Staff Report for Administrative Hillside Review Approval

Weber County Planning Division

Synopsis

Application Information

Application Request:	Consideration and action on a Hillside Review Application for 1013 N Valley View Dr., Eden.
Type of Decision:	Administrative
Applicant:	Ronald A. Barone Living Trust
File Number:	HSR 2021-03

Property Information

Project Area:	1.49 Acres
Zoning:	Forest Valley (FV-3) Zone
Existing Land Use:	Vacant
Proposed Land Use:	Residential
Parcel ID:	20-105-0002

Adjacent Land Use

North:	Vacant	**South:**	Open Space A, Reserve at Crimson Ridge
East:	Valley View Drive	**West:**	Vacant

Staff Information

Report Presenter:	Tammy Aydelotte taydelotte@webercountyutah.gov 801-399-8794
Report Reviewer:	RG

Applicable Ordinances

- Title 101 (General Provisions) Section 7 (Definitions)
- Title 104 (Zones) Section 14 (Forest Valley Zone FV-3)
- Title 108 (Standards) Chapter 14 (Hillside Development)
- Title 108 (Standards) Chapter 22 (Natural Hazard Areas)

Background and Summary

The applicant is requesting approval of a Hillside Review for lot 2R of The Reserve at Crimson Ridge Cluster Subdivision Phase 1 (see **Exhibit A**). Only two lots within this subdivision were platted as restricted lots due to their steep slopes.

The applicant has submitted a geotechnical and geologic hazards investigation prepared by Western Geologic. The hazards evaluation cites the following levels of hazard:

Earthquake Ground Shaking	High Risk
Landslides/Slope Stability:	High Risk
Shallow Groundwater:	Moderate Risk
Problem Soil	Moderate Risk
Rock Fall:	Low Risk
Surface-Fault Rupture:	Low Risk
Liquefaction:	Low Risk
Debris-Flows and Flooding Hazards:	Low Risk

- Regarding Earthquake ground shaking, the submitted report details the following:

  Given the above information, earthquake ground shaking is a high risk to the site. The hazard from earthquake ground shaking can be adequately mitigated by prudent design and construction.

- Regarding Landslides and slope failures, the submitted report details the following:

  We recommend stability of the slopes be evaluated in a geotechnical engineering evaluation prior to building based on site specific data and subsurface information included in this report. Recommendations for reducing the risk from landsliding should be provided if factors of safety are determined to be unsuitable. The stability evaluation should take into account possible perched groundwater and fluctuating season levels, and care should also be taken that site grading does not destabilize slopes in this area without prior geotechnical analysis and grading plans. Water and improper slope cuts appear to be significant factors in slope instability in the site area. Therefore, it is critical that proper drainage be maintained, and that all cuts are engineered and retained properly.

- Regarding the moderate risk for shallow groundwater, the hazards report explains the following:

  Given the existing data, it is expected that groundwater levels will fluctuate both seasonally and annually, and the risk associated with shallow groundwater hazards is considered moderate. Spring thaw and runoff are likely to significantly contribute to elevated groundwater conditions. However, shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of basement levels, or constructing basements with foundation drains.

- Regarding the moderate risk for problem soils, the hazards report explains the following:

  A geotechnical engineering evaluation should therefore be performed to address soil conditions and provide specific recommendations for site grading, subgrade preparation, and footing and foundation design.

In conclusion, the Western Geologic report states the following: *"Earthquake ground shaking and landslides are identified as geologic hazards posing a high relative risk to the project. Shallow groundwater and problem soils also pose a moderate risk. The following recommendations are provided to reduce risk from these hazards and for proper site development:*

- ***Excavation Inspection** – This report does not reflect subsurface variations that may occur laterally away from the exploration trenches and test pits. The nature and extent of such variations may not become evident until course of construction, and are sometimes sufficient to necessitate structural or site plan changes. Thus, we recommend that we inspect the building footing or foundation excavation to recognize any differing conditions that could affect the performance of the planned structure.*
- ***Geotechnical Investigation** – A design-level geotechnical engineering study should be conducted prior to construction to: (1) address soils conditions at the site for use in foundation design, site grading, and drainage; (2) provide recommendations regarding building design to reduce risk from seismic acceleration; (3) evaluate and provide recommendations regarding shallow groundwater and subsurface drainage; and (4) evaluate stability of slopes at the site, including providing recommendations for reducing the risk of landsliding if the factors of safety are deemed unsuitable, based on the geologic characterizations provide in this report and site-specific geotechnical data. The stability evaluation should account for possible perched groundwater and seasonal fluctuations*
- ***Excavation Backfill Considerations** – The trench and test pits may be in areas where structures could subsequently be placed. However, backfill may not have been replaced in the excavations in compacted layers. The fill could settle with time and upon saturation. Should structures be located in an excavated area, no footings or structure should be founded over the excavations unless the backfill has been removed and replaced with structural fill, if the fill is to support a structure. "*

As such, planning staff recommends that all recommendations within the geotechnical and geologic hazards report be followed as this site is developed. Prior to receiving a certificate of occupancy, the applicant will need to provide a letter from the geologist and geotechnical engineer, stating that all recommendations were followed as the house was constructed.

The following section is staff's review of the hillside review requirements of Weber County Land Use Code 108-14 Hillside Development Review Procedure and Standards.

Planning Division Review

The Planning Division Staff has determined that, in compliance with review agency conditions, the requirements and standards provided by the Hillside Review Chapter have been met for the excavation and construction of the dwelling. The following submittals were required:

1. Engineered Plans (see **Exhibit B**)
2. Geotechnical and Geologic Hazard Investigation (see **Exhibit C**).
3. Topographical site Plan (see **Exhibit D**)

Weber County Hillside Review Board comments

The Weber County Hillside Review Board, on this particular application, made the following comments and conditions:

Weber County Engineering Division: The Engineering Division have reviewed the proposed single-family home and have conditioned their approval on the following:

1. Follow the recommendations of the Geologic Hazards Evaluation created by Western Geologic, LLC. Prepared on July 8 2016.
2. Follow the recommendations of the Geotechnical Study created by GSH Geotechnical, Inc. Prepared on August 16, 2016.

Weber Fire District: The Fire Marshall has reviewed and approved this single-family home. Impact fee $315.00

Weber County Building Inspection Department: The Building Department has reviewed and approved this single-family home project, conditioned upon meeting all review agency requirements. Any and all conditions that may be imposed by the Building Department through the Building Permit Process will be applicable and contingent upon this hillside review approval.

Weber-Morgan Health Department: The Health Department has not yet provided a review of this project. Any review comments that may arise from the Health Department prior to the issuance of a Certificate of Occupancy shall be applicable and contingent upon this hillside review approval.

Weber County Planning Division: The Planning Division recommends approval subject to the applicant complying with all Hillside Review Board requirements and conditions. This recommendation for approval is also subject to the findings and conditions listed below.

Planning Division Findings

Staff recommends approval of HSR 2021-03 subject to all review agency requirements and the following conditions:

1. Development of the lot must follow all recommendations outlined in the geotechnical and geologic hazards investigations prepared by GSH Geotechnical Inc., and Western Geologic LLC, respectively.
2. A notice of natural hazards must be recorded against the property before a certificate of occupancy is issued for the proposed single-family residence.
3. Once the dwelling is complete, and prior to the issuance of a certificate of occupancy, the applicant must provide a letter from the geologist and geotechnical engineer, that states the home was built in accordance with the geologic hazards study and the geotechnical report recommendations.

The recommendation for approval is based on the following findings:

1. The application was submitted and has been deemed complete.
2. The requirements and standards found in the Hillside Development Review Procedures and Standards Chapter have been met or will be met during the excavation and construction phase of the dwelling.
3. The Hillside Review Board members reviewed the application individually and have provided their comments.
4. The applicant has met or will meet, as part of the building permit process and/or during the excavation and construction phase of the dwelling, the requirements, and conditions set forth by the Hillside Review Board.

Administrative Approval

Administrative approval of HSR 2021-03 is hereby granted based upon its compliance with the Weber County Land Use Code. This approval is subject to the requirements of applicable review agencies and is based on the findings listed in this staff report.

Date of Administrative Approval: 5/24/21

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Rick Grover

Weber County Planning Director

Exhibits

A. Hillside Review Application
B. Engineered Building Plans
C. IGES Geotechnical and Geologic Hazard Investigation
D. Topographical Site plan

Area Map

Exhibit A – Hillside Review Application

Weber County Hillside Review Application

Application submittals will be accepted by appointment only. (801) 399-8791. 2380 Washington Blvd. Suite 240, Ogden, UT 84401

Date Submitted / Completed	*Fees (Office Use)*	*Receipt Number (Office Use)*	*File Number (Office Use)*

Property Owner Contact Information

Name of Property Owner(s): Ron Barone		Mailing Address of Property Owner(s)
Phone: 818-823-6560	Fax	
Email Address: Ron Barone 123@gmail.com		Preferred Method of Written Correspondence ☐ Email ☐ Fax ☐ Mail

Authorized Representative Contact Information

Name of Person Authorized to Represent the Property Owner(s): Kiet L. Land To Sky Construction Inc. Bovero		Mailing Address of Authorized Person: 5018 E. Whispering Pines Ln. Eden, UT. 84310
Phone: 801-497-1746	Fax	
Email Address: landtoskyconstruction@gmail.com		Preferred Method of Written Correspondence ☒ Email ☐ Fax ☐ Mail

Property Information

Project Name: Barone Res.	Current Zoning
Approximate Address: 1013 N. ~~[illegible]~~ Valley View Dr. Eden, UT. 84310	Land Serial Number(s): 20-105-00
Subdivision Name / Lot Number(s): Reserve at Crimson Ridge Lot #2R	

Project Narrative

Build a single Family Dweling

Property Owner Affidavit

I (We), Ron Barone Ronald Anthony Barone, depose and say that I (we) am (are) the owner(s) of the property identified in this application and that the statements herein contained, the information provided in the attached plans and other exhibits are in all respects true and correct to the best of my (our) knowledge.

_______________ (Property Owner)   _______________ (Property Owner)

Subscribed and sworn to me this 27th day of APRIL, 20 21

HINA AZAM
NOTARY PUBLIC - CALIFORNIA
COMMISSION # 2295572
LOS ANGELES COUNTY
My Comm. Exp. May 14, 2023

_______________ (Notary)

Authorized Representative Affidavit

I (We), Ron Barone Ronald Anthony Barone the owner(s) of the real property described in the attached application, do authorized as my (our) representative(s), Land Tosky / Kieth Bovero, to represent me (us) regarding the attached application and to appear on my (our) behalf before any administrative or legislative body in the County considering this application and to act in all respects as our agent in matters pertaining to the attached application.

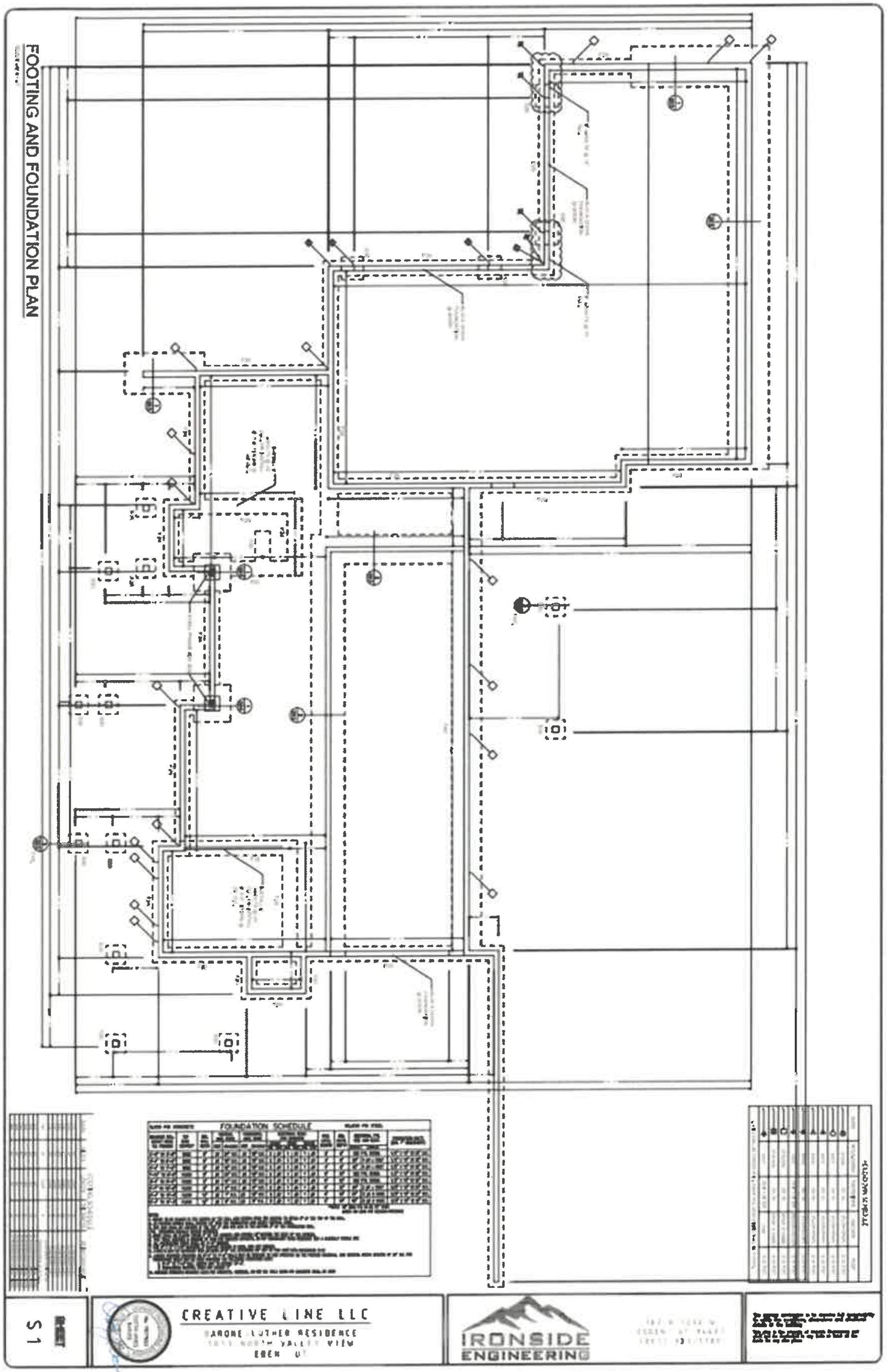
_______________ (Property Owner)   _______________ (Property Owner)

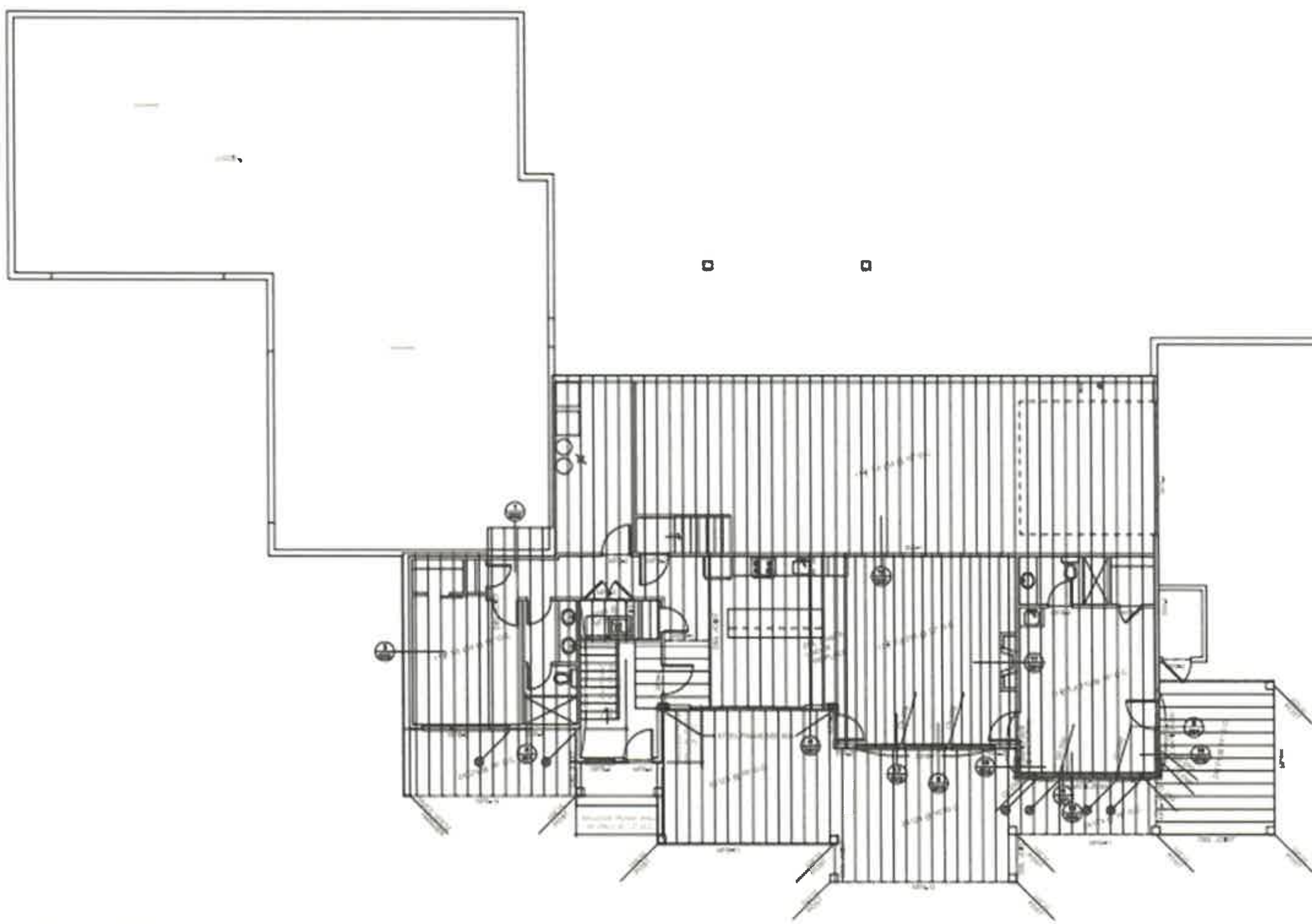
Dated this 27th day of APRIL, 20 21, personally appeared before me RONALD BARONE, the signer(s) of the Representative Authorization Affidavit who duly acknowledged to me that they executed the same.

