling Rig Type: Failing 1600

Drilling Contractor:

Relative Level: m

Groundwater Depth: n/a

Location: 37.9940 N -122.5915 W mN mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill: Cement Grout Drill Cuttings (Top 2')

Sampler Type: HQ Wireline Core System

Hammer Data: n/a

	ROCK CORE										SOIL SAMPLES	SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0	SM/GW	Silty Sand, Lt tan, with angular gravel (½"+), dry, loose.						
								1		Weathered sandstone, tan, v. highly fractured, spacing (<1")						Drilled with tricone bit to 4', set surf. casing + commence coring @ 4'
								2								
								3								
	1	1	48/48 100%	2"-11"	29"/48" 60%	10 min per ft		4	CL	ROCK CORE clayey infill mat'l top of core. Sandstone, Dk gray with Tan/Rust mottles, strong, moderately hard, slight weathering to fresh, fractures 2"-11" at 20° to Vertical angles.						4' cored in 43 minutes.
								5	Franciscan Fm							
								6								
								7								
								8		TD 8.0'						
								9								
								10								
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

. Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt.	**Client:** M.Rothman	B-3A **Sheet** 1 **of** 1

Date(s) Drilled: 7/6/16 to	**Logged By:** WWM	**Checked By:**
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Bucket Auger Carbide Core Bit	**Total Depth Drilled (m):** 8.0'
Drilling Rig Type: Fraste-Track Rig	**Drilling Contractor:** Pitcher	**Relative Level:** m
Groundwater Depth: n/a	**Location:** 37° 59' 38" N 122° 35' 31" W mN mE	**Inclination from Horizontal/Bearing:** Vertical 0 deg
Borehole Backfill: Cement Grout	**Sampler Type:** SPT HQ Wireline Core System	**Hammer Data:** 140# /Automatic

	ROCK CORE										**SOIL SAMPLES**	**SPT**				
Relative Level (m RL)	**Run No.**	**Box No.**	**T C R (%)**	**Fracture Spacing (I_f)**	**R Q D (%)**	**Drill Rate (mm/min)**	**Discontinuity Data**	**Depth**	**Lithology**	**MATERIAL DESCRIPTION**	**Type Number**	**Blows per 150mm**	**N Value Blows/300mm**	**Recovery (m)**	**Water Content (%)**	**REMARKS**
								0		FILL - Silt with Rock Fragments, dry, loose						Flat graded fill.
								1								
								2	ML	Silt to Siltstone, Lt. Brown, v. hard, grading to sandstone w/ clay infilling along fractures, highly fractured, moderate to slight weathering		6 20 41	61	11/18 61%	n/a	
								3								
	1	1	47/48 98%	0.5" to 6"	6/47 13%			4	Franciscan Fm.	ROCK CORE Sandstone, Dk gray, strong to v. strong, moderately hard, highly fractured to close fractures.						
								5								
								6								
								7								
								8		8.0' TD						
								9								
								10								
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt.	**Client:** M. Rothman	B-4A **Sheet** 1 **of** 1

Date(s) Drilled: 7/6/16 to	**Logged By:** pef	**Checked By:**
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Bucket Auger, Tricone, Carbide Core Bit	**Total Depth Drilled (m):** 9.0'
Drilling Rig Type: Failing 1600	**Drilling Contractor:** Pitcher	**Relative Level:** m
Groundwater Depth: n/a	**Location:** 37°59'42"N 122°35'27" W mN mE moved 20' SW of orig. location	**Inclination from Horizontal/Bearing:** Vertical 0 deg
Borehole Backfill: Cement grout (tremied) cuttings-top 2'	**Sampler Type:** HQ Wireline Core System	**Hammer Data:** n/a

Relative Level (m RL)	ROCK CORE Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
										Surf-grass, shrubs veg.						
								0 1	SM/ GW	Silty sand w/ Angular to subangular gravels up to 1", tan, loose, dry						Bucket auger to 3'; tricone to 5' BGS.
								2 3		Wtx Sandstone						
								4		Sandstone						
	1	1	48/48 100%	2" to 8"	36/48 75%			5 6 7 8	Franciscan Fm.	Dk. gray sandstone w/ rust and white mottles. V. few fractures, clean- no infilling. Strong, v. slightly weathered to fresh. Moderately hard to hard.						
								9 10 11 12		TD 9.0'						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt.	**Client:** M. Rothman	B-4B **Sheet** 1 **of** 1

Date(s) Drilled: 7/6/16 to	**Logged By:** WWM	**Checked By:**
Drilling Method: Mud Rotary	**Drill Bit Size/Type:**	**Total Depth Drilled (m):** 8.0
Drilling Rig Type: Fraste - track mt.	**Drilling Contractor:** Pitcher	**Relative Level:** m
Groundwater Depth: n/a	**Location:** 37°59'42"N 122°35'28"W mN mE	**Inclination from Horizontal/Bearing:** Vert. 0 deg
Borehole Backfill: Cement grout	**Sampler Type:** SPT & HQ wireline core system	**Hammer Data:** 140# /Automatic