HINA AZAM
NOTARY PUBLIC - CALIFORNIA
COMMISSION # 2295572
LOS ANGELES COUNTY
My Comm. Exp. May 14, 2023

_______________ (Notary)

Exhibit B – Engineering Building Plans





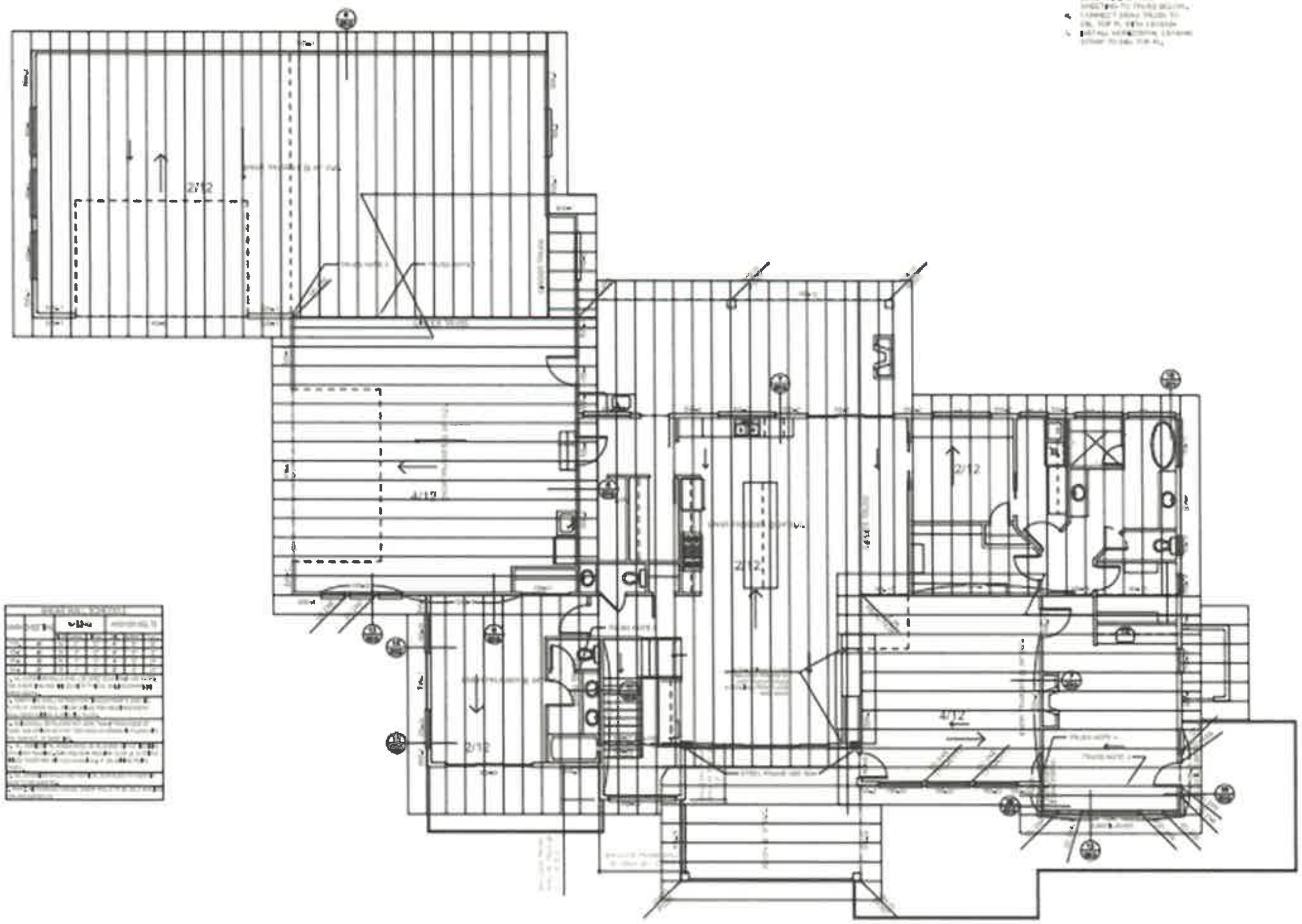
MAIN FLOOR FRAMING PLAN

CREATIVE LINE LLC

IRONSIDE ENGINEERING

SHEET

S 2



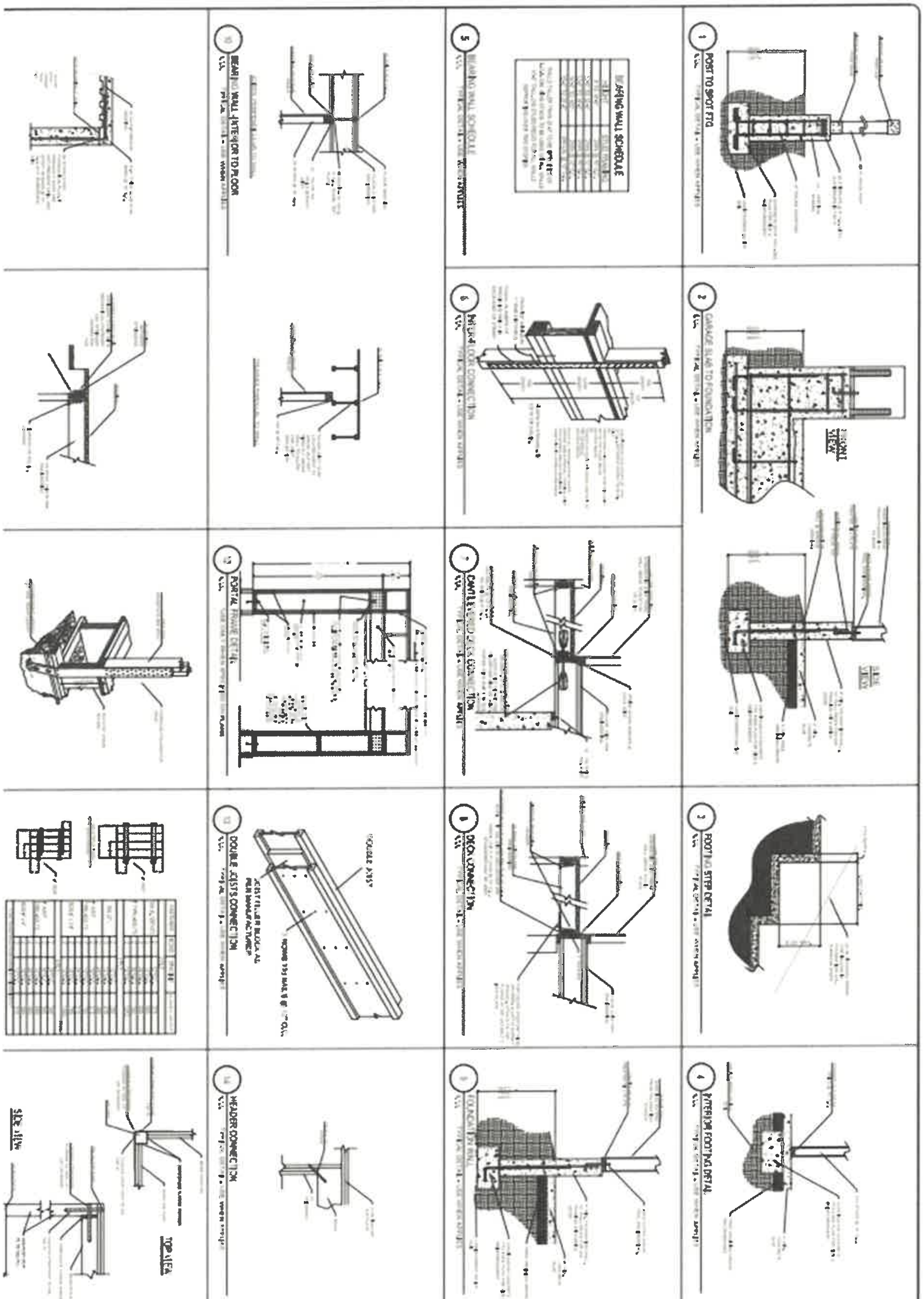
ROOF FRAMING PLAN

CREATIVE LINE LLC

IRONSIDE ENGINEERING

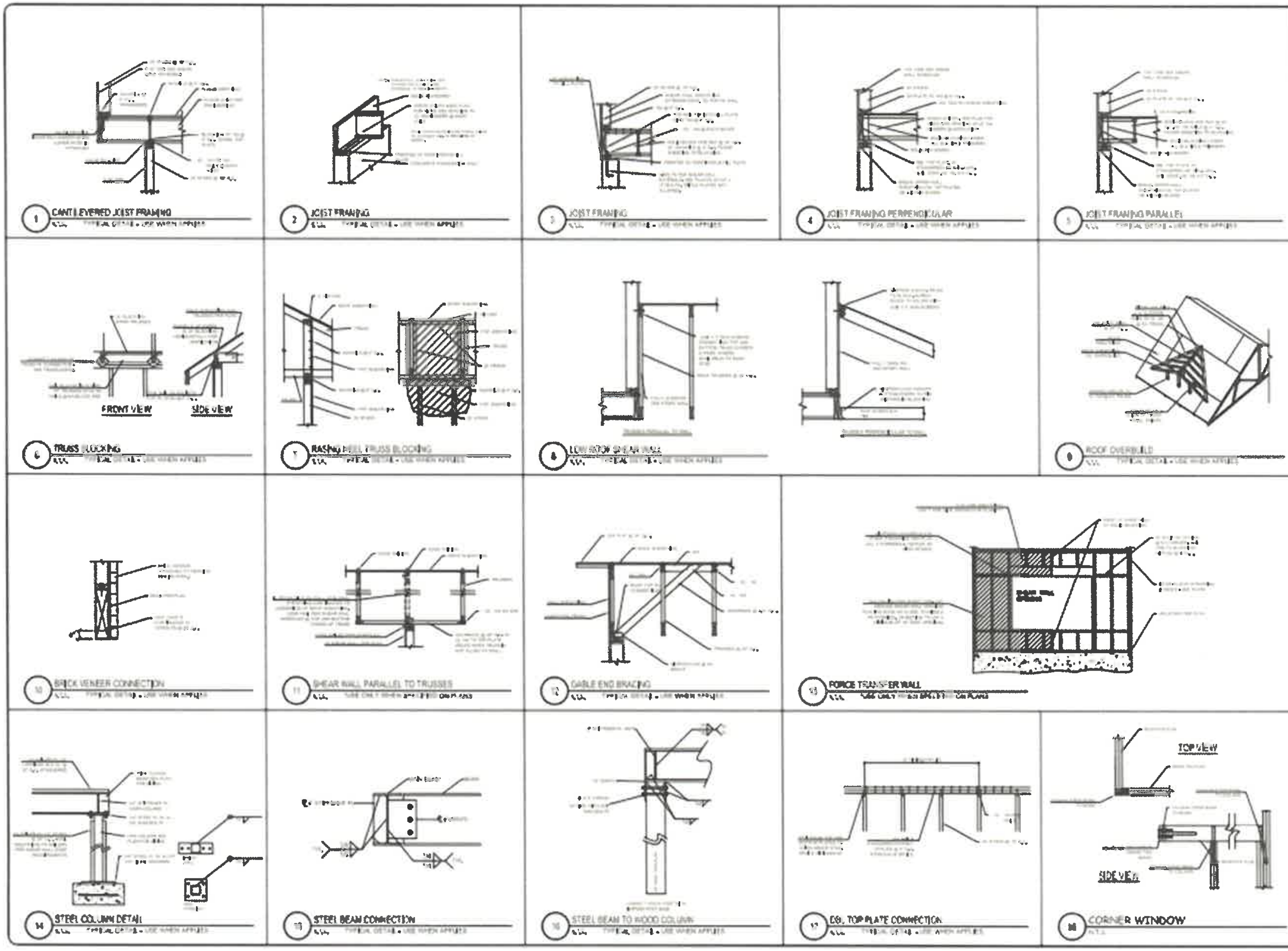
SHEET

S3



STANDARD DETAIL PAGES
**NOTE: NOT ALL DETAILS MAY BE APPLICABLE TO PROJECT

IRONSIDE ENGINEERING



IRONSIDE ENGINEERING

STANDARD DETAIL PAGES

**NOTE: NOT ALL DETAILS MAY BE APPLICABLE TO PROJECT

SHEET

SD2

STEEL FRAME DETAILS

STANDARD DETAIL PAGES

IRONSIDE ENGINEERING

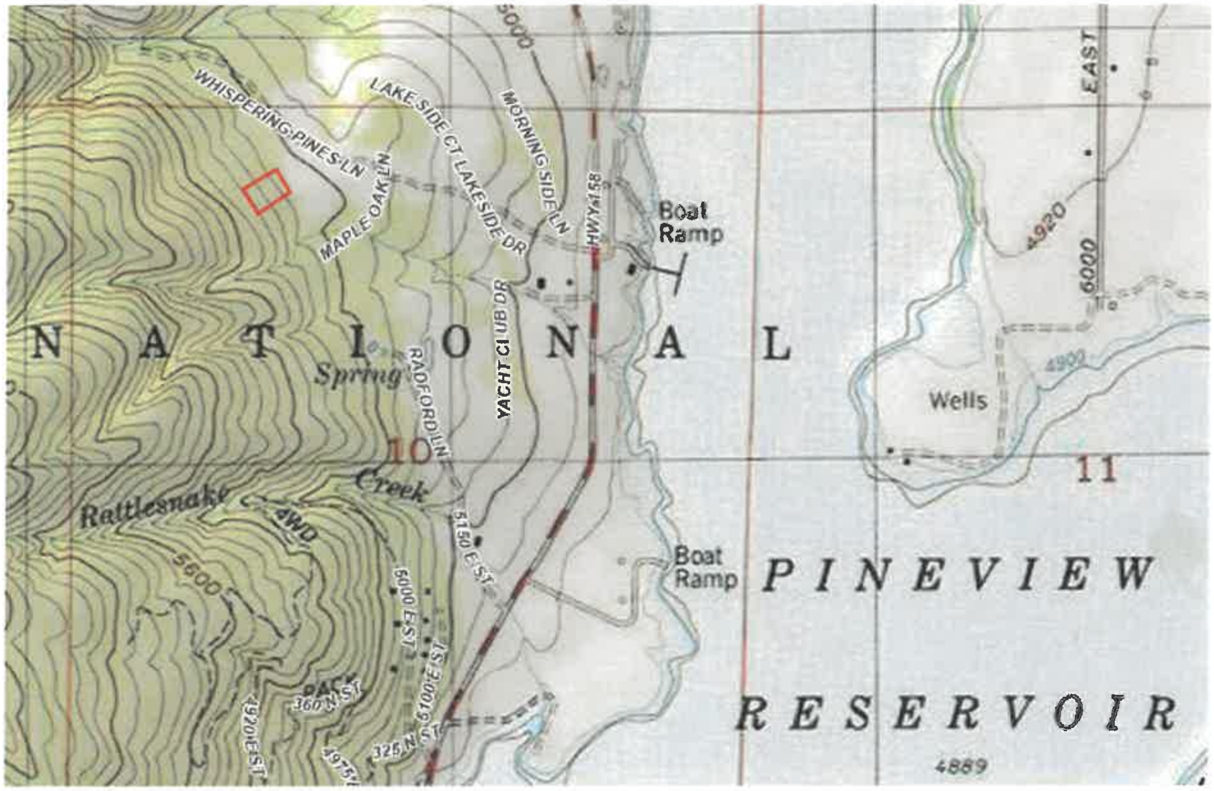
SHEET

SD4

Exhibit C – Western Geologic and GHS Geotech Reports

See attached.

Exhibit D – Topographic Map of Property



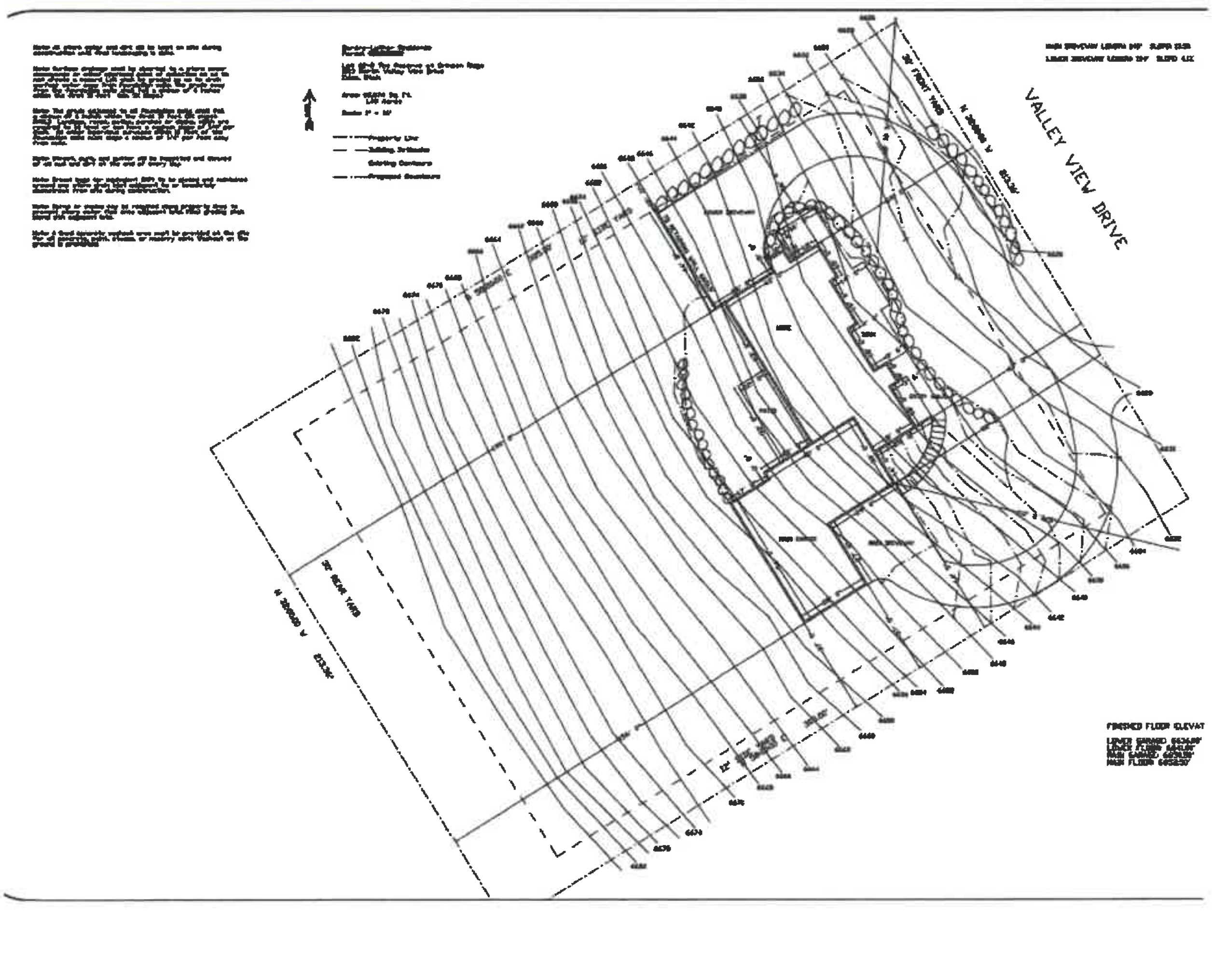


EXHIBIT C

GSH

REPORT
GEOTECHNICAL STUDY
LOT 2R THE RESERVE AT CRIMSON RIDGE SUBIDIVISON
1013 NORTH VALLEY VIEW DRIVE
WEBER COUNTY, UTAH

Submitted To:

Dr. James Anderson
759 West 2525 South
Syracuse, Utah

Submitted By:

GSH Geotechnical, Inc.
1596 West 2650 South
Ogden, Utah 84401

August 16, 2016

Job No. 2070-01N-16

August 16, 2016
Job No. 2070-01N-16

Dr. James Anderson
759 West 2525 South
Syracuse, Utah 84075

Re: Report
Geotechnical Study
Lot 2R The Reserve at Crimson Ridge Subdivision
1013 North Valley View Drive
Weber County, Utah
(41.2774° N; 111.8298° W)

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for Lot 2R of the Reserve at Crimson Ridge Subdivision located at 1013 North Valley View Drive in Weber County, Utah. The general location of the site with respect to major roadways, as of 2014, is presented on Figure 1, Vicinity Map. A more detailed layout of the site showing the proposed improvements is presented on Figure 2, Site Plan. The locations of the borings drilled and test pits excavated in conjunction with this study are also presented on Figure 2.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of our study were planned in discussions among Mr. Joe Sadler of Habitations Residential Design Group, Dr. James Anderson, and Mr. Andrew Harris of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the site.

2. Provide appropriate foundation, earthwork, and slope stability recommendations as well as geoseismic information to be utilized in the design and construction of the proposed home.

In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the excavating, logging, and sampling of 3 borings and 3 test pits.

2. A laboratory testing program.

3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our Professional Services Agreement No. 15-0504Nrev1 dated February 5, 2016.

1.4 PROFESSIONAL STATEMENTS

Supporting data upon which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration test pits/borings, projected groundwater conditions, and the layout and design data discussed in Section 2, Proposed Construction, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, GSH must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings developed, and our recommendations prepared in accordance with generally accepted engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

The proposed project consists of constructing a single-family residence, pool house, and boat house on Lot 2R of the Reserve at Crimson Ridge Subdivision in Weber County, Utah. Construction will likely consist of reinforced concrete footings and basement/crawlspace foundation walls supporting 1 to 3 wood-framed levels above grade. Projected maximum column and wall loads are on the order of 10 to 25 kips and 1 to 3 kips per lineal foot, respectively.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 8 feet. Larger cuts and fills may be required in isolated areas. To facilitate grading at the site, the upslope walls of the structures must be designed as retaining walls. Additionally, a series of rockery landscape walls are planned upslope of the proposed structure.

3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 3 borings were drilled to depths of about 21.5 to 51.5 feet below existing grade. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers. Additionally, 3 test pits were excavated to depths of about 6.5 to 9.0 feet below existing grade. The test pits were excavated using a track-mounted excavator. Boring and test pit locations are presented on Figure 2.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the excavating and drilling operations, a continuous log of the subsurface soil conditions encountered was maintained. In addition, samples of the typical soils encountered were obtained and placed in sealed bags and plastic containers for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 3A through 3C, Boring Log, and on Figures 4A through 4C, Test Pit Log. Soils were classified in accordance with the nomenclature described on Figure 5, Key to Boring Log (USCS) and on Figure 6, Key to Test Pit Log (USCS).