	ROCK CORE										SOIL SAMPLES					
												SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I,)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0		Fill - Lt. Brown SILT with rock fragments. Hard at 16"						
								1								
								2	ML	Lt. Brown SILT, v. stiff, sand content increasing at 3.0, dry	1	8 18 11	22	8/18 44%	n/a	
								3	SM/ML							
								4	SM	sandy silt, Lt. Brown, dry, v. stiff	2	6 11 19	20	11/18 61%	n/a	
								5		ROCK CORE						
	1	1	35"/36" 97%	½" to 3"	0			6	Franciscan Fm	sandstone, med. brown to dk. gray; weak to moderately strong; soft to low hardness moderate weathering. Tree/shrub roots @ 6' BGS.						
								7		Strength increased to strong to very strong, hardness increased to moderately hard to v. hard; weathering slight to v. slight.						
								8		TD 8.0'						
								9								
								10								
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt.	**Client:** M.Rothman	B-5A **Sheet** 1 **of** 1
Date(s) Drilled: 7/6/16 to	**Logged By:** WWM	**Checked By:**	
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Bucket Auger - 6"	**Total Depth Drilled (m):** 2.0'	
Drilling Rig Type: Fraste - Track Mt.	**Drilling Contractor:** Pitcher	**Relative Level:** m	
Groundwater Depth: n/a	**Location:** 37°59'43"N 122°35'27"W mN mE	**Inclination from Horizontal/Bearing:** Vertical 0 deg	
Borehole Backfill: Drill Cuttings	**Sampler Type:** 6" Bucket Auger	**Hammer Data:** n/a	

	ROCK CORE										SOIL SAMPLES	SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I,)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	**MATERIAL DESCRIPTION**	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	**REMARKS**
								0		topsoil						V. Steep, tough access, no water source available for drilling.
								1		sandstone, Lt. Tan, v. hard, cemented, no fractures to few fractures, dry. (Cored w/ Bucket Auger)	1 2	@1.0 BGS @1.8'BGS to 2.0'				
								2		TD 2.0'						
								3								
								4								
								5								
								6								
								7								
								8								
								9								
								10								
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda	**Project No.:** **Project Reference:** RothmanFairfax Develpt.	**Client:** M. Rothman	B-6A **Sheet** 1 **of** 1

Date(s) Drilled: 7/5/16 **to**	**Logged By:** WWM	**Checked By:**
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Tricone Carbide Core Bit	**Total Depth Drilled (m):** 10.0
Drilling Rig Type: Fraste Track Rig	**Drilling Contractor:** Pitcher	**Relative Level:** m
Groundwater Depth: n/a	**Location:** 37°59'45" N 122°35'28" W mN mE	**Inclination from Horizontal/Bearing:** Vertical 0° deg
Borehole Backfill: Cement Grout	**Sampler Type:** SPT HQ Wireline Core System	**Hammer Data:** 140#/ Automatic

	ROCK CORE									**MATERIAL DESCRIPTION**	**SOIL SAMPLES**					**REMARKS**
												SPT				
Relative Level (m RL)	**Run No.**	**Box No.**	**TCR (%)**	**Fracture Spacing (I_f)**	**RQD (%)**	**Drill Rate (mm/min)**	**Discontinuity Data**	**Depth**	**Lithology**	Surf-Scrubgrass	**Type Number**	**Blows per 150mm**	**N Value Blows/300mm**	**Recovery (m)**	**Water Content (%)**	
								0		Topsoil						
								1	ML/GW	Silt to Sandstone, Lt tan, hard, low plasticity dry	1	17 18 25	43	10/18 56%	n/a	
								2								
								3								
										V. hard sandstone, mod. weathering tan to gray; dry	2	27 50/4"		7/10 70%	n/a	
								4								
										ROCK CORE						
	1	1	58"/60" 97%	1/2" to 4"	8"/60" 13%	5'/30min 1'/6min.		5	Franciscan Fm	sandstone, moderate to close fractures, dk gray, clay infilling along some fractures, ∡0-90°, weak to moderately strong, low to moderate hardness; moderately severe to slight weathering, v. close to close fractures						
								6								
								7								
										7.5'. Strength & hardness increasing, weathering decreasing. Moderately strong to v. strong; moderately hard to v. hard; slight to fresh weathering						
								8								
								9								
								10								
										TD 10.0'						
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt.

Client: M. Rothman

B-6B

Sheet 1 **of** 1

Date(s) Drilled: 7/6/16 **to**

Logged By: WWM

Checked By:

Drilling Method: Mud Rotary

Drill Bit Size/Type: Bucket Auger, Carbide Rock Core Bit

Total Depth Drilled (m): 8.0'

Drilling Rig Type: Fraste / Track mt.

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth: n/a

Location: 37°59'46"N 122°35'30"W mN mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill: Cement grout

Sampler Type: SPT / HQ Wireline Core System

Hammer Data: 140# Automatic

Relative Level (m RL)	ROCK CORE: Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SPT: Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0		Topsoil, grading into brown silt. dry.						
								1 2	ML	Brown, silt (wtx sandstone/ Siltstone), w/tr. clay, stiff, low plasticity, dry		1 4 10	14	9/18 50%	–	
								3		Sandstone/ Highly fractured, moderate weathering						Cleanout Boring
								4	GW/ Bedrock			6 13 16	29	13/18 72%	–	
	1	1	35"/36" 97%	4" to 13"	31"/36" 86%			5 6 7 8	Franciscan Fm.	ROCK CORE Sandstone, dk gray to Black, moderately strong to strong, low hardness to hard (increasing with depth), moderate to v. slight weathering; fractures 45° to 80° (∡'s)						
								9 10 11 12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

. Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt

Client: M. Rothman

B-7A

Sheet 1 **of** 1

Date(s) Drilled: 7/6/16 to

Logged By: pef

Checked By:

Drilling Method: Auger, Mud Rotary

Drill Bit Size/Type: Bucket auger, Carbide Core Bit

Total Depth Drilled (m): 11'

Drilling Rig Type:

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth:

Location: 37°59'45" N 122°36'27" W mN mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill:

Sampler Type: Bucket Auger, SPT HQ Wireline Core System

Hammer Data: 140# / Automatic

	ROCK CORE										SOIL SAMPLES					
												SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0 1	SM/ML	Silty sand to sandy SILT, Lt. Tan, w/ angular gravels, loose, dry.						est. 1-2" topsoil
								2 3 4	SM/GW	Rock content increasing.		50/5"	100+	5"/5" 100%	–	Refusal @ 2.5' bgs.
	1	1	32"/42" 76%		4.5"/42" 11%	3.5'/35 min 1'/10 min		5 6 7 8	Franciscan Fm	ROCK CORE Sandstone, dk gray, strong, moderately hard, highly fractured, rust mottles along fractures, fracture ∡'s 30-60°, fracture infilling - cemented w/ silica; clay infilling @ 7.8'						Circulation lost @ 8.5' pulled string. Clay plugged carbide core bit @ ≈7.8'
	2	1	25"/30"	2.5-3.0"	0	2.5'/34 min. 1'/13.6 min.		9 10	↓	Sandstone, dk gray, abundant fractures (20° to nearly vertical); clayey matte infilling at 10.5' bgs. Rust colored mottles, slightly to moderately weathered, strong to moderately strong						
								11 12		TD = 11.0'						

NOTES: Soil classification via AS 1726 - 1993

Borehole log to be read in conjuction with cover sheet.

Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt.

Client: M.Rothman

B-7B

Sheet 1 **of** 1

Date(s) Drilled: 7/6/16 to

Logged By: pef

Checked By:

Drilling Method: Mud Rotary

Drill Bit Size/Type: Tricone, Carbide Core Bit

Total Depth Drilled (m): 8.0'

Drilling Rig Type: Failing 1600

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth: n/a

Location: 25' East of 37° 59'44" N 122° 35'27" W (Moved) mN mE

Inclination from Horizontal/Bearing: Vert. 0 deg

Borehole Backfill: Cement grout

Sampler Type: HQ wireline core system

Hammer Data: n/a

Relative Level (m RL)	ROCK CORE Run No.	Box No.	TCR (%)	Fracture Spacing (l	RQD (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0	SM/GW	Silty SAND, Lt. tan w/ abundant angular gravel, loose, dry						Sitting on nose of hillside - angular gravel on ground surface - up to 3"
								1 2 3 4	GW/Bedrock	Weathered Sandstone, grading to moderately weathered sandstone. Angular fragments, rust colored mottles, dk. gray fresh surfaces. Hard Ledge @2.8' Hard Ledge @4.0'						Rock drilling w/ tricone bit.
	1	1	36"/36"	1" to 5"	9/36 25%			5 6 7	Franciscan Fm	ROCK CORE Sandstone, dk. gray w/ rust mottles & white mottles, fracture ∡'s 20-75°, no preferentrial ∡'s. Slight weathering to fresh, moderately hard to hard, strong.						Rock Coring Rates: 5'-6' (5min) 6'-7' (5min) 7'-8' (13min) Pressure ≈150 psi.
								8 9 10		TD 8.0'						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

. Miranda	**Project No.:** **Project Reference:** Rothman Fairfax Develpt	**Client:** M. Rothman	B-8A **Sheet** 1 **of** 1
Date(s) Drilled: 7/5/16 to	**Logged By:** pef	**Checked By:**	
Drilling Method: Mud Rotary	**Drill Bit Size/Type:** Bucket Auger, Carbide Core Bit	**Total Depth Drilled (m):** 11.5'	
Drilling Rig Type: Fraste / track	**Drilling Contractor:** Pitcher	**Relative Level:** m	
Groundwater Depth: n/a	**Location:** 37°59'46" N 122° 35' 25" W mN mE	**Inclination from Horizontal/Bearing:** Vertical 0 deg	
Borehole Backfill: cement grout	**Sampler Type:** SPT/HQ Wireline Core System	**Hammer Data:** 140#/Automatic	

Relative Level (m RL)	ROCK CORE							Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES					REMARKS
	Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data				Type Number	SPT Blows per 150mm	SPT N Value Blows/300mm	Recovery (m)	Water Content (%)	
								0		Topsoil- v. sparse, silty sand to sandy SILT, dry.						
								1	ML/SM	silt to silty sand. Lt. Tan. w/ trace Gravel (angular), residual soil to severe weathering. v. hard, dry Rock content increasing, degree of weathering decreasing ↓.		50/6"	100+	6"/6"	-	
								2								
								3		ROCK CORE						
								4								
	1	1	36"/36" 100%	1.5" to 3.5"	11"/36" 31%			5	Franciscan Fm.	Sandstone, Dk gray w/Rust colored mottles, strong to v. strong; hard; v. slight to fresh weathering. Fracture ∡'s 0° to 45°.						
								6								
								7								
	2		42"/42" 100%	1" to 9"	25.5"/42" 61%			8	↓	Same as Run 1.						
								9								
								10								
								11		TD 11.5'						
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt.

Client: M. Rothman

B-8B **Sheet** 1 **of** 1

Date(s) Drilled: 7/5/16 **to**

Logged By: pef

Checked By:

Drilling Method: Mud Rotary

Drill Bit Size/Type: Bucket Auger, Carbide Core Bit

Total Depth Drilled (m): 9'

Drilling Rig Type: Fraste - Track

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth: n/a

Location: 37°59'45"N 122°35'26"W mN mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill: cement grout

Sampler Type: SPT/HQ Wireline Core System

Hammer Data: 140# Automatic

	ROCK CORE										SOIL SAMPLES					
												SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0	FILL	Site Fill- Silty sand w/gravel						
								1	ML	Silt to Siltstone/Sandstone, Lt to med tan, hard, dry. (Residual soil grading to mod. severely weathered rock ↓).		17 32 34	66	12/18 67%	–	
								2								
								3		Boring cleanout						
									GW Bedrock	Weathered Siltstone/Sandstone, Brown/gray, hard.		50/6"	100	6"/6" 100%		
								4		Sandstone, fractured Dk. gray						
								5		ROCK CORE						
	1	1	44"/48" 92%	½" to 4"	4"/48" 8%	4'/110min. (1'/27min)		6	Franciscan Fm.	Sandstone, dk gray w/ rust/brown mottles, weak to moderately strong; low to moderate hardness; moderate to slight weathering, highly fractured. Fracture ∡'s 0° to 60°.						
								7								
								8		Fracture spacing 2" to 4"						
								9		TD 9.0'						
								10								
								11								

NOTES: Soil classification via AS 1726 - 1993

[illegible]

Miranda	Project No.: Project Reference: Rothman Fairfax Develpt	Client: M. Rothman	B-9A Sheet 1 of 1
Date(s) Drilled: 7/5/16 to	Logged By: pef	Checked By:	
Drilling Method: Mud Rotary	Drill Bit Size/Type: Bucket Auger, Tricone, Carbide Core Bit	Total Depth Drilled (m): 10'	
Drilling Rig Type: Failing 1600	Drilling Contractor: Pitcher	Relative Level: m	
Groundwater Depth:	Location: 37° 59' 47" N 122° 35' 25" W mN mE	Inclination from Horizontal/Bearing: Vertical 0 deg	
Borehole Backfill: Cement Grout	Sampler Type: Bucket Auger, HQ Wireline Core System	Hammer Data: n/a	

	ROCK CORE										SOIL SAMPLES	SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (l i)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0	SM/GW	Siltysand w/ Angular gravels to cobbles (sandstone), loose, dry						Grab Sample from Bucket Auger
								1		Lt. tan silty SAND w/ angular sandstone cobbles, loose, dry						
								2	GW	Rock content increasing to well graded gravel, w/ trace silt. Hard at 2.5'						
						5min/ft.		3								
								4								Drilling 4.0-5.0' pressure 200psi.
	1	1	12"/12" 100%	2" +/-	0	1'/14min.		5	Franciscan Fm.	ROCK CORE Sandstone, dk gray w/ rust mottles, moderately strong to strong, mod. hard, slight to fresh weathering, Highly fractured, 45-60° ∡s.						
	2	1	48"/48" 100%	1"-5"	13"/48" 27%			6 7 8 9		Fracture ∡'s 45°-70°, mod. strong to strong, slightly weathered to fresh, some fractures infilled with cementatious mat'l, rust coloration along fractures.						
								10		TD 10'						
								11								
								12								

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Miranda

Project No.:

Project Reference: Rothman Fairfax Develpt

Client: M. Rothman

B-9B

Sheet 1 **of** 2

Date(s) Drilled: 7/5/16 to

Logged By: pef

Checked By:

Drilling Method: Auger/ Mud Rotary

Drill Bit Size/Type: Tricone, carbide Core Bit

Total Depth Drilled (m): 15.0'

Drilling Rig Type: Failing 1500

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth: n/a

Location: 37° 59' 47" N 122° 35' 25" W mN mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill: cement grout

Sampler Type: SPT/HQ Wireline Core System

Hammer Data: 140 # Automatic

Relative Level (m RL)	ROCK CORE Run No.	Box No.	T C R (%)	Fracture Spacing (I_f)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0 1 LOCAL FILL from Leveling Building Pad	SM	Silty Sand, Lt to med. tan w/ angular gravels (up to 2", sandstone), loose, dry						Roots to ≈6-8"
								2		Grading to dense		9 18 19	37	6"/18" 33%	—	Poor recovery - mostly wtx. rock, bottom 6".
								3	SM/GW	Silty sand w/ siltstone/ sandstone (highly weathered), Lt tan, soft rock crumbly, dry.		20 23 41	65	13"/18" 72%	—	
								4 5				46 42 30	72	12"/18" 67%		
								6 7		Silty sand to wtx. sandstone, yellowish brown, dense, dry.		26 40 50/1.5"	100+	13"/14" 93%		
								8		Boring Cleanout						
85'	1	1	30"/30" 100%		12"/30" 40%			9 10	Franciscan Fm	~~ROCK CORE~~ Sandstone, dk gray to brown, rust mottles along fractures, fractures 30-60°, moderately strong to strong, well indurated, moderately hard.						
	2	1	48"/48" 100%		26"/48" 54%	10 min per ft.		11 12		con't p.2 of 2.						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