A 3.0-inch outside diameter, 2.42-inch inside diameter drive sampler (Dames & Moore) and a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) were utilized in the subsurface soil sampling at select locations within the boring. The blow counts recorded on the boring logs were those required to drive the sampler 12 inches with a 140-pound hammer dropping 30 inches.

A 2.42-inch inside diameter thin-wall drive sampler was utilized in the subsurface sampling of the test pits at the site.

Following completion of drilling and excavation operations, one and one-quarter-inch diameter slotted PVC pipe was installed in borings B-1, B-2, and B-3 in order to provide a means of monitoring the groundwater fluctuations. The borings were backfilled with auger cuttings. Following completion of excavating and logging, each test pit was backfilled. Although an effort was made to compact the backfill with the trackhoe, backfill was not placed in uniform lifts and compacted to a specific density. Consequently, the backfill soils must be considered as non-engineered and settlement of the backfill with time is likely to occur.

3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was performed. The program included moisture, density, Atterberg limits, partial gradations, consolidation, and direct shear tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture and Density

To provide index parameters and to correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented on the boring logs, Figures 3A through 3C, and on the test pit logs, Figure 4A through 4C.

3.2.3 Atterberg Limit Tests

To aid in classifying the soils, Atterberg limit tests were performed on samples of the fine-grained cohesive soils. Results of the test are tabulated below:

Boring/ Test Pit No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
B-1	5.0	35	18	17	SC
B-2	10.0	87	26	61	CH
B-3	37.5	36	14	22	CL
TP-1	5.0	52	16	36	CH
TP-2	0.5	45	30	15	ML
TP-2	1.0	36	18	18	CL
TP-2	3.0	43	18	25	CL
TP-3	3.0	28	18	10	SC

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3.2.4 Partial Gradation Tests

To aid in classifying the granular soils, partial gradation tests were performed. Results of the tests are tabulated below:

Boring/ Test Pit No.	Depth (feet)	Percent Passing No. 200 Sieve	Soil Classification
B-1	5.0	21.4	SC
B-2	10.0	73.5	CH
B-3	45.0	18.8	SC
B-3	50.0	23.3	SC
TP-1	2.5	62.3	CL
TP-1	5.0	82.4	CH
TP-3	1.0	56.9	CL
TP-3	3.0	23.6	SC

3.2.5 Consolidation Tests

To provide data necessary for our settlement analyses, consolidation tests were performed on each of 2 representative samples of the fine grained soils encountered at the site. Based upon data obtained from the consolidation tests, the silty clay/clayey silt soils are moderately over-consolidated and will exhibit moderate strength and compressibility characteristics under the anticipated loadings. Additionally, the in-situ clays exhibit a moderate swell potential when wetted, resulting in a swell pressure measured at about 1,200 pounds per square foot. Detailed results of the test are maintained within our files and can be transmitted, at the client's request.

3.2.6 Laboratory Direct Shear Test

To determine the shear strength of the soils encountered at the site, a laboratory direct shear test was performed on a sample of the site soils. The results of the test are tabulated on the following page.

Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
B-1	15.0	CL	32	91	28	250
B-2	22.5	CL	22	97	28	930
B-3	25.0	SC	81	31	36	155

4. SITE CONDITIONS

4.1 GEOLOGIC SETTING

A geologic hazards reconnaissance study[1] dated July 8, 2016 was prepared for the subject property by Western Geologic, LLC, and a copy of that report is included in the attached Appendix.

4.2 SURFACE

The subject property is a vacant, generally rectangular shaped lot located at 1013 North Valley View Drive in Weber County, Utah. The topography of the site slopes downward to the northeast at grades of about 10H:1V (Horizontal:Vertical) to about 2.5H:1V (Horizontal:Vertical) with an overall change in elevation of about 85 feet across the site. Vegetation at the site consists primarily of native weeds, grasses, brush, and numerous mature trees, particularly over the slope area. The site is bordered on the east by Valley View Drive, and on the west, north, and south by undeveloped property.

4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the test pit and boring locations varied slightly across the site. Topsoil and disturbed soils were observed in the upper 1.5 to 3.0 feet at the boring and test pit locations. Non-engineered fill extending about 5.0 foot below existing site grades was encountered at boring B-2. Natural soils were observed beneath the non-engineered fill and topsoil/disturbed soils to the full depth penetrated, about 6.5 to 51.5 feet below surrounding grades and consisted of silty clay with varying fine to coarse sand content, fine to coarse sandy clay with varying amounts of gravel, clayey silt, clayey fine to coarse sand, weathered bedrock (weathered claystone/siltstone), and occasional mixture of these soils.

1 "Report, Geologic Hazards Evaluation, The Reserve at Crimson Ridge, Lot 2-R, 1013 North Valley View Drive, Liberty, Weber County, Utah," Western Geologic, LLC, July 8, 2016.

The natural granular soils encountered were very dense, saturated, light brown in color, and will generally exhibit moderately high strength and low compressibility characteristics under the anticipated vertical loading.

The natural silt/clay soils encountered were medium stiff to hard, dry to saturated, brown to gray in color, and will generally exhibit moderate strength and compressibility characteristics under the anticipated vertical loading.

For a more detailed description of the subsurface soils encountered, please refer to Figures 3A through 3C, Boring Log, and Figures 4A through 4C, Test Pit Log. The lines designating the interface between soil types on the test pit and boring logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 GROUNDWATER

Static groundwater measurements were taken on Friday July 8, 2016, (37 days following drilling of individual borings). The results of these measurements are tabulated below.

Boring No.	Static Groundwater Level Below Existing Grade (feet) July 8, 2016
B-1	12.5
B-2	14.9
B-3	17.5

Seasonal and longer-term groundwater fluctuations of 1.0 to 2.0 feet should be anticipated. The highest seasonal levels will generally occur during the late spring and summer months. Depending on the time of year construction occurs, the moderately shallow groundwater levels could affect construction of the building.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analyses indicate that the proposed structure may be supported upon conventional spread and/or continuous wall foundations established upon a minimum of 2 feet of granular structural fill extending to suitable natural soils.

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The most significant geotechnical aspects of the site are:

1. The surficial non-engineered fills encountered at boring B-2 and resulting from the test pits/trench associated with the geotechnical/geological study;
2. The moderate strength characteristics of the natural silts and clays
3. The moderate swell potential of the natural silts and clays; and
4. Maintaining stability of the slope at the property.

All non-engineered fill materials must be removed in their entirety from beneath all structures and flatwork and replaced with properly placed and compacted structural fill.

Due to the moderate strength characteristics and moderate swell potential of the natural silt and clay soils at the site, a minimum of 2 feet of structural replacement fill is required beneath all footings floor slabs, and flatwork. Additionally, to control the potential for differential movement beneath the proposed pool, the pool must be established on a reinforced concrete mat slab constructed over a minimum of 2 feet of structural replacement fill.

A subdrain system must be installed upslope of the home, pool house, boat house and rockery landscape walls to reduce the potential for surface water infiltration, as discussed further within this report. A foundation subdrain must be constructed for all exterior foundations. Additionally, a subdrain system with lateral tie-ins must be constructed beneath/around the proposed pool.

Maintaining stability of the slopes at the site is critical to construction at the site. The upslope walls of all structures must be designed as retaining walls. Additionally, a series of rockery landscape walls are planned upslope of the structures. Though these rockery walls are planned a landscape walls less than 4 feet in height, consideration must be given to proper construction of the rockery walls.

The on-site soils are not appropriate to be used as structural site grading fill, however, they may be used as general grading fill in landscape areas.

A geotechnical engineer from GSH will need to verify that all mass movement deposit soils, fill material (if encountered) and topsoil/disturbed soils have been completely removed and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, foundations, or rigid pavements.

In the following sections, detailed discussions pertaining to earthwork, foundations, lateral pressure and resistance, floor slabs, slope stability, and the geoseismic setting of the site are provided.

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5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the removal of surface vegetation, topsoil, and other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building, pavements, and exterior flatwork areas.

Additional site preparation will consist of the removal of existing non-engineered fills (if encountered) from an area extending out at least 3 feet from the perimeter of residential structures and 1 foot beyond rigid pavements.

Non-engineered fills/disturbed soil may remain in asphalt pavement and sidewalk areas as long as they are free of deleterious materials and properly prepared. Below rigid pavements non-engineered fills/disturbed soils must be removed. Additionally, the surface of any existing engineered fills must be prepared prior to placing additional site grading fills.

Proper preparation shall consist of scarifying, moisture conditioning, and re-compacting the upper 12 inches to the requirements for structural fill. As an option to proper preparation and recompaction, the upper 12 inches of non-engineered fill (where encountered) may be removed and replaced with granular subbase over unfrozen proofrolled subgrade. Even with proper preparation, pavements established overlying non-engineered fills may encounter some long-term movements unless the non-engineered fills are completely removed.

It must be noted that from a handling and compaction standpoint, onsite soils containing high amounts of fines (silts and clays) are inherently more difficult to rework and are very sensitive to changes in moisture content requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. Additionally, the onsite soils are likely above optimum moisture content for compacting at present and would require some drying prior to recompacting.

Subsequent to stripping and prior to the placement of structural site grading fill, pavements, driveway, and parking slabs on grade, the prepared subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or loose soils are encountered, they must be removed to a maximum depth of 2 feet and replaced with structural fill. Beneath footings, all loose and disturbed soils must be totally removed. Fill soils must be handled as described above.

Surface vegetation, debris, and other deleterious materials shall generally be removed from the site. Topsoil, although unsuitable for utilization as structural fill, may be stockpiled for subsequent landscaping purposes.

A representative of GSH must verify that suitable natural soils and/or proper preparation of existing fills have been encountered/met prior to placing site grading fills, footings, slabs, and pavements.

5.2.2 Excavations

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, shall be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 10 feet, in granular soils and above the water table, the slopes shall be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering. Excavations deeper than 10 feet are not anticipated at the site.

Temporary excavations up to 10 feet deep in fine-grained cohesive soils (if encountered), above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1V).

To reduce disturbance of the natural soils during excavation, it is recommended that smooth edge buckets/blades be utilized.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated.

5.2.3 Structural Fill

Structural fill will be required as site grading fill, as backfill over foundations and utilities, and possibly as replacement fill beneath some footings. All structural fill must be free of sod, rubbish, construction debris, frozen soil, and other deleterious materials.

Structural site grading fill is defined as fill placed over fairly large open areas to raise the overall site grade. The maximum particle size within structural site grading fill should generally not exceed 4 inches; although, occasional particles up to 6 to 8 inches may be incorporated provided that they do not result in "honeycombing" or preclude the obtainment of the desired degree of compaction. In confined areas, the maximum particle size should generally be restricted to 2.5 inches.

Only granular soils are recommended in confined areas such as utility trenches, below footings, etc. Generally, we recommend that all imported granular structural fill consist of a well-graded mixture of sands and gravels with no more than 20 percent fines (material passing the No. 200 sieve) and less than 30 percent retained on the 3/4 inch sieve. The plasticity index of import fine-grained soil shall not exceed 18 percent.

To stabilize soft subgrade conditions or where structural fill is required to be placed closer than 1.0 foot above the water table at the time of construction, a mixture of coarse gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized. It may also help to utilize a stabilization fabric, such as Mirafi 600X or equivalent, placed on the native ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

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On-site soils are not recommended as structural fill but may be used as non-structural grading fill in landscape areas. Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

5.2.4 Fill Placement and Compaction

All structural fill shall be placed in lifts not exceeding 8 inches in loose thickness. Structural fills shall be compacted in accordance with the percent of the maximum dry density as determined by the ASTM[2] D-1557 (AASHTO[3] T-180) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Site Grading Fills outside area defined above	0 to 5	90
Site Grading Fills outside area defined above	5 to 10	95
Trench Backfill	--	96
Pavement granular base/subbase	--	96

Structural fills greater than 10 feet thick are not anticipated at the site.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 5.2.1, Site Preparation, of this report. In confined areas, subgrade preparation shall consist of the removal of all loose or disturbed soils.

If utilized for stabilizing fill, coarse gravel and cobble mixtures should be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the "fines" are "worked into" the voids in the underlying coarser gravels and cobbles.

2 American Society for Testing and Materials
3 American Association of State Highway and Transportation Officials

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling may be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proofrolling, they must be removed (to a maximum depth of 2 feet below design finish grade) and replaced with structural fill.

Most utility companies and City-County governments are now requiring that Type A-1-a/A-1-b (AASHTO Designation – basically granular soils with limited fines) soils be used as backfill over utilities. These organizations are also requiring that in public roadways the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry density as determined by the AASHTO T-180 (ASTM D-1557) method of compaction. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

Natural or imported silt/clay soils are not recommended for use as trench backfill, particularly in structurally loaded areas.

5.3 SLOPE STABILITY

5.3.1 Parameters

The properties of the soils at this site were estimated using the results of our laboratory testing, published correlations, and our experience with similar soils. Accordingly, we estimated the following parameters for use in the stability analyses:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Saturated Unit Weight (pcf)
Natural Clay/Silt	26	200	115
Concrete	0	28,800	150
Boulders	0 (45)	8000 (0)	145

For the seismic analysis, a peak horizontal ground acceleration of 0.279 using IBC 2012 guidelines and adjusted for Site Class effects (for Site Class D soils) was obtained for site (grid) locations of 41.2774 degrees latitude (north) and 111.8298 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically used. Accordingly, a value of 0.14 was used as the pseudostatic coefficient in the seismic analyses.

5.3.2 Stability Analyses

Using these input parameters, the internal (rock-to-rock) stability of the walls was evaluated considering sliding, overturning, and bearing capacity to achieve respective minimum factors of safety of 1.5, 2.0, and 3.0 for static conditions and 1.1, 1.5, and 1.5 for seismic conditions. The results of this analysis (see attached Figure 7) indicate that a maximum rock wall height of about 6 feet can be achieved in 1 tier using boulder sizes ranging from 24 inches (top row) to 36 inches (bottom row) retaining relatively level backfill.

We evaluated the global stability of the existing slope using the computer program *SLIDE*. This program uses a limit equilibrium (Simplified Bishop) method for calculating factors of safety against sliding on an assumed failure surface and evaluates numerous potential failure surfaces, with the most critical failure surface identified as the one yielding the lowest factor of safety of those evaluated. We analyzed the following configuration based on the cross-section provided in the referenced geologic study and proposed grading plan provided by Habitations Residential Design Group (see geological study in appendix for cross-section information and location):

- An approximately 6 foot high slopes graded at about 10H:1V (Horizontal:Vertical) followed by 2 building pads for the home and pool house followed by a series of 5 tiers of rockery walls about 4 feet tall per tier and separated by 6 feet measured from wall face to wall face. Above the rockery walls the slope continues to the edge of the property at a grade of about 2.5H:1V (Horizontal:Vertical). The overall change in elevation is about 145 feet across the site. To simulate the load imposed on the slope by the proposed home, a load of 1,500 psf was modeled over the proposed building areas. In addition, a phreatic surface was included in our analyses to account for encountered groundwater.

Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses indicate that the proposed slope configurations and rockery walls analyzed will meet both these requirements provided our recommendations are followed (see Figures 8 and 9).

Slope movements or even failure can occur if the slope soils are undermined or become saturated. Groundwater was encountered during the course of our field investigation as shallow as 12.5 feet below existing site grades. Further saturation of the slope soils can adversely affect the stability of the slope. Measures must be implemented to reduce the potential for saturation of the soils at the site. Surface drainage at the bottom and top of the slope should be directed to prevent ponding at the toe or crest of the slope. Subdrains must be constructed behind the rockery walls as discussed below. Additionally, cut-off drains on the slope above the home, above the pool house, and above the rockery walls are recommended to reduce the potential for infiltration of surface water at the site, as discussed further in Section 5.8, Subdrains. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

Changes to the grading at the site and any retaining walls must be properly engineered to maintain stability of the slopes. The upslope walls of structures at this site must be properly engineered to act as retaining walls and must be a minimum of 12 inches thick. The footing must be appropriately sized by the structural engineer to act as a cantilevered concrete retaining wall. GSH must review the final grading plans for the project prior to initiation of any construction.

5.3.3 Rockery Wall Recommendations

Based on the results of our analyses, the block retaining walls at this site will be stable if constructed as follows (also see Figure 10, attached):

- The five tier rockery walls may be constructed to a maximum exposed height of 4 feet per tier, with each tier separated by a minimum of 6 feet from wall face to wall face. The rockery wall tiers must be composed of boulders with a minimum nominal size (diameter) of 36 inches for the lowest row of boulders, grading in size to 24 inches for the top row of boulders, with the lowest row of boulders embedded a minimum of 1 foot below the ground surface.

- The rockery wall facing should slope at 1.0H:2.0V or flatter.

- Boulders used in the rock walls should be durable (i.e. not limestone, soft sandstone, conglomerate, or other rocks which have weakened planes that could cause rocks to split) and placed in a manner that will not significantly weaken their internal integrity. There should be maximum rock-to-rock contact when placing the rock boulders and no rocks should bear on a downward-sloping face of any supporting rocks. Larger gaps may be filled with smaller rocks or sealed with a cement grout.

- Drainage behind the walls must be provided, as shown on Figure 10. The drain shall consist of a perforated 4-inch minimum diameter pipe wrapped in fabric and placed at the bottom and behind the lowest row of boulders. The pipe shall daylight at one or both ends of the wall and discharge to an appropriate drainage device or area. Clean gravel up to 2 inches in maximum size, with less than 10 percent passing the No. 4 sieve and less than 5 percent passing the No. 200 sieve, shall be placed around the drain pipe. A fabric, such as Mirafi 140N or equivalent, shall be placed between the clean gravel and the adjacent soils. A zone of clean gravel and fabric at least 12 inches wide shall also extend above the drain, upward and behind the boulders to about 2 feet below the top of the wall, as shown on Figures 16 and 17.

- Structural site grading fill must be placed per the recommendations discussed with this study.

It should be noted that rockery walls are constructed of natural materials and are therefore subject to natural weathering processes and environmental attacks that may compromise the stability of the rockery wall. Boulders used during construction are subject to natural weathering by seasonal changes, wind, frost action, chemical reaction, water, etc. Additionally, the stability of rockery walls can be affected by other onsite and offsite influences such as saturation of retained soils, saturation of supporting soils, root action of vegetation and trees adjacent to the wall, and animal activities including burrowing and nesting. Rockery walls and the associated slopes must be closely monitored for signs of excessive weathering, drainage characteristics, signs of movement in the boulder, obstruction of drain outlets, etc. Frequent maintenance, repair, and inspection must be performed on the wall at least weekly and more often if any signs of erosion or movement are noticed. If any signs of erosion or movement are noticed, GSH must be contacted immediately to provide recommendations.

5.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.4.1 Design Data

The proposed structure may be supported upon conventional spread and continuous wall foundations established upon a minimum of 2 feet of structural fill extending to suitable natural soils. For design, the following parameters are provided:

Minimum Recommended Depth of Embedment for Frost Protection	- 30 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 16 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches
Recommended Net Bearing Pressure for Real Load Conditions	- 1,500 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 50 percent

The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

5.4.2 Installation

Footings shall not be installed upon mass movement soil deposits, soft or disturbed soils, non-engineered fill, construction debris, frozen soil, or within ponded water. If the granular structural fill upon which the footings are to be established becomes disturbed, it shall be recompacted to the requirements for structural fill or be removed and replaced with structural fill.

The width of structural fill, where placed below footings, shall extend laterally at least 6 inches beyond the edges of the footings in all directions for each foot of fill thickness beneath the footings. For example, if the width of the footing is 2 feet and the thickness of the structural fill beneath the footing is 2.0 feet, the width of the structural fill at the base of the footing excavation would be a total of 4.0 feet, centered below the footing.

5.4.3 Settlements

Maximum settlements of foundations designed and installed in accordance with recommendations presented herein and supporting maximum anticipated loads as discussed in Section 2, Proposed Construction, are anticipated to be 1 inch or less.

Approximately 40 percent of the quoted settlement should occur during construction.

5.5 LATERAL RESISTANCE

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the foundations and the supporting soils. In determining frictional resistance, a coefficient of 0.40 should be utilized for foundations placed over granular structural fill. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.