. Miranda

Project No.:
Project Reference:
Client:
B-9B (con't) **Sheet** 2 **of** 2

Date(s) Drilled: 7/5/2016 to
Logged By: pef
Checked By:
Drilling Method:
Drill Bit Size/Type:
Total Depth Drilled (m):
Drilling Rig Type:
Drilling Contractor:
Relative Level: m
Groundwater Depth:
Location: mN mE
Inclination from Horizontal/Bearing: deg
Borehole Backfill:
Sampler Type:
Hammer Data:

	ROCK CORE										SOIL SAMPLES	SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
	2	1	100		54	10min/ft.		12 13 14		Dk gray sandstone V.slight to fresh weathering, moderately hard to hard, rust colored mottles along fractures (30 to 60°∡'s), med. rough to rough fracture surfaces.						Does not break w/ hammer- Scratch w/ Knife.
								15		TD 15.0'						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Ridgway

Project No.:

Project Reference: Rothman Fairfax Develpt.

Client: M. Rothman

B-10

Sheet 1 **of** 2

Date(s) Drilled: 7/7/16 to

Logged By: pef

Checked By:

Drilling Method: Mud Rotary

Drill Bit Size/Type: Bucket Auger, Tricone, Carbide Core Bit

Total Depth Drilled (m): 18.0

Drilling Rig Type: Failing 1600

Drilling Contractor: Pitcher

Relative Level: m

Groundwater Depth: n/a

Location: 37° 59' 27" N mN 122° 35' 19" W mE

Inclination from Horizontal/Bearing: Vertical 0 deg

Borehole Backfill: cement grout

Sampler Type: SPT, HQ Wireline Core System

Hammer Data: 140# / Automatic

	ROCK CORE										SOIL SAMPLES	SPT				
Relative Level (m RL)	Run No.	Box No.	T C R (%)	Fracture Spacing (I	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	Type Number	Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								0 1	SM	Med brown to Lt. Tan silty SAND w/ trace angular gravels, dry, loose to med. dense.						
								2 3	SM/ML	Silty sand to sandy SILT, trace clay, dense, dry to moist, med. tan to brown.		18 22 22	44	9"/18" 50%	Tr.	
								4	ML/CL	Silty CLAY to clayey SILT, low plasticity, med. tan to yellowish brown, v. stiff to hard, crumbles easily, tr. moisture		10 14 13	27	11"/18" 61%	Tr	
								5 6	CL/ML	same		14 18 21	39	12"/18" 67%	Tr	
								7 8	SC/CL	Sandy CLAY to clayey SAND, med tan-brown, low plasticity, v. stiff/med. dense, trace moisture		9 12 15	27	5"/18" 28%	Tr	
								9		gray mottles @ 10'		11 11 21	32	13"/18" 72%	Tr	
								10 11	CL	Sandy CLAY, med tan, v. stiff to hard w/ tr. sandy silt, tr. moisture		10 25 38	63	12"/18" 67%	tr.	
								12		con'td. p. 2 of 2						

NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Ridgeway

Project No.:
Project Reference:
Client:

B-10 con't. **Sheet** 2 **of** 2

Date(s) Drilled: 7/7/16 to
Logged By: PEF
Checked By:
Drilling Method:
Drill Bit Size/Type:
Total Depth Drilled (m):
Drilling Rig Type:
Drilling Contractor:
Relative Level: m
Groundwater Depth:
Location: mN mE
Inclination from Horizontal/Bearing: deg
Borehole Backfill:
Sampler Type:
Hammer Data:

Relative Level (m RL)	ROCK CORE Run No.	Box No.	T C R (%)	Fracture Spacing (I)	R Q D (%)	Drill Rate (mm/min)	Discontinuity Data	Depth	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type Number	SPT Blows per 150mm	N Value Blows/300mm	Recovery (m)	Water Content (%)	REMARKS
								12	CL/SC	Clayey SAND to sandy CLAY, yellowish brown, v. hard, highly wtx. shale/sandstone w/greenish gray mottles + rust mottles		18 29 34	63	10"/18" 56%		
								13								
	1	1	31"/48" 65%		0	13min/ft		14	Franciscan Fm	ROCK CORE Interbedded sandstone and claystone - Rust to med. brown, highly weathered, low hardness, weak.						
								15								
				½" to 2"		10min/ft		16		Highly fractured @ 16.5'						
						22min/ft.		17		Dk. gray sandstone, hard, strong. Fractures 30-60°∠'s Clayey fracture infill mat'l 17.5-18.0'						
								18		18' TD.						
								19								
								20								
								21								
								22								

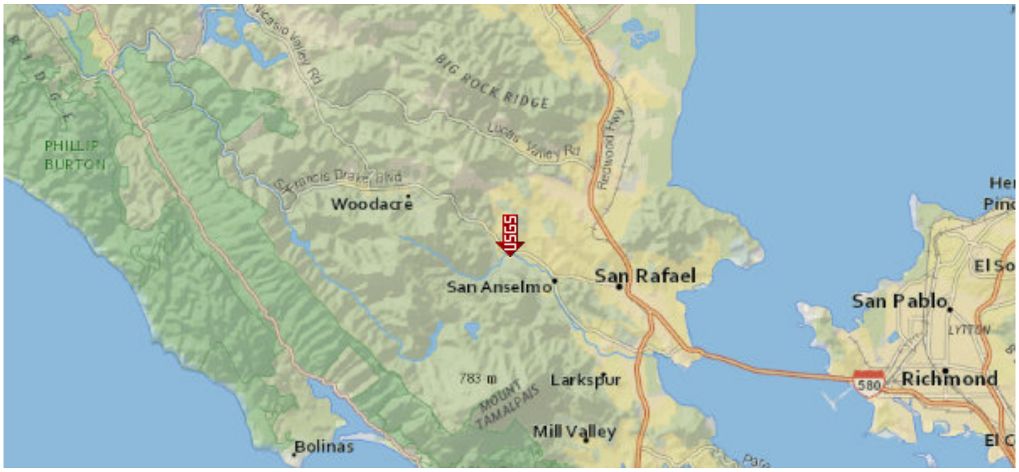
NOTES: Soil classification via AS 1726 - 1993
Borehole log to be read in conjuction with cover sheet.

Appendix B. Seismic Design Parameters

USGS Design Maps Summary Report

User–Specified Input

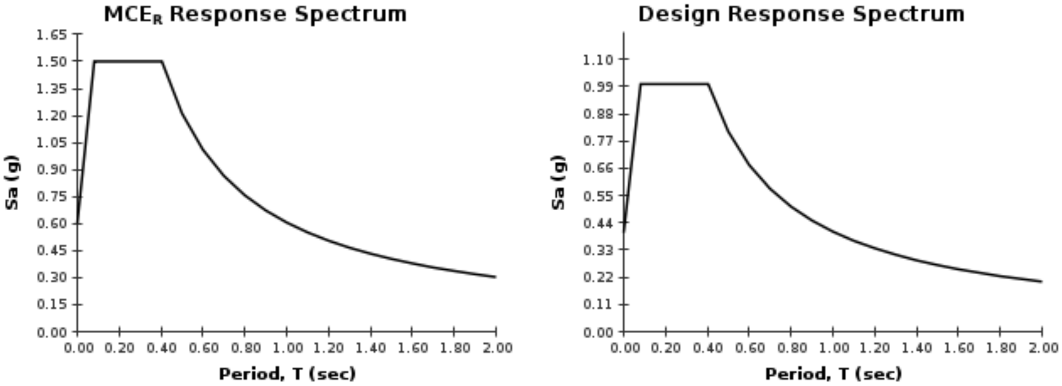
Report Title	MARINDA DRIVE Sat October 29, 2016 18:33:19 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	37.99415°N, 122.58654°W
Site Soil Classification	Site Class B – “Rock”
Risk Category	I/II/III



USGS–Provided Output

S_S = 1.500 g	S_{MS} = 1.500 g	S_{DS} = 1.000 g
S_1 = 0.606 g	S_{M1} = 0.606 g	S_{D1} = 0.404 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.



For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Detailed Report

ASCE 7-10 Standard (37.99415°N, 122.58654°W)

Site Class B – "Rock", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1] [1]	$S_S = 1.500$ g
From Figure 22-2 [2] [2]	$S_1 = 0.606$ g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class B, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_S$	$\bar{N}$ **or** $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = B and S_s = 1.500 g, F_a = 1.000

Table 11.4–2: Site Coefficient F_v

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = B and S_1 = 0.606 g, F_v = 1.000

Equation (11.4–1): $S_{MS} = F_aS_S$ = 1.000 x 1.500 = 1.500 g

Equation (11.4–2): $S_{M1} = F_vS_1$ = 1.000 x 0.606 = 0.606 g

Section 11.4.4 — Design Spectral Acceleration Parameters

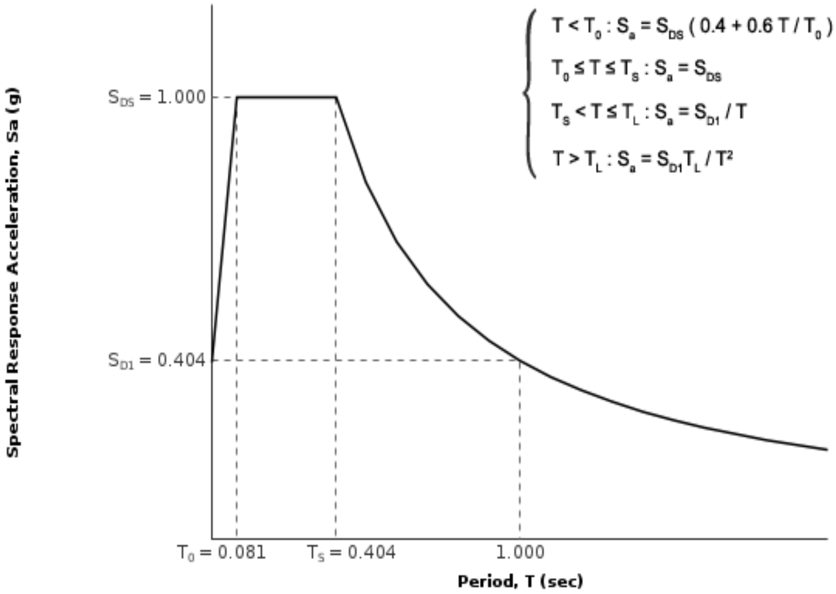
Equation (11.4–3): S_{DS} = ⅔ S_{MS} = ⅔ x 1.500 = 1.000 g