5.6 LATERAL PRESSURES

The lateral pressure parameters, as presented within this section, are for backfills which will consist of drained granular soil placed and compacted in accordance with the recommendations presented herein. The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), granular backfill may be considered equivalent to a fluid with a density of 35 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), generally not exceeding 8 feet in height, granular backfill may be considered equivalent to a fluid with a density of 45 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is no steeper than 4 horizontal to 1 vertical and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading, a uniform pressure shall be added. The uniform pressures based on different wall heights are provided in the following table:

Wall Height (feet)	Seismic Loading Active Case (psf)	Seismic Loading Moderately Yielding (psf)
4	25	55
6	40	85
8	55	115

5.7 FLOOR SLABS

Floor slabs may be established upon a minimum of 2 feet of structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over mass movement deposit soils, non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. In order to provide a capillary break and facilitate curing of the concrete, it is recommended that floor slabs be directly underlain by 4 inches of "free-draining" fill, such as "pea" gravel or three-quarters- to one-inch minus clean gap-graded gravel.

Settlement of lightly loaded floor slabs (average uniform pressure of 100 to 150 pounds per square foot or less) is anticipated to be less than 1/4 inch.

The tops of all floor slabs in habitable areas must be established at least 4 feet above the highest anticipated normal water level or 1.5 feet above the maximum groundwater level controlled by land drains.

5.8 POOLS

A pool and pool house are planned upslope of the proposed home at the site. Measures must be taken to reduce the potential for differential movement across the pool. The pool must be established on a reinforced concrete mat slab constructed over a minimum of 2 feet of compacted structural replacement fill. The mat slab must be a minimum of 6 inches thick and reinforced to minimize movement to 0.25 inches or less. Above the mat slab and immediately below the pool, a drainage layer consisting of a minimum of 12 inches of free-draining gravel must be placed. Within this layer of free-draining gravel, the pool subdrain must be constructed with lateral tie-ins at a maximum of 20 feet on center connecting to the exterior foundation subdrain discussed below.

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5.9 SUBDRAINS

5.9.1 General

We recommend that the perimeter foundation subdrains and a cutoff drain above the home, upslope of the pool house, and above the rockery walls be installed as indicated below.

5.9.2 Foundation Subdrains

Foundation subdrains should consist of a 4-inch diameter perforated or slotted plastic or PVC pipe enclosed in clean gravel. The invert of a subdrain should be at least 2 feet below the top of the lowest adjacent floor slab. The gravel portion of the drain should extend 2 inches laterally and below the perforated pipe and at least 1 foot above the top of the lowest adjacent floor slab. The gravel zone must be installed immediately adjacent to the perimeter footings and the foundation walls. To reduce the possibility of plugging, the gravel must be wrapped with a geotextile, such as Mirafi 140N or equivalent. Above the subdrain, a minimum 4-inch-wide zone of "free-draining" sand/gravel should be placed adjacent to the foundation walls and extend to within 2 feet of final grade. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain. As an alternative to the zone of permeable sand/gravel, a prefabricated "drainage board," such as Miradrain or equivalent, may be placed adjacent to the exterior below-grade walls. Prior to the installation of the footing subdrain, the below-grade walls should be dampproofed. The slope of the subdrain should be at least 0.3 percent. The gravel placed around the drain pipe should be clean 0.75-inch to 1.0-inch minus gap-graded gravel and/or "pea" gravel. The foundation subdrains can be discharged into the area subdrains, storm drains, or other suitable down-gradient location.

We recommend final site grading slope away from the structures at a minimum 2 percent for hard surfaces (pavement) and 5 percent for soil surfaces within the first 10 feet from the structures.

5.9.3 Cutoff Drain

To reduce potential infiltration of surface water and groundwater into the subsurface soils at the site, a cutoff drain should be installed upslope of the home, upslope of the pool house, and upslope of the rockery walls. Final location of the required cutoff drains must be reviewed by GSH prior to construction. The drain should consist of a perforated 4-inch minimum diameter pipe wrapped in fabric and placed near the bottom of a minimum 24 inch wide trench excavated to a depth of at least 15 feet below existing grade and lined in filter fabric. The pipe should daylight at one or both ends of the drain and discharge to an appropriate drainage device or area. Clean gravel up to 2 inches in maximum size, with less than 10 percent passing the No. 4 sieve and less than 5 percent passing the No. 200 sieve, should be placed around the drain pipe. A fabric, such as Mirafi 140N or equivalent, should be placed between the clean gravel and the adjacent soils. A zone of clean gravel wrapped in fabric at least 24 inches wide should also extend above the drain, to within 2 feet of the ground surface, with fabric placed over the top of the gravel. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain.

5.10 SITE IRRIGATION

Proper site drainage is important to maintaining slope stability at the site. Saturation of soils at the site may result in slope movement or failure. Therefore, we recommend that no irrigation lines should be placed on the slope. Landscaping at the site should be planned to utilize drought resistant plants that require minimal watering. Plants or lawn may be placed on the slope, with plants watered using direct drip systems targeted only for each plant, and any lawn areas watered using sprinklers placed in a manner such that watering is a minimum of 30 feet back from the crest of the slope. Overwatering should be strictly avoided. The surface of the site should be graded to prevent the accumulation or ponding of surface water at the site. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

To reduce the potential for saturation of the site soils, overwatering at the site should be strictly avoided. Watering at the site should be limited to a maximum equivalent rainfall of 0.5 inches per week. Irrigation at the site should be strictly avoided during periods of natural precipitation.

5.11 GEOSEISMIC SETTING

5.11.1 General

Utah municipalities have adopted the International Building Code (IBC) 2012. The IBC 2012 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

The structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2012 edition.

5.11.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest active fault is the Wasatch Fault Zone Weber Section, approximately 6.0 miles west of the site.

5.11.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2012) can be utilized.

5.11.4 Ground Motions

The IBC 2012 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D soil profile. Based on the site latitude and longitude (41.2774 degrees north and -111.8298 degrees west, respectively), the values for this site are tabulated below:

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class D [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	37.1	F_a = 1.129	41.9	27.9
0.2 Seconds (Short Period Acceleration)	S_S = 92.7	F_a = 1.129	S_{MS} = 104.7	S_{DS} = 69.8
1.0 Second (Long Period Acceleration)	S_1 = 31.7	F_v = 1.766	S_{M1} = 56	S_{D1} = 37.3

5.11.5 Liquefaction

The site is located in an area that has been identified by the Utah Geologic Survey as having "very low" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, finer-grained sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clay soils, even if saturated, will generally not liquefy.

Liquefaction of the site soils is not anticipated during the design seismic event due to the cohesive (clayey) nature of the site soils.

5.12 SITE OBSERVATIONS

As stated previously, prior to placement of foundations, floor slabs, pavements, and site grading fills, a geotechnical engineer from GSH must verify that all non-engineered fill materials, topsoil, and disturbed soils have been removed and/or properly prepared and suitable subgrade conditions encountered. Additionally, GSH must observe fill placement and verify in-place moisture content and density of fill materials placed at the site.

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5.13 CLOSURE

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 393-2012.

Respectfully submitted,

GSH Geotechnical, Inc.

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AMH/MSH:mmh

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	Boring Log
	Figures	4A	through 4C, Test Pit Logs
	Figure	5,	Key to Boring Log (USCS)
	Figure	6,	Key to Test Pit Log (USCS)
	Figure	7	Rockery Wall Stability Evaluation
	Figures	8	and 9, Stability Results
	Figure	10	Rockery Wall Detail
	Appendix,		Geologic Hazards Reconnaissance Study

Addressee (email)

DR. JAMES ANDERSON
JOB NO. 2070-01N-16

FIGURE 1
VICINITY MAP

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REFERENCE:
DELORME STREET ATLAS

DR. JAMES ANDERSON
JOB NO. 2070-01N-16

FIGURE 2
SITE PLAN
GSH

REFERENCE:
ADAPTED FROM DRAWING ENTITLED SITE PLAN

GSH

BORING LOG

BORING: B-1

CLIENT: Dr. James Anderson — PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision — DATE STARTED: 6/1/16 — DATE FINISHED: 6/1/16

LOCATION: Lot 2 Crimson Ridge Subdivision — GSH FIELD REP.: JM

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger — HAMMER: Automatic — WEIGHT: 140 lbs — DROP: 30"

GROUNDWATER DEPTH: Not Encountered (6/2/16), 12.5' (7/8/16) — ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	REMARKS
		Ground Surface	0	
	CL	SILTY CLAY with trace fine to coarse sand; trace fine and coarse gravel; major roots (topsoil) to 3'; brown to dark brown	0–5	moist stiff
	SC	CLAYEY FINE TO COARSE SAND brown	5–9	
	CL	SILTY CLAY with trace fine to coarse sand; gray grades with coarse gravel	9–15	very stiff
	CL	SILTY CLAY/WEATHERED CLAYSTONE with trace fine to coarse sand; trace fine and coarse gravel; gray	15–21.5	moist hard
		End of Exploration at 21.5' No groundwater encountered at time of drilling	21.5–25	

DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX
~2.5	14	X	25	84			
~5	11	X	15		21	35	17
~7.5	11	X					
~10	15	X	28	91			
~12.5	24	X					
~15	80	X					
~17.5	71	X					
~20	86	X	26	91			

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

GSH

BORING LOG

BORING: B-2

CLIENT: Dr. James Anderson | PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision | DATE STARTED: 6/2/16 | DATE FINISHED: 6/2/16

LOCATION: Lot 2 Crimson Ridge Subdivision | GSH FIELD REP.: JM

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger | HAMMER: Automatic | WEIGHT: 140 lbs | DROP: 30"

GROUNDWATER DEPTH: 22.0' (6/2/16), 14.9' (7/8/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	CL FILL	SILTY CLAY, FILL with trace fine to coarse sand; trace fine and coarse gravel; trace organics; gray	0								moist very stiff
	CH	SILTY CLAY with trace fine to coarse sand; trace fine and coarse gravel; gray	5	19		35	70				
				28		31	84				
			10	22		41		74	87	61	
	CL	SILTY CLAY/CLAYSTONE/SILTSTONE with trace fine to coarse sand; gray		50+							moist hard
			15	50+							
				50+							
			20	86							
											saturated
				50+		22	97				
			25								

See Subsurface Conditions section in the report for additional information.

GSH

BORING LOG

BORING: B-2

CLIENT: Dr. James Anderson

PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision

DATE STARTED: 6/2/16

DATE FINISHED: 6/2/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25	50+	X						hard
				50+	X	24	100				
			30	50+	X	22	83				
		End of Exploration at 31.5' Installed 1.25" diameter slotted PVC pipe to 30.0'									
			35								
			40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B
(continued)

GSH — BORING LOG

BORING: B-3

CLIENT: Dr. James Anderson | PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision | DATE STARTED: 6/2/16 | DATE FINISHED: 6/2/16

LOCATION: Lot 2 Crimson Ridge Subdivision | GSH FIELD REP.: JM

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger | HAMMER: Automatic | WEIGHT: 140 lbs | DROP: 30"

GROUNDWATER DEPTH: 32.0' (6/2/16), 17.5' (7/8/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
	CL	SILTY CLAY with trace fine to coarse sand; trace organics; brown to black									moist very stiff
				19							
			5	43							
	CL	SILTY CLAY/CLAYSTONE/SILTSTONE with trace fine to coarse sand; whitish-gray		62		19	94				moist hard
			10	50+							
				50+		23	100				
	CL	FINE TO COARSE SANDY CLAY with trace fine and coarse gravel; light brown to brown	15	50+							moist hard
				50+							
			20	86							
				52							
		grades gray	25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3C

CLIENT: Dr. James Anderson | PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision | DATE STARTED: 6/2/16 | DATE FINISHED: 6/2/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		grades gray	25	30	X	31	81				very stiff
		grades light brown		50+	X						hard
			30	50+	X						
▼				50/4"	X						saturated
			35	50/3"	X						
				50/4"	X				36	22	
			40	50/6"	X						
				50/5"	X						
	SC	CLAYEY FINE TO COARSE SAND light brown	45	50/5"	X	11		19			saturated very dense
				50/6"	X						
			50	50/5"	X	13		23			
		End of Exploration at 51.5'									

See Subsurface Conditions section in the report for additional information.

GSH

BORING LOG

BORING: B-3

CLIENT: Dr. James Anderson | PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision | DATE STARTED: 6/2/16 | DATE FINISHED: 6/2/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Installed 1.25" diameter slotted PVC pipe to 30.0'	52								
			55								
			60								
			65								
			70								
			75								

See Subsurface Conditions section in the report for additional information.

FIGURE 3C
(continued)

GSH

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-1

CLIENT: Dr. James Anderson
PROJECT NUMBER: 2070-01N-16
PROJECT: Lot 2 Crimson Ridge Subdivision
DATE STARTED: 6/2/16
DATE FINISHED: 6/2/16
LOCATION: Lot 2 Crimson Ridge Subdivision
GSH FIELD REP.: AA
EXCAVATING METHOD/EQUIPMENT: CAT 430D - Backhoe
GROUNDWATER DEPTH: Not Encountered (6/2/16)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	CH	SILTY CLAY with trace fine sand; major roots (topsoil) to 3'; dark brown								dry medium stiff
				▮	22	99				
		trace roots		▮	16		62			moist stiff
		grades reddish-brown		▮						
			5	▮	21		82	52	36	
		roots grade out; gray								saturated
		End of Exploration at 6.5' No significant sidewall caving No groundwater encountered at time of excavation								
			10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4A

TEST PIT LOG

GSH

Page: 1 of 1

TEST PIT: TP-2

CLIENT: Dr. James Anderson | PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision | DATE STARTED: 6/2/16 | DATE FINISHED: 6/2/16

LOCATION: Lot 2 Crimson Ridge Subdivision | GSH FIELD REP.: AA

EXCAVATING METHOD/EQUIPMENT: CAT 430D - Backhoe

GROUNDWATER DEPTH: Not Encountered (6/2/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	ML	CLAYEY SILT with trace fine sand; trace organics; black		■				45	15	moist stiff
	CL	SILTY CLAY with trace fine sand; dark brown		■	21	84		36	18	
		grades brown		■				43	25	
			5							
				■	30	85				hard
		End of Exploration at 6.5' No significant sidewall caving No groundwater encountered at time of excavation								
			10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4B

TEST PIT LOG

TEST PIT: TP-3

CLIENT: Dr. James Anderson
PROJECT NUMBER: 2070-01N-16

PROJECT: Lot 2 Crimson Ridge Subdivision
DATE STARTED: 6/2/16
DATE FINISHED: 6/2/16

LOCATION: Lot 2 Crimson Ridge Subdivision
GSH FIELD REP.: AA

EXCAVATING METHOD/EQUIPMENT: CAT 430D - Backhoe

GROUNDWATER DEPTH: Not Encountered (6/2/16)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	CL	SILTY CLAY with trace fine to coarse sand; trace fine and coarse gravel; dark brown								moist stiff
				▮	26		57			
		grades with interbedded clayey sand layers								
				▮	24		16	28	10	
				▮						
			5							medium stiff
	CL	FINE TO COARSE SANDY CLAY with trace fine and coarse gravel; brown								moist very stiff
				▮						
		End of Exploration at 9.0' No significant sidewall caving No groundwater encountered at time of excavation								
			10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4C

CLIENT: Dr. James Anderson
PROJECT: Lot 2 Crimson Ridge Subdivision
PROJECT NUMBER: 2070-01N-16

KEY TO BORING LOG

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫

COLUMN DESCRIPTIONS

① **Water Level:** Depth to measured groundwater table. See symbol below.

② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.

③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,

④ **Depth (ft.):** Depth in feet below the ground surface.

⑤ **Blow Count:** Number of blows to advance sampler 12" beyond first 6", using a 140-lb hammer with 30" drop.

⑥ **Sample Symbol:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

⑦ **Moisture (%):** Water content of soil sample measured in laboratory; expressed as percentage of dryweight of

⑧ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.

⑨ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

⑩ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.

⑪ **Plasticity Index (%):** Range of water content at which a soil exhibits plastic properties.

⑫ **Remarks:** Comments and observations regarding drilling or sampling made by driller or field personnel. May include other field and laboratory test results using the following abbreviations:

CEMENTATION:

Weakly: Crumbles or breaks with handling or slight finger pressure.

Moderately: Crumbles or breaks with considerable finger pressure.

Strongly: Will not crumble or break with finger pressure.

MODIFIERS:

Trace	<5%
Some	5-12%
With	> 12%

MOISTURE CONTENT (FIELD TEST):

Dry: Absence of moisture, dusty, dry to the touch.

Moist: Damp but no visible water.

Saturated: Visible water, usually soil below water table.

Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on the logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** More than 50% of coarse fraction retained on No. 4 sieve.	**CLEAN GRAVELS** (little or no fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (appreciable amount of fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (little or no fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (appreciable amount of fines)	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	**SILTS AND CLAYS** Liquid Limit less than 50%		ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL	Organic Silts and Organic Silty Clays o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications.

STRATIFICATION:

DESCRIPTION	THICKNESS
Seam	up to 1/8"
Layer	1/8" to 12"

Occasional: One or less per 6" of thickness

Numerous; More than one per 6" of thickness

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk/Bag Sample
- Standard Penetration Split Spoon Sampler
- Rock Core
- No Recovery
- 3.25" OD, 2.42" ID D&M Sampler
- 3.0" OD, 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

WATER SYMBOL

Water Level

FIGURE 5

GSH

CLIENT: Dr. James Anderson
PROJECT: Lot 2 Crimson Ridge Subdivision
PROJECT NUMBER: 2070-01N-16

KEY TO TEST PIT LOG

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪

COLUMN DESCRIPTIONS

① **Water Level:** Depth to measured groundwater table. See symbol below.

② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.

③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,

④ **Depth (ft.):** Depth in feet below the ground surface.

⑤ **Sample Symbol:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

⑥ **Moisture (%):** Water content of soil sample measured in laboratory; expressed as percentage of dryweight of

⑦ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.

⑧ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

⑨ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.

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			GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (appreciable amount of fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (little or no fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (appreciable amount of fines)	SM	Silty Sands, Sand-Silt Mixtures
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			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL	Organic Silts and Organic Silty Clays o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications.

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DESCRIPTION	THICKNESS
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TYPICAL SAMPLER GRAPHIC SYMBOLS

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- Standard Penetration Split Spoon Sampler
- Rock Core
- No Recovery
- 3.25" OD, 2.42" ID D&M Sampler
- 3.0" OD, 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

WATER SYMBOL

Water Level

FIGURE 6

GSH

ROCK WALL STABILITY EVALUATION

Project:	Lot 2R The Reserve at Crimson Ridge				Date:	8/16/2016	
Location:	Weber County, Utah				By:	AMH	
Backfill slope angle, β:	18	degrees (β)		Foundation soil γ :	115	pcf	
Batter angle (from vertical):	26.6	degrees (α)		Foundation soil ϕ :	26	degrees	
Soil/wall interface friction:	0	degrees (δ)		Found. soil cohesion:	200	psf	
Surcharge pressure:	0	psf		Retained soil γ :	115	pcf	
	static	**seismic**		Retained soil ϕ :	26	degrees	
FS against sliding (Stat/Seis):	1.5	1.1		Retain. soil cohesion:	200	psf	
FS against overturning (St/Se):	2.0	1.5		Rock boulder γ :	145	psf	
FS for bearing (Static/Seismic):	2.5	1.5		Rock boulder ϕ :	45	degrees	
Horizontal seismic coeff., k_h:	0.14	(typically ½ of PGA)		Embedment depth:	1	feet	
Vertical seismic coeff., k_v:	0	(typically 0)		Average rock wall γ :	145	pcf	
Rock to Rock interface factor:	1	(typically 2/3)		Min. top rock size:	24	inches	
Bearing Capacity	11079	psf (Meyerhoff)		Min.bottom rock size:	36	inches	

STATIC

Wall Ht, H (ft)	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Back of wall, ψ (°)	0.0	9.5	14.0	16.7	18.4	19.7	20.6	21.3
Wall Wt, W (lbs/ft)	725	1088	1450	1813	2175	2538	2900	3263
Wall $x_{centroid}$ (ft)	1.73	1.97	2.20	2.43	2.67	2.76	2.87	2.99
Wall $y_{centroid}$ (ft)	0.933	1.400	1.867	2.333	2.800	3.300	3.787	4.259
Coulomb K_a	0.5143	0.4326	0.3966	0.3761	0.3629	0.3537	0.3469	0.3416
F_a (lbs/ft)	1	1	1	1	27	154	313	502
$F_{sliding}$ (lbs/ft)	1	1	1	1	26	145	293	468
$F_{resisting}$ (lbs/ft)	354	530	707	884	1057	1212	1361	1502
$FS_{base\ sliding}$	**> 100**	**> 100**	**> 100**	**> 100**	**41.4**	**8.3**	**4.6**	**3.2**
$FS_{interface\ shear}$	**> 100**	**> 100**	**> 100**	**> 100**	**85.3**	**17.5**	**9.9**	**7.0**
$M_{overturn}$ (ft-lbs/ft)	0	1	1	2	51	339	781	1405
$M_{resisting}$ (ft-lbs/ft)	1257	2138	3189	4409	5769	6814	7890	9008
$FS_{overturn}$	**> 100**	**> 100**	**> 100**	**> 100**	**> 100**	**20.1**	**10.1**	**6.4**
Eccentricity, e (ft)	-0.23	-0.47	-0.70	-0.93	-1.14	-1.10	-1.05	-0.97
Bearing Pressure	354	700	1159	1730	2368	2660	2879	3015
$FS_{bearing}$	**31.3**	**15.8**	**9.6**	**6.4**	**4.7**	**4.2**	**3.8**	**3.7**

SEISMIC

Mononobe-Okabe K_{ae} =	0.8936	0.7911	0.7497	0.7273	0.7132	0.7036	0.6965	0.6911
F_{ae} (lbs/ft)	0	0	0	193	463	808	1228	1723
$F_{sliding}$ (lbs/ft)	102	152	203	438	744	1116	1556	2062
$F_{resisting}$ (lbs/ft)	354	530	707	857	989	1105	1204	1287
$FS_{base\ sliding}$	**3.5**	**3.5**	**3.5**	**2.0**	**1.3**	**1.0**	**0.8**	**0.6**
$FS_{interface\ shear}$	**7.1**	**7.1**	**7.1**	**4.1**	**2.9**	**2.3**	**1.9**	**1.6**
$M_{overturn}$ (ft-lbs/ft)	94	213	378	1144	2393	4097	6431	9491
$M_{resisting}$ (ft-lbs/ft)	1257	2139	3190	4195	5190	5825	6348	6753
$FS_{overturn}$	**13.3**	**10.1**	**8.4**	**3.7**	**2.2**	**1.4**	**1.0**	**0.7**
Eccentricity (ft)	-0.10	-0.27	-0.44	-0.24	0.12	0.74	1.53	2.54
Bearing Pressure	192	166	59	309	840	1869	3347	5343
$FS_{bearing}$	**57.7**	**66.8**	**189.1**	**35.8**	**13.2**	**5.9**	**3.3**	**2.1**

Max. Recommended Wall Height: 6 feet for 24-inch (top row) to 36-inch (bottom row) size boulders

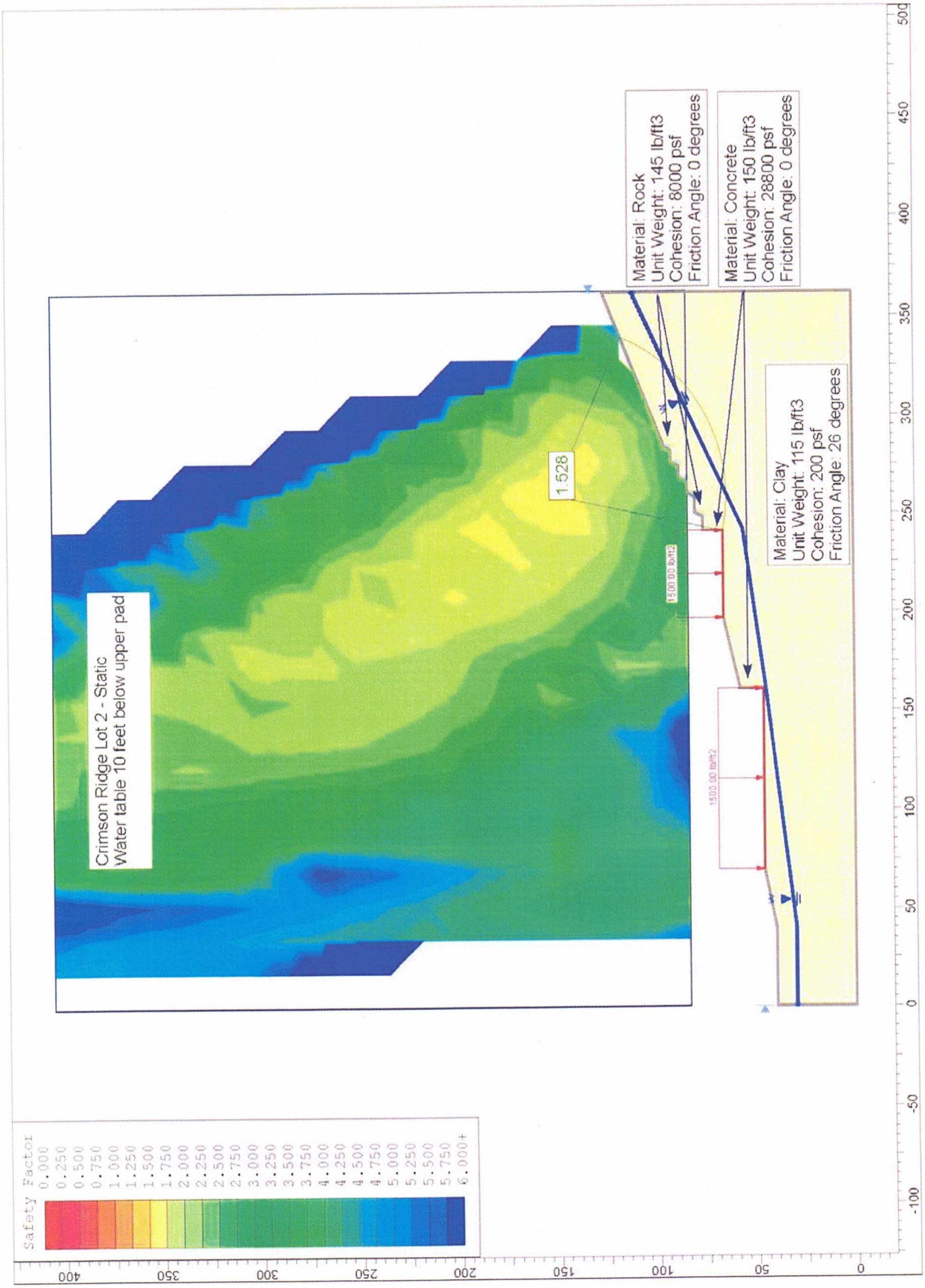
Notes:

1. Equations from "Recommended Rockery Design & Construction Guidelines" Publication FHWA-CLF/TD-06-006, Nov. 2006.
2. Cohesion included in active pressure force by subtracting ($2 * c * \sqrt{K_a}$), but force is not allowed to be less than 0.
3. Other equations: $W=[\pi*(\text{average rock radius})^2 * H] * \gamma_{rock}$; $FS_{interface\ shear}=(\text{Rock to Rock interface factor})*[W*\tan(\phi_{rock})/P_{sliding}]$

PROJECT NO.: 2070-01N-16	GSH	**FIGURE NO.:** 7

STABILITY RESULTS

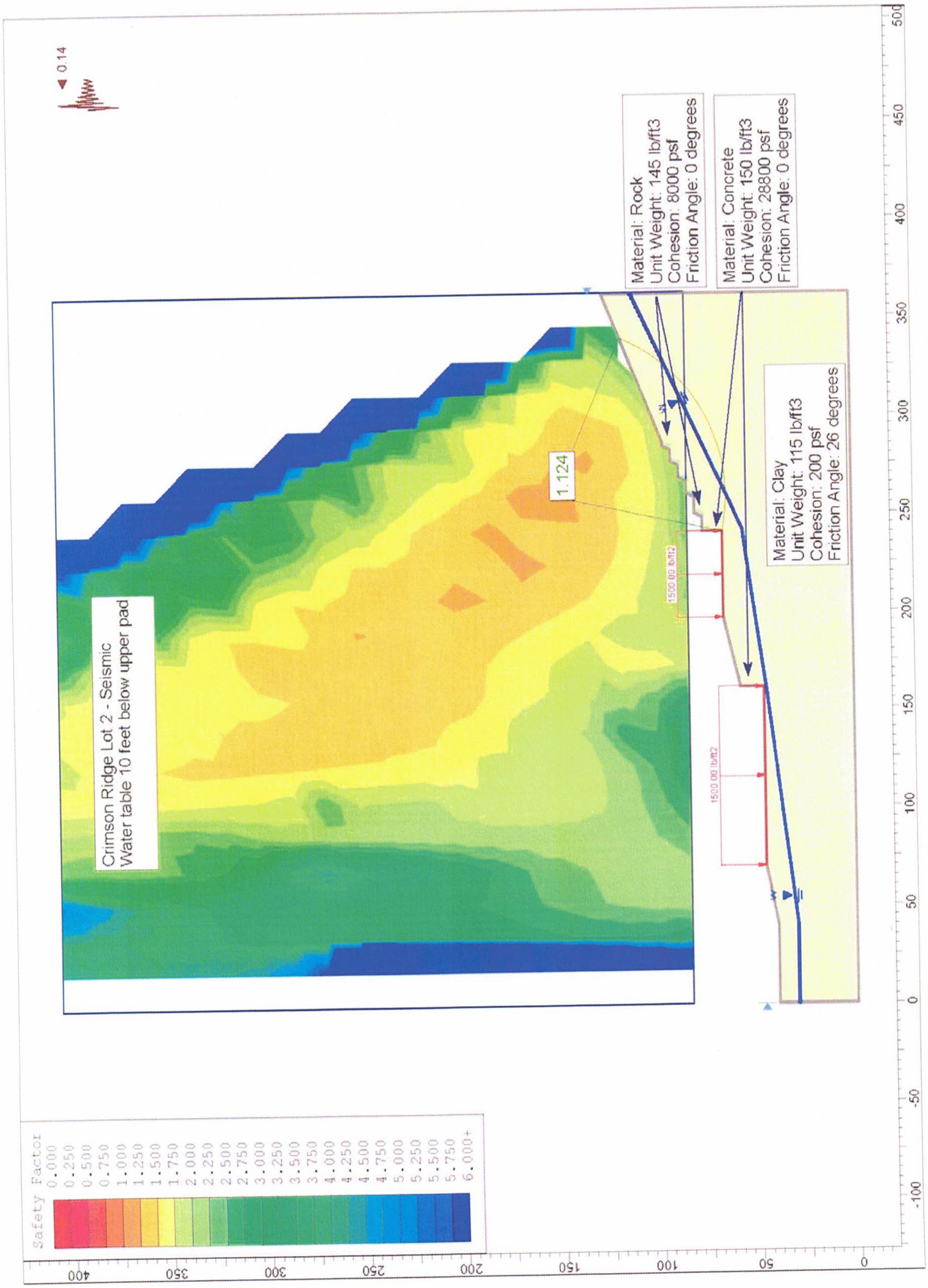
LOT 2 CRIMSON RIDGE SUBDIVISION



PROJECT NO.: 2070-01N-16	GSH	**FIGURE NO.:** 8

STABILITY RESULTS

LOT 2 CRIMSON RIDGE SUBDIVISION



PROJECT NO.: 2070-01N-16	GSH	**FIGURE NO.:** 9

ROCK WALL DETAIL

LOT 2R THE RESERVE AT CRIMSON RIDGE, WEBER COUNTY

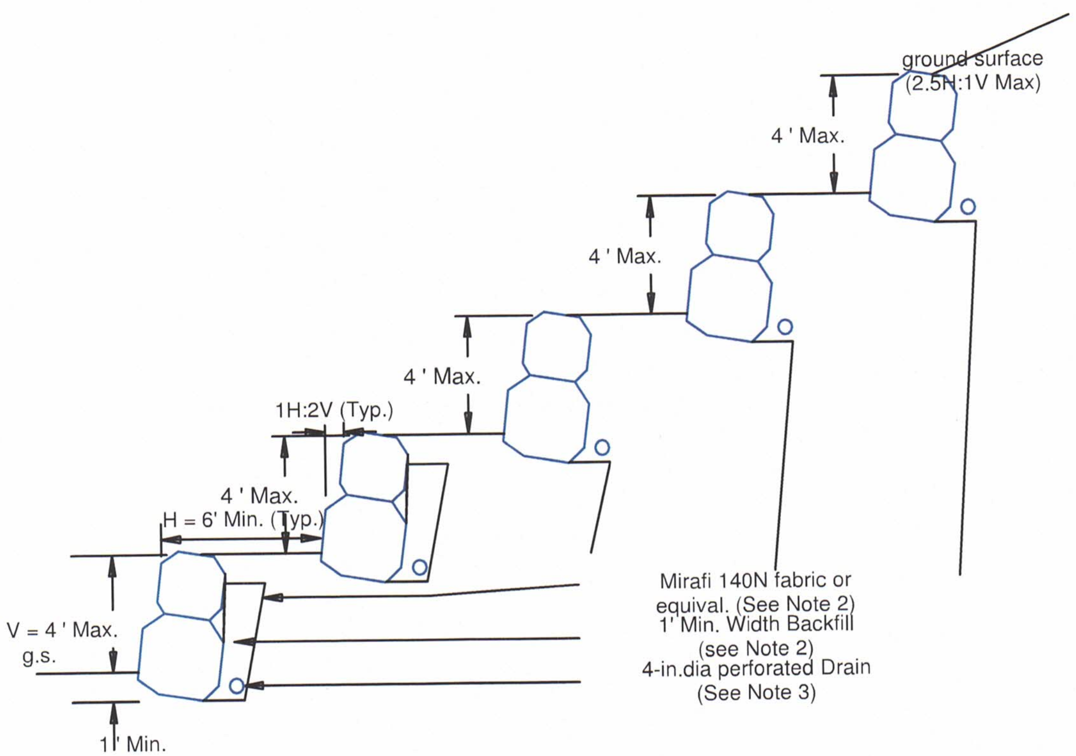
NOTES:

1. BACKFILL SOILS SHOULD BE PLACED IN LOOSE LIFTS NOT EXCEEDING A THICKNESS OF 12 INCHES, MOISTURE CONDITIONED TO WITHIN 2% OF OPTIMUM, AND COMPACTED TO A MINIMUM 95% OF THE MAXIMUM DRY DENSITY AS DETERMINED BY ASTM D1557.

2. FREE-DRAINING BACKFILL SHALL CONSIST OF GRAVEL HAVING LESS THAN 5% PASSING No. 200 SIEVE, OR MAY USE MIRADRAIN (OR EQUIVALENT) INSTEAD OF GRAVEL & FABRIC.

3. PERFORATED DRAIN SHALL BE WRAPPED WITH FABRIC, SLOPED A MINIMUM 2% TO SIDE OF WALL, AND DISCHARGED TO APPROPRIATE DRAINAGE DEVICE.

4. BOULDER SIZES SHALL BE A MINIMUM 36 INCHES FOR THE BOTTOM ROW AND A MINIMUM 24 INCHES FOR THE UPPER ROW FOR EACH TIER.



NOT TO SCALE

PROJECT NO.: 2070-01N-16	GSH	FIGURE NO.: 10

REPORT

GEOLOGIC HAZARDS EVALUATION

THE RESERVE AT CRIMSON RIDGE, LOT 2-R

1013 NORTH VALLEY VIEW DRIVE

LIBERTY, WEBER COUNTY, UTAH

Prepared for

Dr. James Anderson
759 West 2525 South
Syracuse, Utah 84075

July 8, 2016

Prepared by

Western GeoLogic, LLC
2150 South 1300 East, Suite 500
Salt Lake City, Utah 84106

Voice: 801.359.7222
Fax: 801.990.4601
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Phone: 801.359.7222 Fax: 801.990.4601 Email: cnelson@westerngeologic.com

July 8, 2016

Dr. James Anderson
759 West 2525 South
Syracuse, Utah 84075

SUBJECT: Geologic Hazards Evaluation
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

Dear Mr. Anderson:

This report presents results of an engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for lot 2-R in The Reserve at Crimson Ridge subdivision in Eden, Utah (Figure 1 – Project Location). The Project is identified as Weber County Assessor's parcel number 20-105-0002 (1013 North Valley View Drive). The site is on east- to northeast-facing slopes in western Ogden Valley at the eastern base of the Wasatch Range, and is in the NW1/4 Section 10, Township 6 North, Range 1 East (Salt Lake Base Line and Meridian; Figure 1). Elevation of the property ranges from about 6,630 feet to 6,730 feet above sea level. It is our understanding that the current intended site use is for development of a single-family residential home.

A prior geologic hazards and engineering geotechnical evaluation was conducted for the original Pineview Estates at Radford Hills development by Western GeoLogic (2006) and Earthtec Testing & Engineering (ETE, 2006). This development subsequently became the current Reserve at Crimson Ridge subdivision. The Project is identified as lot 5 on the site plan included in the 2006 investigation. Portions of this report may include discussions from Western GeoLogic (2006) or ETE (2006) where relevant to our current investigation, although this study should be considered to replace the findings and recommendations previously provided in 2006.

PURPOSE AND SCOPE

The purpose and scope of this investigation is to identify and interpret geologic conditions at the site to identify potential risk from geologic hazards to the Project. This investigation is intended to: (1) provide geologic information and assessment of geologic conditions at the site; (2) identify potential geologic hazards that may be present and qualitatively assess their risk to the intended site use; and (3) provide recommendations for additional site- and hazard-specific studies or mitigation measures, as may be needed based on our findings. Such recommendations could require further multi-disciplinary evaluations, and/or may need design criteria that are beyond our professional scope.

The following services were performed in accordance with the above stated purpose and scope:

- A site reconnaissance conducted by an experienced certified engineering geologist to assess the site setting and look for adverse geologic conditions;
- Excavation and logging of one trench and three test pits at the site between June 30 and July 2, 2016 to evaluate subsurface conditions at the property;
- Review of readily-available geologic maps, reports, and air photos; and
- Evaluation of available data and preparation of this report, which presents the results of our study.

The engineering geology section of this report has been prepared in accordance with current generally accepted professional engineering geologic principles and practice in Utah, and meets specifications provided in Chapter 27 of the Weber County Land Use Code.

PRIOR STUDIES

Western GeoLogic (2006) conducted a previous geologic hazards evaluation for the Pineview Estates development in 2006. This report identified potential geologic hazards from earthquake ground shaking, stream flooding, debris flows, and landsliding based on surficial observations, review of geologic mapping and aerial photos, and subsurface data. The 2006 investigation included excavation and logging of one trench across the presumed location of the West Ogden Valley fault about 215 feet southeast of the property, as well as 11 test pits in other areas of the development. With regard to potential geologic hazards at the site, Western GeoLogic (2006) recommended that: (1) proposed homes be designed and constructed to current seismic standards; (2) site hydrology, runoff, and/or potential for debris-flow hazards be addressed in civil engineering design for the development; and (3) a design-level geotechnical engineering study be conducted to address soil conditions with regard to foundation design and site preparation, provide recommendations to reduce seismic risk, and evaluate stability of slopes along the western site margin. Western Geologic (2006) further identified a potential hazard from radon, although this hazard is an indoor environmental health issue that is no longer addressed in our reports.

Western GeoLogic (2006) was incorporated as an appendix to a geotechnical engineering evaluation prepared for the Pineview Estates development by ETE (2006). ETE (2006) conducted a slope stability evaluation for the proposed development that found the lots along the western margin of the subdivision to have a high risk for slope instability due to low factors of safety. The Project is one of these high-risk lots. ETE (2006) further provided recommendations regarding footing and foundation design, seismic design, site grading, surface and subsurface drainage, and pavement construction.

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows the site is on the western margin of Ogden Valley about 2,500 feet west of the west marina for Pineview Reservoir (Figure 1). The Project is in an area between two unnamed canyons on the northwest and southwest and Ogden Valley to the east (Figure 1). Both of these canyons have small drainages that flow into Pineview Reservoir. The unnamed drainage flowing from the canyon on the southwest is nearest and about 300 feet to the southeast. No active drainages are shown crossing the Project on Figure 1.

The site is at the western margin of Ogden Valley, which is dominated in the valley bottom by unconsolidated lacustrine and alluvial basin-fill deposits. Slopes in the site area are mainly underlain by weathered Tertiary-age tuffaceous bedrock and a surficial veneer of unconsolidated Quaternary alluvial and colluvial deposits. Three borings were conducts for a concurrent geotechnical study being conducted by GSH. Field logs indicate that boring B-2 southwest of the proposed home encountered groundwater at a depth of 22 feet below the ground surface (bgs), and boring B-3 to the northwest encountered groundwater at 32 feet bgs. No groundwater was encountered in boring B-1, which only extended to a depth of 20 feet. Seeps were also encountered in the trench excavated for this study, as well as test pit TP-1. The latter filled with water shortly after excavation. Groundwater depths at the site likely vary seasonally from snowmelt runoff and annually from climatic fluctuations, as would be expected for an alpine environment, and locally above less-permeable, clay-rich bedrock layers in the subsurface. Perched conditions were observed at one location by ETE (2006), and groundwater seepage was also observed in the trench and TP-1 exposures conducted for this study. Given the above, we anticipate groundwater to be around 35 feet bgs in the upper (western) part of the site and gradually shallow to around 10 feet bgs in the lower (eastern) part.

Avery (1994) indicates groundwater in Ogden Valley occurs under perched, confined, and unconfined conditions in the valley fill to depths of 750 feet or more. A well-stratified lacustrine silt layer forms a leaky confining bed in the upper part of the valley-fill aquifer. The aquifer below the confining beds is the principal aquifer, which is in primarily fluvial and alluvial-fan deposits. The principal aquifer is recharged from precipitation, seepage from surface water, and subsurface inflow from bedrock into valley fill along the valley margins (Avery, 1994). The confined aquifer is typically overlain by a shallow, unconfined aquifer recharged from surface flow and upward leakage. Groundwater flow is generally from the valley margins into the valley fill, and then toward the head of Ogden Canyon (Avery, 1994). Based on topography, we expect groundwater flow at the site to be generally to the east.

GEOLOGY

Surficial Geology

The site is located on the western margin of Ogden Valley, a sediment-filled intermontane valley within the Wasatch Range, a major north-south trending mountain range marking the eastern boundary of the Basin and Range physiographic province (Stokes; 1977, 1986). Surficial geology of the site is mapped by Coogan and King (2016; Figure 2) as Quaternary mass-movement deposits (unit Qms), although we note that prior published and unpublished mapping (including Coogan and King, 2001) show the site in alluvium and colluvium (unit Qac) rather than landslide deposits. Coogan and King (2016) describe surficial geologic units in the site area on Figure 2 as follows:

Qlamh - *Lacustrine, marsh, and alluvial deposits, undivided (Historical).* Sand, silt, and clay mapped where streams enter Pineview Reservoir, and reservoir levels fluctuate such that lacustrine, marsh, and alluvial deposits are intermixed; thickness uncertain.

Qaf, Qafy, Qaf3, Qaf3?, Qaf4, Qaf4?, Qaf5 - *Alluvial-fan deposits (Holocene and Pleistocene).* Mostly sand, silt, and gravel that is poorly bedded and poorly sorted and that is not close to late Pleistocene Lake Bonneville and is geographically in the Huff Creek and upper Bear River drainages; variably consolidated; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Qaf with no suffix used where age uncertain or for composite fans where portions of fans with multiple ages cannot be shown separately at map scale; toes of some fans have been removed by human disturbances, so their age cannot be determined.

Where possible, subdivided into relative ages, indicated by letter and number suffixes (like Qa and Qat suffixes) and relative ages only apply to the local drainage, with unit Qafy being the lowest (youngest) fans and unit 3 may or may not post-date Lake Bonneville. Relative ages of these fans are partly based on heights above present drainages at drainage-eroded edge of fan. The relative age is queried where the age is uncertain, generally due to the height not fitting into the typical order of surfaces. The various deposits listed, Qafy and Qaf3 through Qaf5, are 20 to 140 feet (6-40 m) above and west of Saleratus Creek, and also above Yellow Creek and the Bear River. Qafy fans are active, impinge on present-day floodplains, divert active streams, and overlie low terraces.

Qac - *Alluvium and colluvium (Holocene and Pleistocene).* Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits too small to show at map scale; typically mapped along smaller drainages that lack flat bottoms; more extensive east of Henefer where Wasatch Formation (Tw) strata easily weather to debris that "chokes" drainages; 6 to 20 feet (2-6 m) thick. Some deposits are "perched" on benches 80 feet (25 m) and more above present-day drainages like Left Fork Heiners Creek (Heiners Creek quadrangle) and Harris Canyon (Henefer quadrangle). In the Devils Slide quadrangle, some deposits are "perched" on benches about 60 to 130 feet (18-40 m) above Quarry Cottonwood Canyon indicating the alluvium is at least partly Lake Bonneville age and older (see Qab and Qao in tables 1 and 2).

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso? - *Landslide deposits (Holocene and upper and middle? Pleistocene).* Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks;

composition depends on local sources; morphology becomes more subdued with time and amount of water in material during emplacement; Qms may be in contact with Qms when landslides are different/distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are "perched" above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qmc - *Landslide and colluvial deposits, undivided (Holocene and Pleistocene).* Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flow and flood deposits; typically mapped where landslides are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 6 to 40 feet (2-12 m) thick. These deposits are as unstable as other landslide units (Qms, Qmsy, Qmso).

Qafp, Qafp?, Qafb, Qafb?, Qafpb, Qafpb? - *Lake Bonneville-age alluvial-fan deposits (upper Pleistocene).* Like undivided alluvial fans, but height above present drainages appears to be related to shorelines of Lake Bonneville and is within certain limits (see table 1); these fans are inactive, unconsolidated to weakly consolidated, and locally dissected; fans labeled Qafp and Qafb are related to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively, while unit Qafpb is used where fans may be related to the Provo or Bonneville shoreline (for example Qafpb is ~40 feet [12 m] above Lost Creek Valley), or where fans of different ages cannot be shown separately at map scale; Qafp fans typically contain well-rounded, recycled Lake Bonneville gravel and sand

and are moderately well sorted; generally 10 to less than 60 feet (3-18 m) thick. Lake Bonneville-age fans are queried where relative age is uncertain (see Qaf for details); fans labeled Qafpb? are above the Bonneville shoreline and might be Qafo or like Qafm; see the note under Qao about two possible ages of older alluvium (Qao, Qato, and Qafo). Most of the Lake Bonneville-age fans in the James Peak quadrangle are far from the Bonneville shoreline and their age is inferred from their stratigraphic relationship(s) to coeval Pinedale glacial outwash (see age equality in Table 3).

The channels (Qafp/Qdlb) on the Weber River delta and Lake Bonneville fines (Qafp on Qlfb) probably record scour and fill during the rapid drawdown of the lake as it fell from the Bonneville shoreline to the Provo shoreline.

Qls, Qls?, Qlsp, Qlsb, Qlsb? - *Lake Bonneville sand (upper Pleistocene).* Mostly sand with some silt and gravel deposited nearshore below and near the Provo shoreline (Qlsp) and between the Provo and Bonneville shorelines (Qlsb); Qls mapped downslope from slope break below Provo shoreline beach deposits where thin Lake Bonneville regressional sand may overlie transgressional sand; grades downslope into unit Qlf with decreasing sand content and laterally with more gravel into units Qdlp, Qdlb, and upslope with more gravel into unit Qlgb; Qls and Qlsb queried where grain size or unit identification uncertain; may be as much as 75 feet (25 m) thick, and thickest near Ogden; typically less than 20 feet (6 m) thick in Morgan Valley; may include small deltas and deltas that lack typical delta shape.

Qla, Qla? - *Lake Bonneville lacustrine deposits and post- and pre-Lake Bonneville alluvial deposits, undivided (Holocene and upper? Pleistocene).* Mostly poorly sorted and poorly bedded sand, silt, and clay, with some gravel; mapped where Lake Bonneville deposits are reworked by later stream action or covered by thin stream and fan deposits, and where lake deposits are thin and overlie older alluvial deposits; unit queried where may be dominantly alluvium; deposits typically eroded from shallow Norwood Formation; mostly mapped near Bonneville shoreline; also mapped in Peterson quadrangle along upper Deep Creek above Bonneville shoreline where lake deposits seem to indicate landslide dam of creek; thickness uncertain.

Tn, Tn? - *Norwood Formation (lower Oligocene and upper Eocene).* Typically light-gray to light-brown altered tuff (claystone), altered tuffaceous siltstone and sandstone, and conglomerate; unaltered tuff, present in type section south of Morgan, is rare; locally colored light shades of red and green; variable calcareous cement and zeolitization; involved in numerous landslides of various sizes; estimate 2000-foot *(600 m) thick in exposures on west side of Ogden Valley (based on bedding dip,* outcrop width, and topography). Norwood Formation queried where poor exposures may actually be surficial deposits. For detailed Norwood Formation information see description under heading "Sub-Willard Thrust - Ogden Canyon Area" since most of this unit is in and near Morgan Valley and covers the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Zmcg, Zmcg? - *Maple Canyon Formation, Lower (green arkose) member (Neoproterozoic).* Grayish-green, fine-grained arkosic (feldspathic) meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses up to 200 feet (60 m) thick; weathers darker gray to brown to greenish-gray and greenish-brown; 500 to 1000 feet (150-305 m) thick and lower thickness would eliminate the need for faulting in southwest part of Huntsville quadrangle. This unit is prone to slope failures.

Zarx - *Argillite of lower member of Maple Canyon Formation or upper member of Formation of Perry Canyon (Proterozoic).* Greenish-gray argillite to meta-graywacke in poor exposures on east side of Ogden Valley (Zarx and Qdlb/Zarx) and on dip slope west of Ogden Valley; weathering, lack of bedding, and lack of exposures of overlying conglomerate member of Maple Canyon preclude separation of these stratigraphically adjacent units. This unit is prone to slope failures.

Zpu, Zpu? - *Formation of Perry Canyon, Upper member (Neoproterozoic).* Olive drab to gray, thin-bedded slate to argillite to phyllite to micaceous meta-siltstone to meta-graywacke to meta-sandstone in variable proportions such that unit looks like both the "greywacke-sandstone" and "mudstone" members of previous workers; unit identification based on underlying diamictite in Mantua quadrangle; rare meta-gritstone and meta-diamictite (actually conglomerate?); locally schistose; meta-sandstone contains poorly sorted lithic, quartz, and feldspar grains in silty to micaceous matrix; meta-sandstone is quartzose in outcrops on west margin of Mantua quadrangle (Crittenden and Sorensen, 1985a) and medial zone of sandstone is feldspathic east of Ogden Valley, where mapped and described as argillite member of Maple Canyon Formation by Crittenden (1972) and Sorensen and Crittenden (1979); thickness uncertain, but appears to be about 600 feet (180 m) thick on west flank of Grizzly Peak in the Mantua quadrangle and about 1000 feet (300 m) thick between Ogden Canyon and North Ogden divide. In Ogden Valley typically non-resistant and tan weathering such that gray to green to dark-gray fresh color is seldom seen except in cut slopes and excavations. This unit is prone to slope failures.

Citations, tables, and/or figures noted above are not provided herein, but are in Coogan and King (2016).

Norwood Formation bedrock in the area has average dips of about 30 to 45 degrees, although this unit has local depositional variations that may produce lower and higher dips within a relatively short distance (Jon King, Utah Geological Survey, verbal communication, February 29, 2016). Figure 2 shows one field measurement reportedly in Norwood Formation bedrock about 2,500 feet north of the site that shows a strike/dip of N49°W 40° NE. Two additional measurements inferred from photo interpretation are in Norwood Formation east and northeast of the site and reported in GIS data in Coogan and King (2016). These measurements show strikes of N33°W and N17°W and dips of 33° and 17° to the northeast (respectively).

Seismotectonic Setting
The property is located at the western margin of Ogden Valley, a roughly 40-square mile back valley described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys of the northern Wasatch Range are in a transition zone between the Basin and Range and Middle Rocky Mountains provinces (Stokes, 1977, 1986). The Basin and Range is characterized by a series of generally north-trending elongate mountain ranges, separated by predominately alluvial and lacustrine sediment-filled valleys and typically bounded on one or both sides by major normal faults (Stewart, 1978). The boundary between the Basin and Range and Middle Rocky Mountains provinces is the prominent, west-facing escarpment along the Wasatch fault zone at the base of the Wasatch Range. Late Cenozoic normal faulting, a characteristic of the Basin and Range, began between about 17 and 10 million years ago in the Nevada (Stewart, 1980) and Utah (Anderson, 1989) portions of the province. The faulting is a result of a roughly east-west directed, regional extensional stress regime that has continued to the present (Zoback and Zoback, 1989; Zoback, 1989). The back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the east and west sides of the valley. The Ogden Valley southwestern margin fault (aka West Ogden Valley fault; Black and others, 2003) is shown on Figure 2 (dotted line) trending northwestward near the eastern site boundary. The most recent movement on this fault is pre-Holocene (Sullivan and others, 1986). Western GeoLogic (2006) excavated one trench across the presumed fault location slightly southeast of the Project. This trench reportedly exposed a sequence of latest Pleistocene to Holocene-age alluvium and colluvium displaying no evidence for active faulting.

The site is also situated near the central portion of the Intermountain Seismic Belt (ISB). The ISB is a north-south-trending zone of historical seismicity along the eastern margin of the Basin and Range province which extends for approximately 900 miles from northern Arizona to northwestern Montana (Sbar and others, 1972; Smith and Sbar, 1974). At least 16 earthquakes of magnitude 6.0 or greater have occurred within the ISB since 1850, with the largest of these events the M_S 7.5 1959 Hebgen Lake, Montana earthquake. However, none of these events have occurred along the Wasatch fault zone or other known late Quaternary faults in the region (Arabasz and others, 1992; Smith and Arabasz, 1991). The closest of these events to the site was the 1934 Hansel Valley (M_S 6.6) event north of the Great Salt Lake and south of the town of Snowville.

Lake Bonneville History
Lakes occupied nearly 100 basins in the western United States during late-Quaternary time, the largest of which was Lake Bonneville in northwestern Utah. The Bonneville basin consists of several topographically closed basins created by regional extension in the Basin and Range (Gwynn, 1980; Miller, 1990), and has been an area of internal drainage for much of the past 15 million years. Lake Bonneville consisted of numerous topographically closed basins, including the Salt Lake and Cache Valleys (Oviatt and others, 1992). Portions of Ogden Valley were inundated by Lake Bonneville at its highstand, and sediments from Lake Bonneville are mapped in the Project area on Figure 2.

Timing of events related to the transgression and regression of Lake Bonneville is indicated by calendar age estimates of significant radiocarbon dates in the Bonneville Basin (Oviatt, 2015). Approximately 30,000 years ago, Lake Bonneville began a slow transgression (rise) to its highest level of 5,160 to 5,200 feet above mean sea level. The lake rise eventually slowed as water levels approached an external basin threshold in northern Cache Valley at Red Rock Pass near Zenda, Idaho. Lake Bonneville reached the Red Rock Pass threshold and occupied its highest shoreline, termed the Bonneville beach, around 18,000 years ago. During the transgression and highstand, major drainages that emanate from within the Wasatch Range (such as the Weber River) formed large deltaic complexes in the lake at their canyon mouths. Headward erosion of the Snake River-Bonneville basin drainage divide then caused a catastrophic incision of the threshold and the lake level lowered by roughly 360 feet in fewer than two months (Jarrett and Malde, 1987; O'Conner, 1993). The site would be above the elevation of the highest (Bonneville) shoreline.

Following the Bonneville flood, the lake stabilized and formed a lower shoreline referred to as the Provo shoreline between about 16,500 and 15,000 years ago. Climatic factors then caused the lake to regress rapidly from the Provo shoreline, and by about 13,000 years ago the lake had eventually dropped below historic levels of Great Salt Lake. Drainages that fed Lake Bonneville began downcutting through stranded deltaic complexes and near-shore deposits as the lake receded from the Provo shoreline. Oviatt and others (1992) deem this low stage the end of the Bonneville lake cycle. Great Salt Lake then experienced a brief transgression around 11,600 years ago to the Gilbert level at about 4,250 feet before receding to and remaining within about 20 feet of its historic average level (Lund, 1990).

SITE CHARACTERIZATION

Empirical Observations

On June 30, 2016, Bill D. Black of Western GeoLogic conducted a reconnaissance of the property. Weather at the time of the site reconnaissance was clear and sunny with temperatures in the 80's (°F). The site is at the western margin of Ogden Valley on east- to northeast-facing slopes overlooking Ogden Valley. Native vegetation consists mainly of trees and brush. A substantial area of the site had previously been cleared of vegetation to facilitate access and the proposed development. No active streams were observed crossing the Project, and no bedrock outcrops or evidence of ongoing or recent slope instability was also observed. Slopes at the site have a steepness of from about 2.5:1 on the west to about 4:1 (horizontal to vertical) on the east. No other evidence of geologic hazards was observed.

Air Photo Observations

High-resolution orthophotography from 2012 (Figure 3B) and 1-meter bare earth DEM LIDAR from 2011 available from the Utah AGRC (Figure 3A) were reviewed to obtain information about the geomorphology of the Project area. The site is at the western margin of Ogden Valley on east- to northeast-facing slopes overlooking Pineview Reservoir. One slope failure is evident on the air photos about 400 feet northwest of the site. This failure reportedly occurred around April-May 2006. The existing paved street was reportedly installed in 2009, although it is possible that this slide was caused by grading activity. The failure toe has been removed and buttressed with a retained rock wall. An unnamed ephemeral drainage appears to have crossed the slide area, which now follows the scarp base to the northeast, cuts across the left-lateral margin of the slide, and then crosses the road (Figures 3A-B). Below the road, the drainage re-enters its former course and proceeds downslope to the east. No other geologic hazards were evident at the site or in the area on the photos.

Subsurface Investigation
One trench and three walk-in test pits were excavated at the property between June 30 and July 2, 2016 to evaluate subsurface conditions. Figure 4 is a site plan at a scale of one inch equals 60 feet (1:720) showing the site boundaries, surveyed topography, the proposed home location and footprint, locations of the trench and test pits, and approximate locations of the borings conducted by GSH. Figures 5 and 6A-C are logs of the trench and test pits at a scale of 1 inch equals five feet (1:60). Due to the length of the trench and scale, Figure 5 occupies four 11"x17" sheets (A-D). The trench and test pit locations were measured using a hand-held GPS unit and by trend and distance methods from known points. Trench logging generally followed methodology in McAlpin (1996). The trench and test pit exposures were also digitally photographed at 5-foot intervals to document subsurface conditions. The photos are not provided herein, but are available on request. No complications were encountered that substantially impacted the subsurface investigation, except for groundwater seepage in test pit TP-1, which caused this test pit to rapidly fill with water to a depth of several feet during and following the logging.

The trench at the site was excavated generally along the north site boundary and extended an overall N34°E for a total distance of 247 feet (Figure 4). The trench exposed a sequence of inclined bedrock units of the Tertiary Norwood Formation in which the modern A-horizon soil and a Bt to Bw horizon was forming. The exposed bedrock sequence showed strikes ranging from N40°W to N42°W and dips of from 37° to 42° to the northeast (Figures 5A-D), which appears similar to nearby measurements (discussed above). Unit descriptions are provided on Figure 5D. No evidence of landsliding was exposed in the trench, except for one suspect iron-oxide stained crack near station 1+61 feet (Figure 5C) that may be related to slow slope creep. One seep was also observed near station 0+67 feet (Figure 5B), although this seep was weak and only caused a muddy area in the trench floor.

Test pit TP-1 at the site (Figures 4 and 6A) exposed a sequence of alluvium and colluvium in which the A- and B-horizon soils were forming. The lowermost unit in this test pit appeared to be a shallow slump deposit, whereas the overlying unit (1b) appeared to be a mix of slope colluvium (Figure 6A). No source area for this slump was evident on Figures 3A-B, suggesting it was either small or has been eroded away (and therefore is old). Test pit TP-2 (Figures 4 and 6B) exposed a sequence of colluvium overlying tuffaceous conglomerate and claystone bedrock of the Norwood Formation. We infer the latter correlates to unit 1h in the trench (Figure 5B), although no overlying conglomerate unit was observed in the trench and may reflect a lateral variation between the trench and TP-1. Such variations are commonly found in the Norwood Formation. Test pit TP-3 (Figures 4 and 6C) exposed a sequence of tuffaceous conglomerate and sandstone that we infer correlates to units 1b and 1c in the trench (Figure 5A), although the measured strike/dip in TP-3 differed slightly (N44°W 29°NE.

Cross Section

Figure 7 shows a cross section across the slope at the site at a scale of 1 inch equals 30 feet with no vertical exaggeration. The profile location is shown on Figure 4. Units and contacts are inferred based on the subsurface data discussed above. We use an overall dip of 40 degrees for contacts within the Norwood Formation. Presumed existing groundwater levels are also indicated based on the GSH field logs for the borings, although we note that future levels may fluctuate seasonally and in response to landscape irrigation.

GEOLOGIC HAZARDS

Assessment of potential geologic hazards and the resulting risks imposed is critical in determining the suitability of the site for development. Table 1 below shows a summary of the geologic hazards reviewed at the site, as well as a relative (qualitative) assessment of risk to the Project for each hazard. A "high" hazard rating (H) indicates a hazard is present at the site (whether currently or in the geologic past) that is likely to pose significant risk and/or may require further study or mitigation techniques. A "moderate" hazard rating (M) indicates a hazard that poses an equivocal risk. Moderate-risk hazards may also require further studies or mitigation. A "low" hazard rating (L) indicates the hazard is not present, poses little or no risk, and/or is not likely to significantly impact the Project. Low-risk hazards typically require no additional studies or mitigation. We note that these hazard ratings represent a conservative assessment for the entire site and risk may vary in some areas. Careful selection of development areas can minimize risk by avoiding known hazard areas.

Table 1. *Geologic hazards summary.*

Hazard	H	M	L	...Hazard Rating
Earthquake Ground Shaking	X			
Surface Fault Rupture			X	
Liquefaction and Lateral-spread Ground Failure			X	
Tectonic Deformation			X	
Seismic Seiche and Storm Surge			X	
Stream Flooding			X	
Shallow Groundwater		X		
Landslides and Slope Failures	X			
Debris Flows and Floods			X	
Rock Fall			X	
Problem Soil		X		

Earthquake Ground Shaking

Ground shaking refers to the ground surface acceleration caused by seismic waves generated during an earthquake. Strong ground motion is likely to present a significant risk during moderate to large earthquakes located within a 60 mile radius of the project area (Boore and others, 1993). Seismic sources include mapped active faults, as well as a random or "floating" earthquake source on faults not evident at the surface. Mapped active faults within this distance include the East and West Cache fault zones; the Brigham City, Weber, Salt Lake, and Provo segments of the Wasatch fault zone; the East Great Salt Lake fault zone; the Morgan fault; the West Valley fault zone; the Oquirrh fault zone; and the Bear River fault zone (Black and others, 2003).

The extent of property damage and loss of life due to ground shaking depends on factors such as: (1) proximity of the earthquake and strength of seismic waves at the surface (horizontal motions are the most damaging); (2) amplitude, duration, and frequency of ground motions; (3) nature of foundation materials; and (4) building design (Costa and Baker, 1981). Assuming 2012/2015 IBC design codes, a site class of D (stiff soil), and a risk category of II, USGS calculated uniform-hazard and deterministic ground motion values with a 2% chance of exceedance in 50 years are as follows:

Table 2. *Seismic hazards summary.*
(Site Location: 41.27688° N, - 111.82975° W)

S_S	*0.927g*
S_1	*0.317g*
S_{MS} (F_a x S_S)	*1.047g*
S_{M1} (F_v x S_1)	*0.559g*
S_{DS} (2/3 x S_{MS})	*0.698g*
S_{D1} (2/3 x S_{M1})	*0.373g*
Site Coefficient, F_a	*=1.129*
Site Coefficient, F_v	*=1.767*

Given the above information, earthquake ground shaking is a high risk to the site. The hazard from earthquake ground shaking can be adequately mitigated by prudent design and construction.

Surface Fault Rupture

Movement along faults at depth generates earthquakes. During earthquakes larger than Richter magnitude 6.5, ruptures along normal faults in the intermountain region generally propagate to the surface (Smith and Arabasz, 1991) as one side of the fault is uplifted and the other side down dropped. The resulting fault scarp has a near-vertical slope. The surface rupture may be expressed as a large singular rupture or several smaller ruptures in a broad zone. Ground displacement from surface fault rupture can cause significant damage or even collapse to structures located on an active fault.

The nearest active fault to the site is the Weber segment of the WFZ about 6.1 miles to the west, and no evidence of active surface faulting is mapped or was evident at the site. Based on this, the hazard from surface faulting is rated as low. The Ogden Valley southwestern margin fault (Black and others, 2003) is near the eastern site boundary (Figure 2, dotted line), however the most-recent movement on this fault is believed to be middle to late Quaternary. Western GeoLogic (2006) found no evidence for active (Holocene-age) faulting in one trench excavated across the presumed fault location slightly southeast of the site.

Liquefaction and Lateral-spread Ground Failure

Liquefaction occurs when saturated, loose, cohesionless, soils lose their support capabilities during a seismic event because of the development of excessive pore pressure. Earthquake-induced liquefaction can present a significant risk to structures from bearing-capacity failures to structural footings and foundations, and can damage structures and roadway embankments by triggering lateral spread landslides. Earthquakes of Richter magnitude 5 are generally regarded as the lower threshold for liquefaction. Liquefaction potential at the site is a combination of expected seismic (earthquake ground shaking) accelerations, groundwater conditions, and presence of susceptible soils.

No soils likely susceptible to liquefaction were observed in the trench and test pit exposures at the site, or were evident in the borings conducted by GSH. Based on this, the hazard from liquefaction and lateral spreading is rated as low.

Tectonic Deformation

Tectonic deformation refers to subsidence from warping, lowering, and tilting of a valley floor that accompanies surface-faulting earthquakes on normal faults. Large-scale tectonic subsidence may accompany earthquakes along large normal faults (Lund, 1990). Tectonic subsidence is believed to mainly impact those areas immediately adjacent to the downthrown side of a normal fault. Western GeoLogic (2006) previously identified the site as having a low risk from tectonic deformation given the lack of active faults in the site area.

Seismic Seiche and Storm Surge

Earthquake-induced seiche presents a risk to structures within the wave-oscillation zone along the edges of large bodies of water, such as the Great Salt Lake. Given the elevation of the subject property and distance from large bodies of water, the risk to the subject property from seismic seiches is rated as low.

Stream Flooding

Stream flooding may be caused by direct precipitation, melting snow, or a combination of both. In much of Utah, floods are most common in April through June during spring snowmelt. High flows may be sustained from a few days to several weeks, and the potential for flooding depends on a variety of factors such as surface hydrology, site grading and drainage, and runoff.

No active drainages cross the site or were evident, and based on this the hazard from stream flooding should be low. However, site hydrology and runoff should be addressed in the civil engineering design and grading plan for the Project given the substantial impact that groundwater may have on slope stability.

Shallow Groundwater

No springs are shown on the topographic map for the site or were reported or observed. However, groundwater seeps were observed in the trench and TP-1 at the site, and borings B-2 and B-3 encountered groundwater at depths of 22 and 32 feet (respectively). We anticipate groundwater to be around 35 feet bgs in the upper (western) part of the site and gradually shallow to around 10 feet bgs in the lower (eastern) part. Given this and that substantial slope cuts may be required for the proposed development; we rate the risk from shallow groundwater as moderate.

Landslides and Slope Failures

Slope stability hazards such as landslides, slumps, and other mass movements can develop along moderate to steep slopes where a slope has been disturbed, the head of a slope loaded, or where increased groundwater pore pressures result in driving forces within the slope exceeding restraining forces. Slopes exhibiting prior failures, and also deposits from large landslides, are particularly vulnerable to instability and reactivation.

The site is in an area mapped as being underlain by mass-movement deposits. One small slide is evident on air photos to the north of the property, although no evidence for recent or ongoing slope instability was observed at the site. Except for possible shallow slump deposits in TP-1 and a crack suggestive of possible slope creep in the trench (discussed above), no landslide deposits or deformation was also observed in the trench or test pits. The exposed stratigraphy in the trench and test pits appear to show a fairly consistent sequence of tuffaceous bedrock across the site. This evidence, and the general correspondence between measured strike/dip measurements in the exposures and nearby measurements (discussed above), suggests that the geologic mapping on Figure 2, which shows the site in Quaternary mass-movement deposits, is inaccurate.

Although air photo evidence and the subsurface information from the trench and test pits do not indicate any existing landslides at the site, slopes at the property are steep and in landslide-prone bedrock, and a small landslide is also nearby in similar slopes. Given this, we rate the hazard from landsliding as high. We recommend stability of the slopes be evaluated in a geotechnical engineering evaluation prior to building based on site specific data and subsurface information included in this report. Recommendations for reducing the risk from landsliding should be provided if factors of safety are determined to be unsuitable. The stability evaluation should take into account possible perched groundwater and fluctuating seasonal levels, and care should also be taken that site grading does not destabilize slopes in this area without prior geotechnical analysis and grading plans. Water and improper slope cuts appear to be significant factors in slope instability in the site area. Therefore, it is critical that proper drainage be maintained, and that all cuts are engineered and retained properly.

Debris Flows
Debris flow hazards are typically associated with unconsolidated alluvial fan deposits at the mouths of large range-front drainages, such as those along the Wasatch Front. Debris flows have historically significant damage in the Wasatch Front area. No evidence for debris-flow channels, levees, or other debris-flow features was observed at the site or on air photos. Based on the above, we rate the existing risk from debris flows at the site as low.

Rock Fall
No bedrock outcrops were observed at the site or in higher slopes that could present a source area for rock fall clasts. Based on the above, we rate the hazard from rock falls as low.

Swelling and Collapsible Soils
Surficial soils that contain certain clays can swell or collapse when wet. Given the subsurface soil conditions observed at the site, it is possible that clayey interbeds may be present in the subsurface that could pose a moderate risk from problem soils. A geotechnical engineering evaluation should therefore be performed to address soil conditions and provide specific recommendations for site grading, subgrade preparation, and footing and foundation design.

CONCLUSIONS AND RECOMMENDATIONS

Earthquake ground shaking and landslides are identified as geologic hazards posing a high relative risk to the Project. Shallow groundwater and problem soils also pose a moderate risk. The following recommendations are provided to reduce risk from these hazards and for proper site development:

- ***Excavation Inspection*** - This report does not reflect subsurface variations that may occur laterally away from exploration trenches and test pits. The nature and extent of such variations may not become evident until the course of construction, and are sometimes sufficient to necessitate structural or site plan changes. Thus, we recommend that we inspect the building footing or foundation excavation to recognize any differing conditions that could affect the performance of the planned structure.

- ***Geotechnical Investigation*** - A design-level geotechnical engineering study should be conducted prior to construction to: (1) address soil conditions at the site for use in foundation design, site grading, and drainage; (2) provide recommendations regarding building design to reduce risk from seismic acceleration; (3) evaluate and provide recommendations regarding shallow groundwater and subsurface drainage; and (4) evaluate stability of slopes at the site, including providing recommendations for reducing the risk of landsliding if the factors of safety are deemed unsuitable, based on the geologic characterizations provided in this report and site-specific geotechnical data. The stability evaluation should account for possible perched groundwater and seasonal fluctuations.

- ***Excavation Backfill Considerations*** **-** The trench and test pits may be in areas where structures could subsequently be placed. However, backfill may not have been replaced in the excavations in compacted layers. The fill could settle with time and upon saturation. Should structures be located in an excavated area, no footings or structure should be founded over the excavations unless the backfill has been removed and replaced with structural fill, if the fill is to support a structure.

- ***Availability of Report*** **-** The report should be made available to architects, building contractors, and in the event of a future property sale, real estate agents and potential buyers. This report should be referenced for information on technical data only as interpreted from observations and not as a warranty of conditions throughout the site. The report should be submitted in its entirety, or referenced appropriately, as part of any document submittal to a government agency responsible for planning decisions or geologic review. Incomplete submittals void the professional seals and signatures we provide herein. Although this report and the data herein are the property of the client, the report format is the intellectual property of Western Geologic and should not be copied, used, or modified without express permission of the authors.

LIMITATIONS

This investigation was performed at the request of the Client using the methods and procedures consistent with good commercial and customary practice designed to conform to acceptable industry standards. The analysis and recommendations submitted in this report are based upon the data obtained from site-specific observations and compilation of known geologic information. This information and the conclusions of this report should not be interpolated to adjacent properties without additional site-specific information. In the event that any changes are later made in the location of the proposed site, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or approved in writing by the engineering geologist.

This report has been prepared by the staff of Western GeoLogic for the Client under the professional supervision of the principal and/or senior staff whose seal(s) and signatures appear hereon. Neither Western GeoLogic, nor any staff member assigned to this investigation has any interest or contemplated interest, financial or otherwise, in the subject or surrounding properties, or in any entity which owns, leases, or occupies the subject or surrounding properties or which may be responsible for environmental issues identified during the course of this investigation, and has no personal bias with respect to the parties involved.

The information contained in this report has received appropriate technical review and approval. The conclusions represent professional judgment and are founded upon the findings of the investigations identified in the report and the interpretation of such data based on our experience and expertise according to the existing standard of care. No other warranty or limitation exists, either expressed or implied.

The investigation was prepared in accordance with the approved scope of work outlined in our proposal for the use and benefit of the Client; its successors, and assignees. It is based, in part, upon documents, writings, and information owned, possessed, or secured by the Client. Neither this report, nor any information contained herein shall be used or relied upon for any purpose by any other person or entity without the express written permission of the Client. This report is not for the use or benefit of, nor may it be relied upon by any other person or entity, for any purpose without the advance written consent of Western GeoLogic.

In expressing the opinions stated in this report, Western GeoLogic has exercised the degree of skill and care ordinarily exercised by a reasonable prudent environmental professional in the same community and in the same time frame given the same or similar facts and circumstances. Documentation and data provided by the Client, designated representatives of the Client or other interested third parties, or from the public domain, and referred to in the preparation of this assessment, have been used and referenced with the understanding that Western GeoLogic assumes no responsibility or liability for their accuracy. The independent conclusions represent our professional judgment based on information and data available to us during the course of this assignment. Factual information regarding operations, conditions, and test data provided by the Client or their representative has been assumed to be correct and complete. The conclusions presented are based on the data provided, observations, and conditions that existed at the time of the field exploration.

It has been a pleasure working with you on this project. Should you have any questions, please call.

Sincerely,
Western GeoLogic, LLC

Bill. D. Black, P.G.
Senior Engineering Geologist

Reviewed by:

Craig V. Nelson, P.G.
Principal Engineering Geologist

ATTACHMENTS

- Figure 1. Location Map (8.5"x11")
- Figure 2. Geologic Map (8.5"x11")
- Figure 3A. 2011 LIDAR Image (8.5"x11")
- Figure 3B. 2012 Air Photo (8.5"x11")
- Figure 4. Site Plan (8.5"x11")
- Figures 5A-D. Trench Log (four 11"x17" sheets)
- Figures 6A-C. Test Pit Logs (three 8.5"x11" sheets)
- Figure 7. Cross Section (11"x17")

G:\Western GeoLogic\PROJECTS\James Anderson\Liberty, Weber County, UT - Geologic Hazards Evaluation - 1013 North Valley View Drive #4083\Geologic Hazards Evaluation - Crimson Ridge Lot 2R.docx

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Project location NW1/4, Section 10, T6N, R1E (SLBM).

WESTERN GEOLOGIC

N W E S

0 1000 2000 feet

Scale 1:24,000
(1 inch = 2000 feet)

LOCATION MAP

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 1

Source: Coogan and King (2016); original map scale 1:100,000. See text for explanation of nearby surficial geologic units.

WESTERN GEOLOGIC

N W E S

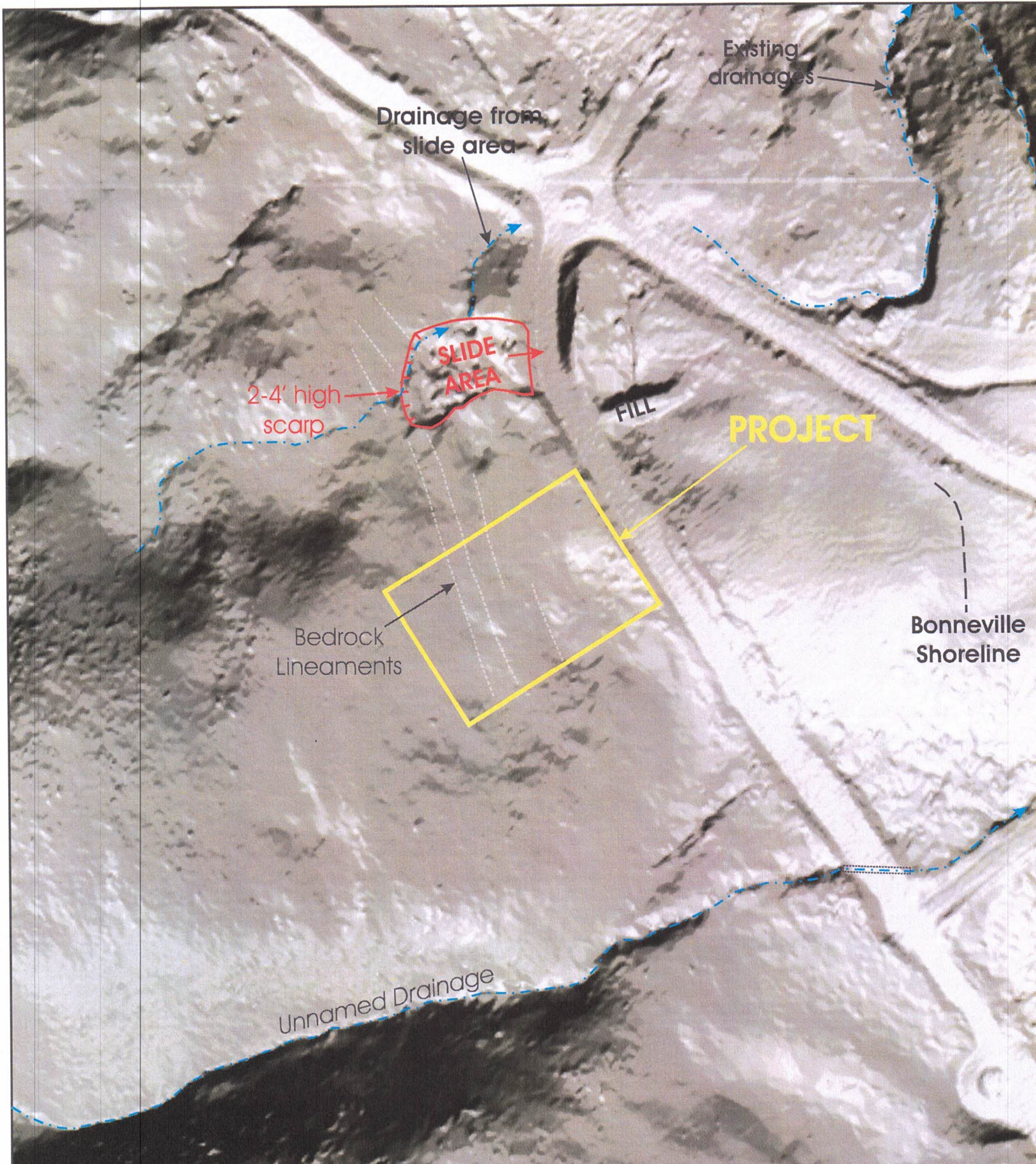
0 1000 2000 feet

Scale 1:24,000
(1 inch = 2000 feet)

GEOLOGIC MAP

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 2



Source: Utah AGRC, 1-meter LIDAR Bare Earth DEM, 2011.

N W E S

0 100 250 feet

Scale 1:2,400
(1 inch = 200 feet)

WESTERN GEOLOGIC

2011 LIDAR IMAGE

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 3A

Source: Utah AGRC, High Resolution Orthophoto, 6-inch resolution, 2012.

N
W E
S

0 100 250 feet

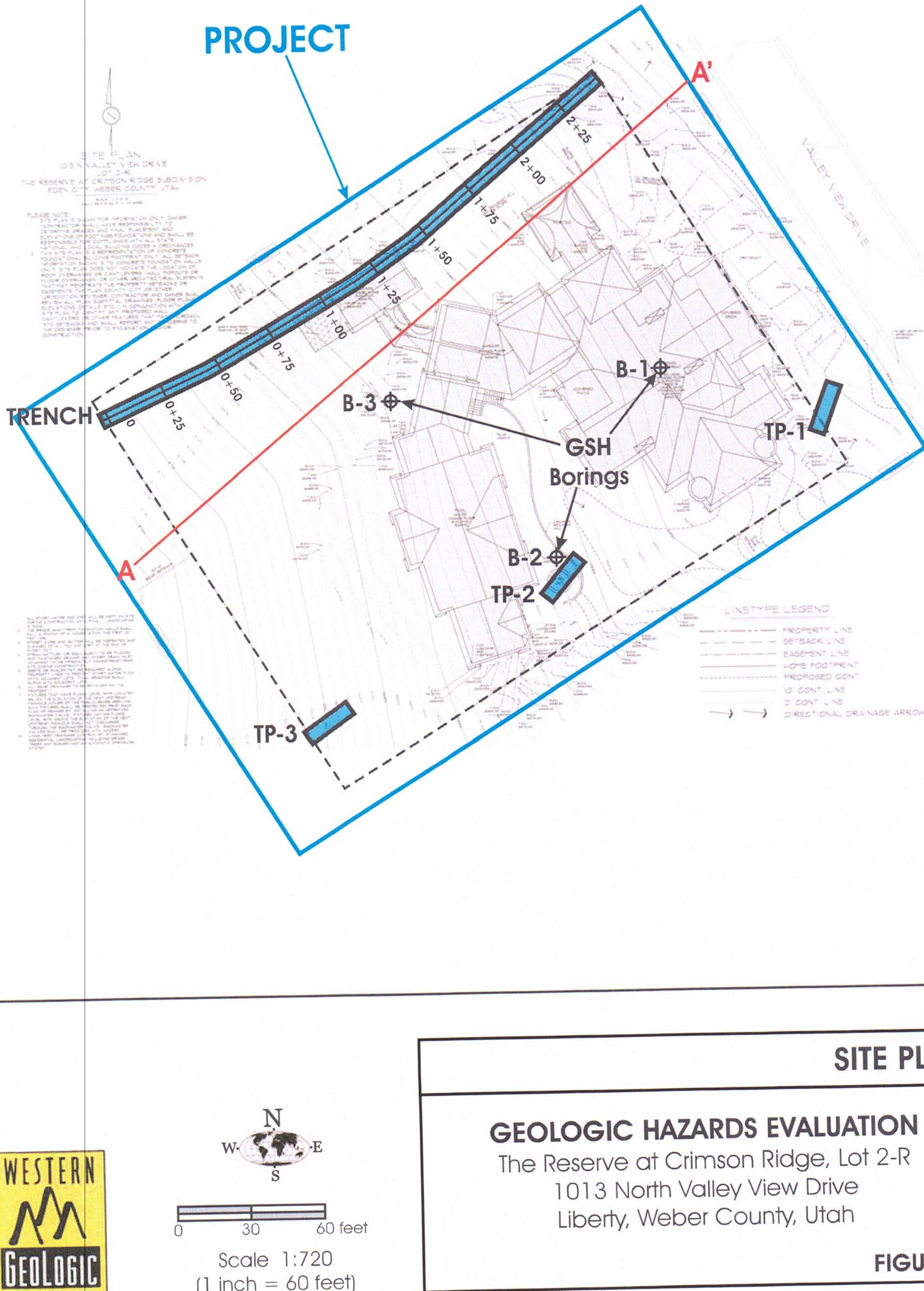
Scale 1:2,400
(1 inch = 200 feet)

WESTERN GEOLOGIC

2012 AIR PHOTO

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 3B



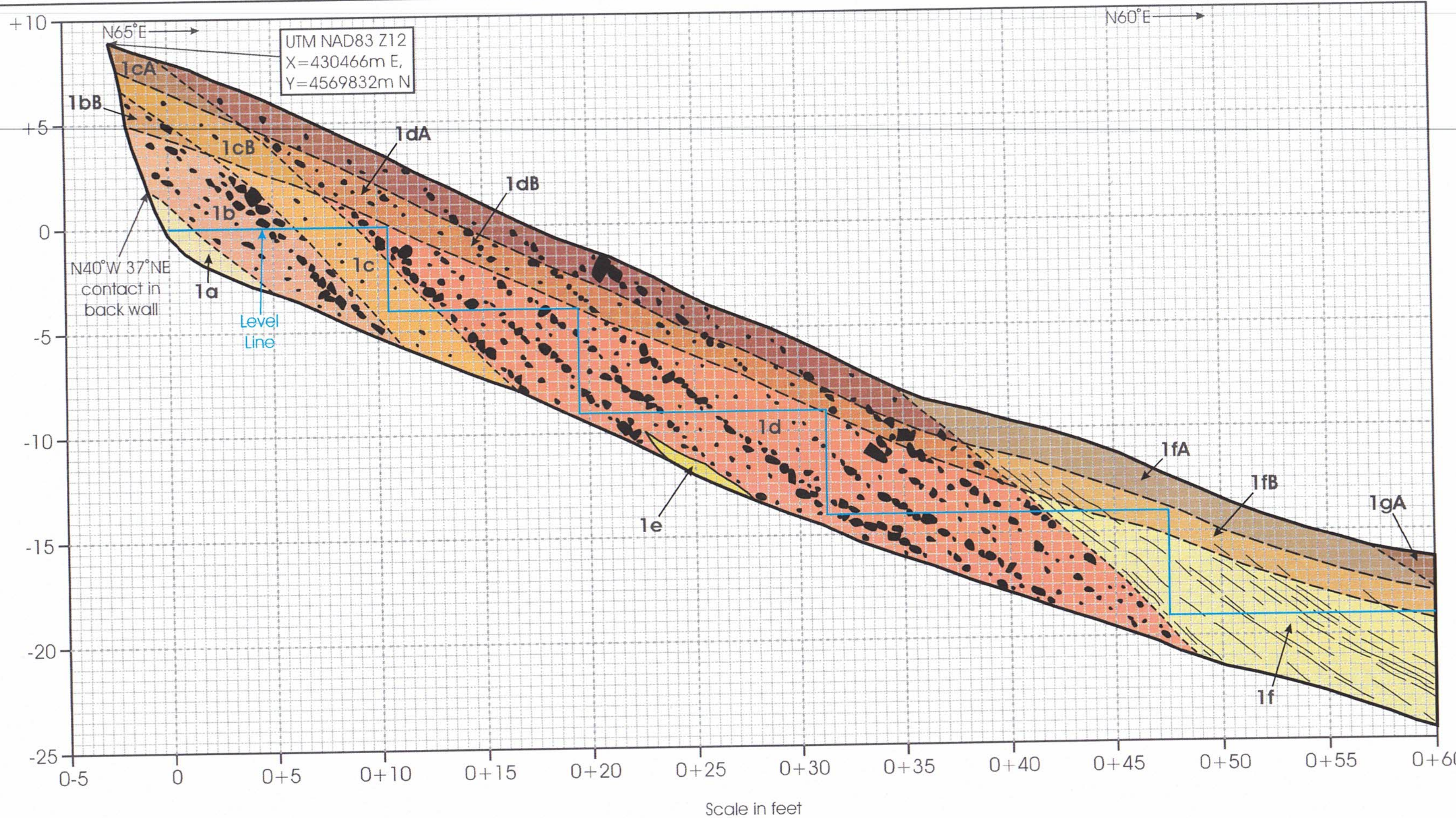
WESTERN GEOLOGIC

SITE PLAN

GEOLOGIC HAZARDS EVALUATION

The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 4



SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on June 1-2, 2016

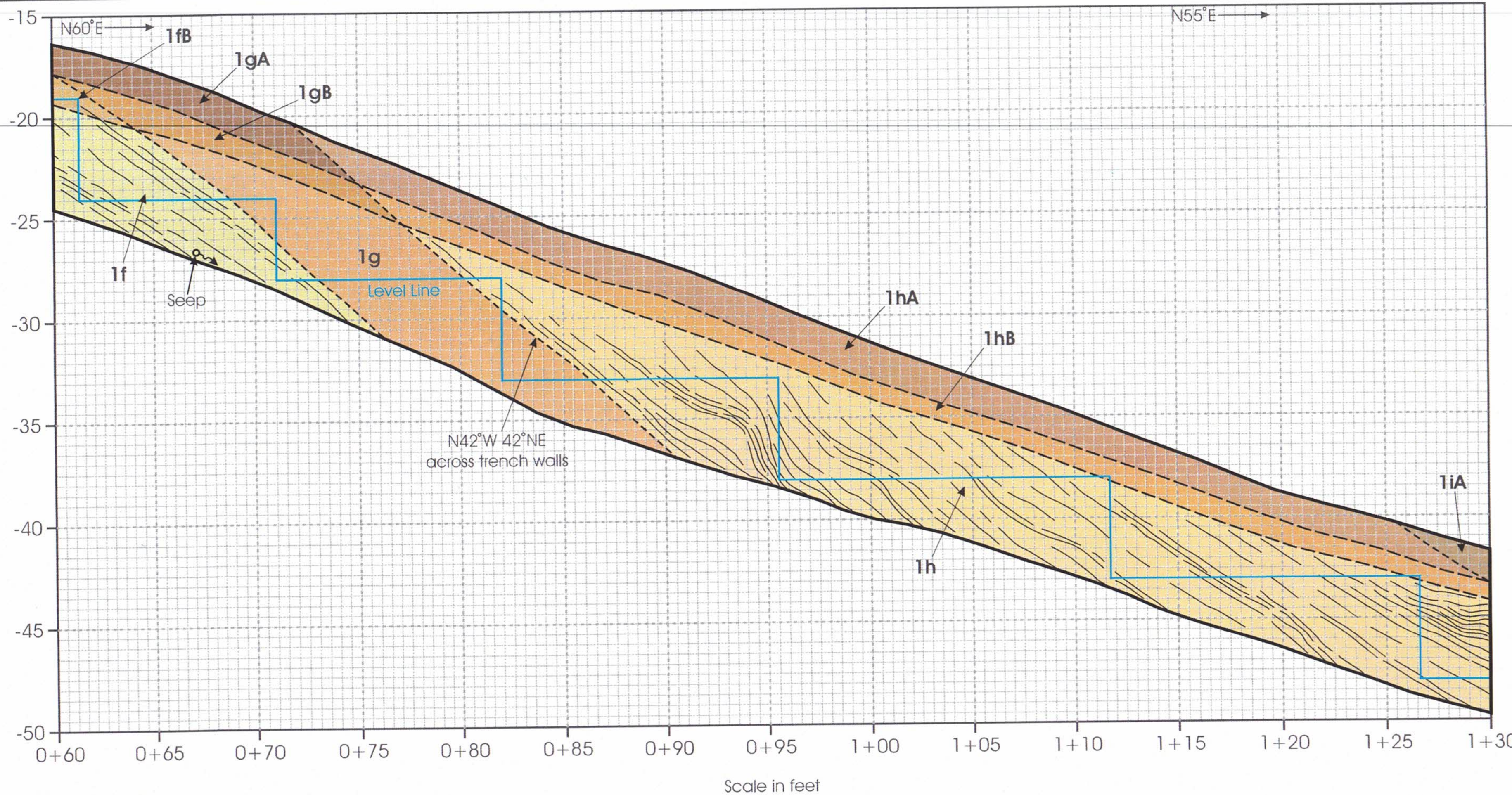
See Figure 5d for unit descriptions

TRENCH LOG, SHEET 1

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 5A

WESTERN GeoLogic



SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on June 1-2, 2016

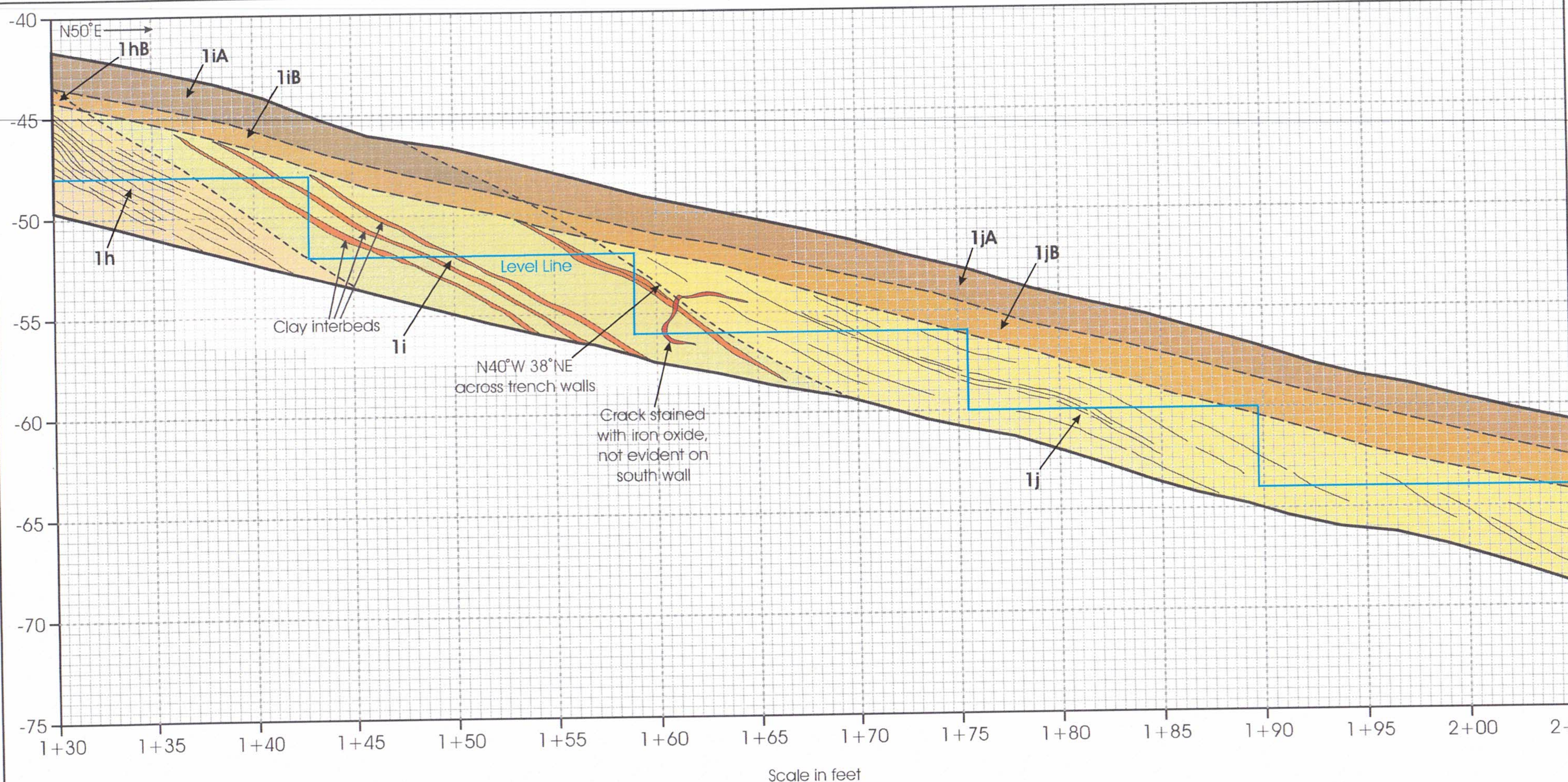
See Figure 5d for unit descriptions

WESTERN GEOLOGIC

TRENCH LOG, SHEET 2

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 5B



SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on June 1-2, 2016

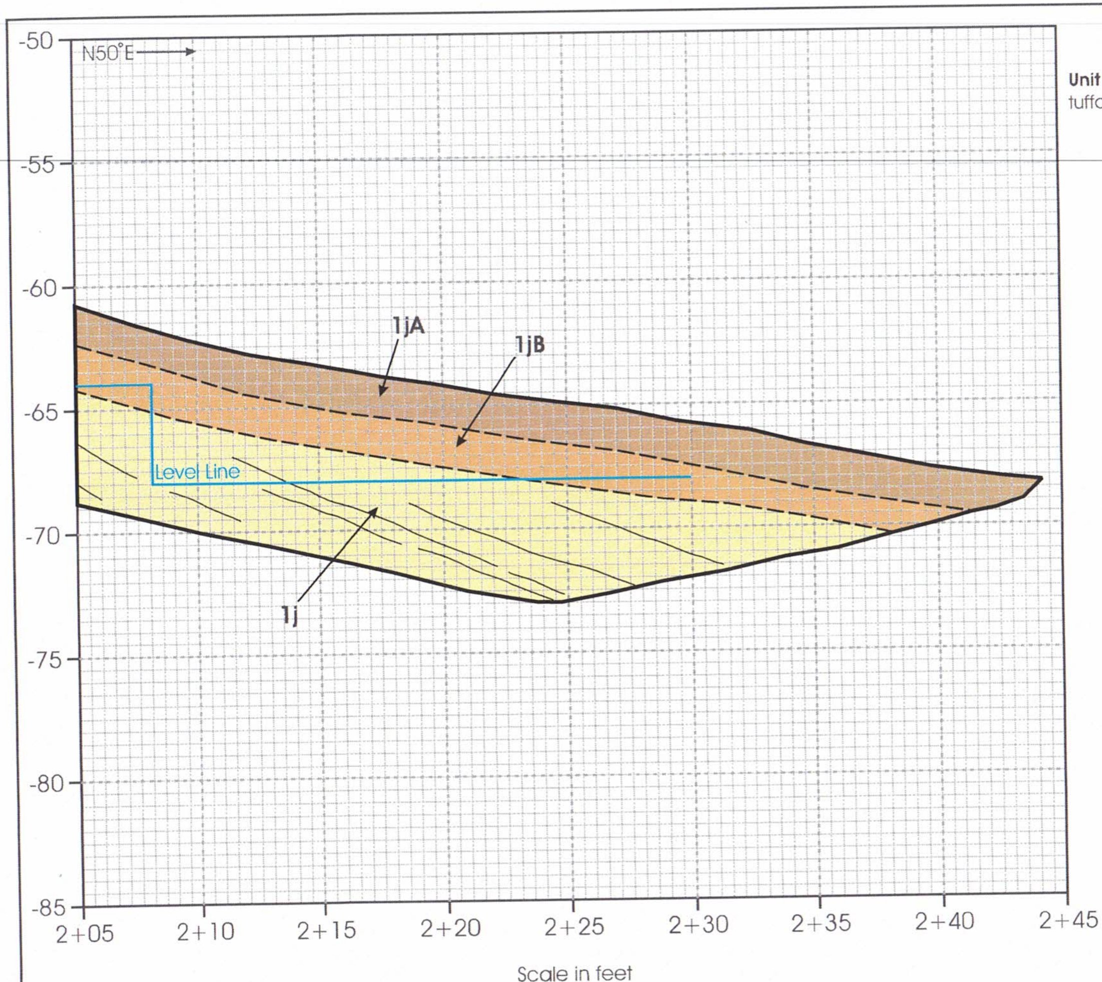
See Figure 5d for unit descriptions

WESTERN GEOLOGIC

TRENCH LOG, SHEET 3

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 5C



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of moderate to high density, poorly to well bedded, tuffaceous bedrock units striking northwestward and dipping to the northeast.

1a. Pale-olive-brown clayey sand to sandy clay (SC/CL); likely weathered tuffaceous sandstone.

1b. Reddish-olive-brown sandy gravel to gravelly sand with clay and cobbles (GW/SW); likely weathered tuffaceous conglomerate.

1bB. Vertisol B horizon formed in unit.

1c. Olive-orange clayey sand with trace gravel (SC); likely weathered tuffaceous sandstone.

1cA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1cB. Vertisol B horizon formed in unit.

1d. Reddish-brown gravelly sand to sandy gravel with cobbles and rare boulders (GW/SW); likely weathered tuffaceous conglomerate.

1dA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1dB. Vertisol B horizon formed in unit.

1e. Discontinuous interbed in unit 1d comprised of yellowish-olive sandy lean to fat clay (CL/CH).

1f. Pale-olive to pale-reddish-brown sandy clay (CL/CH); likely weathered tuffaceous sandy claystone.

1fA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1fB. Vertisol B horizon formed in unit.

1g. Olive-reddish-brown clayey sand (SC); likely weathered tuffaceous sandstone.

1gA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1gB. Vertisol B horizon formed in unit.

1h. Pale-brown lean to fat clay (CL/CH) with carbonate stringers; likely weathered claystone.

1hA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1hB. Vertisol B horizon formed in unit.

1i. Olive clayey sand (SC) with interbeds of reddish-brown lean to fat clay (CL/CH); likely weathered tuffaceous sandstone; fractured in places and with zones of iron-oxide staining.

1iA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1iB. Vertisol B horizon formed in unit.

1j. Very-pale-brown to pale-olive sandy clay to silt (CL/ML) with stage III-IV carbonate; likely weathered tuffaceous claystone to siltstone.

1jA.Organic-enriched, root-penetrated, A-horizon soil formed in unit.

1jB. Vertisol B horizon formed in unit.

WESTERN GEOLOGIC

See Figure 5d for unit descriptions