Equation (11.4–4): S_{D1} = ⅔ S_{M1} = ⅔ x 0.606 = 0.404 g

Section 11.4.5 — Design Response Spectrum

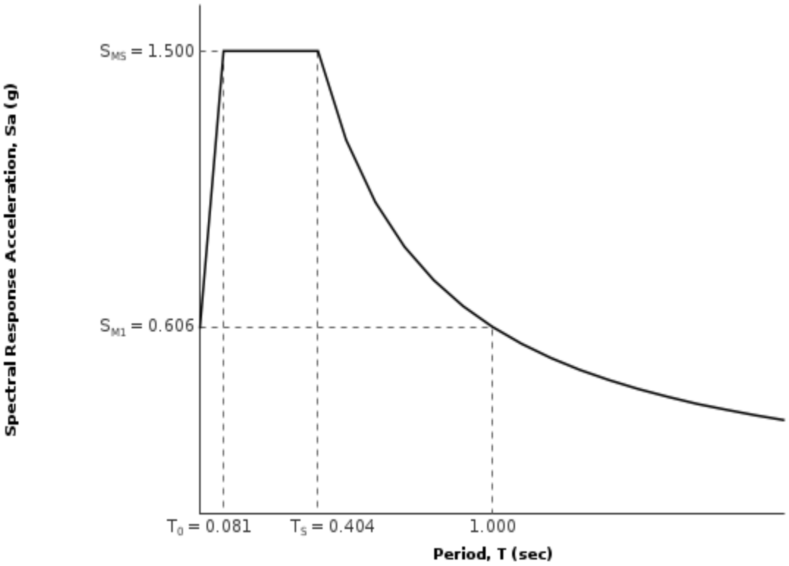
From Figure 22-12 [3] [3] T_L = 12 seconds

Figure 11.4–1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] [4] PGA = 0.537

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.000 \times 0.537 = 0.537$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = B and PGA = 0.537 g, F_{PGA} = 1.000

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Sei Design)

From Figure 22-17 [5] [5] C_{RS} = 1.047

From Figure 22-18 [6] [6] C_{R1} = 0.996

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 1.000 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.404 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

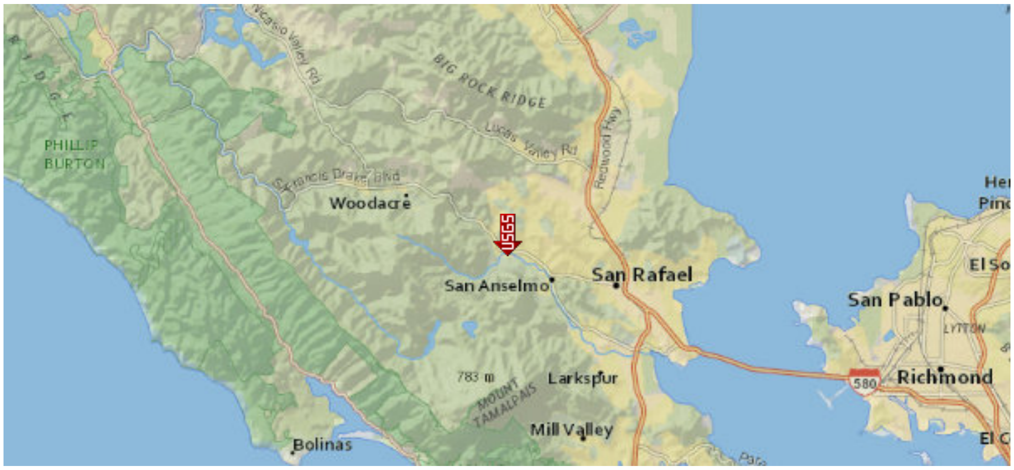
References

1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

Design Maps Summary Report

User–Specified Input

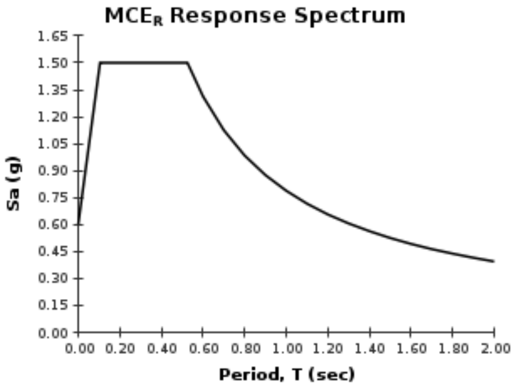
Report Title	Ridgewway Sat October 29, 2016 18:37:19 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	37.99415°N, 122.58654°W
Site Soil Classification	Site Class C – “Very Dense Soil and Soft Rock”
Risk Category	I/II/III

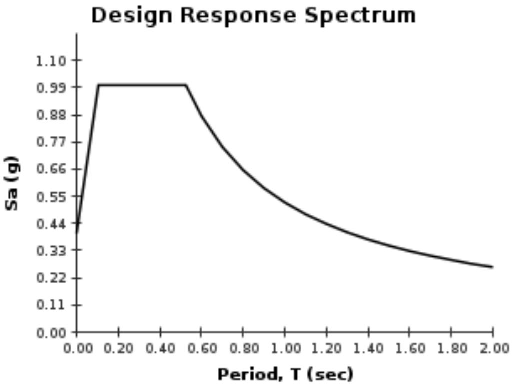


USGS–Provided Output

S_S =	1.500 g	S_{MS} =	1.500 g	S_{DS} =	1.000 g
S_1 =	0.606 g	S_{M1} =	0.788 g	S_{D1} =	0.525 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.


MCE_R Response Spectrum


Design Response Spectrum

For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Detailed Report

ASCE 7-10 Standard (37.99415°N, 122.58654°W)

Site Class C – “Very Dense Soil and Soft Rock”, Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1] [1]	$S_S = 1.500$ g
From Figure 22-2 [2] [2]	$S_1 = 0.606$ g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_S$	$\bar{N}$ **or** $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MC Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = C and S_s = 1.500 g, F_a = 1.000

Table 11.4–2: Site Coefficient F_v

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = C and S_1 = 0.606 g, F_v = 1.300

Equation (11.4–1): $S_{MS} = F_aS_S = 1.000 \text{ x } 1.500 = 1.500 \text{ g}$

Equation (11.4–2): $S_{M1} = F_vS_1 = 1.300 \text{ x } 0.606 = 0.788 \text{ g}$

Section 11.4.4 — Design Spectral Acceleration Parameters

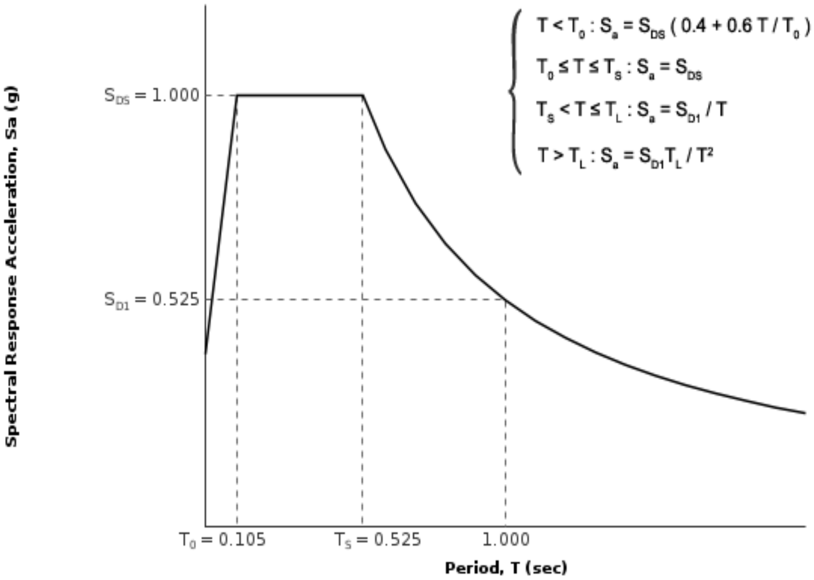
Equation (11.4–3): $S_{DS} = ⅔ S_{MS} = ⅔ \text{ x } 1.500 = 1.000 \text{ g}$

Equation (11.4–4): $S_{D1} = ⅔ S_{M1} = ⅔ \text{ x } 0.788 = 0.525 \text{ g}$

Section 11.4.5 — Design Response Spectrum

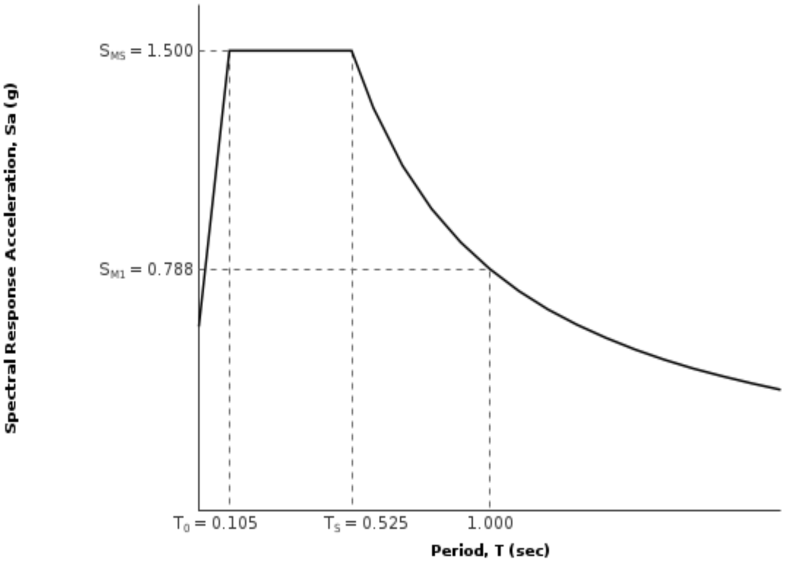
From Figure 22-12 [3] [3] $T_L = 12$ seconds

Figure 11.4–1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] [4]	PGA = 0.537
Equation (11.8–1):	$PGA_M = F_{PGA}PGA = 1.000 \times 0.537 = 0.537$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = C and PGA = 0.537 g, F_{PGA} = 1.000

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] [5]	C_{RS} = 1.047
From Figure 22-18 [6] [6]	C_{R1} = 0.996

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 1.000 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.525 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

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1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
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5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf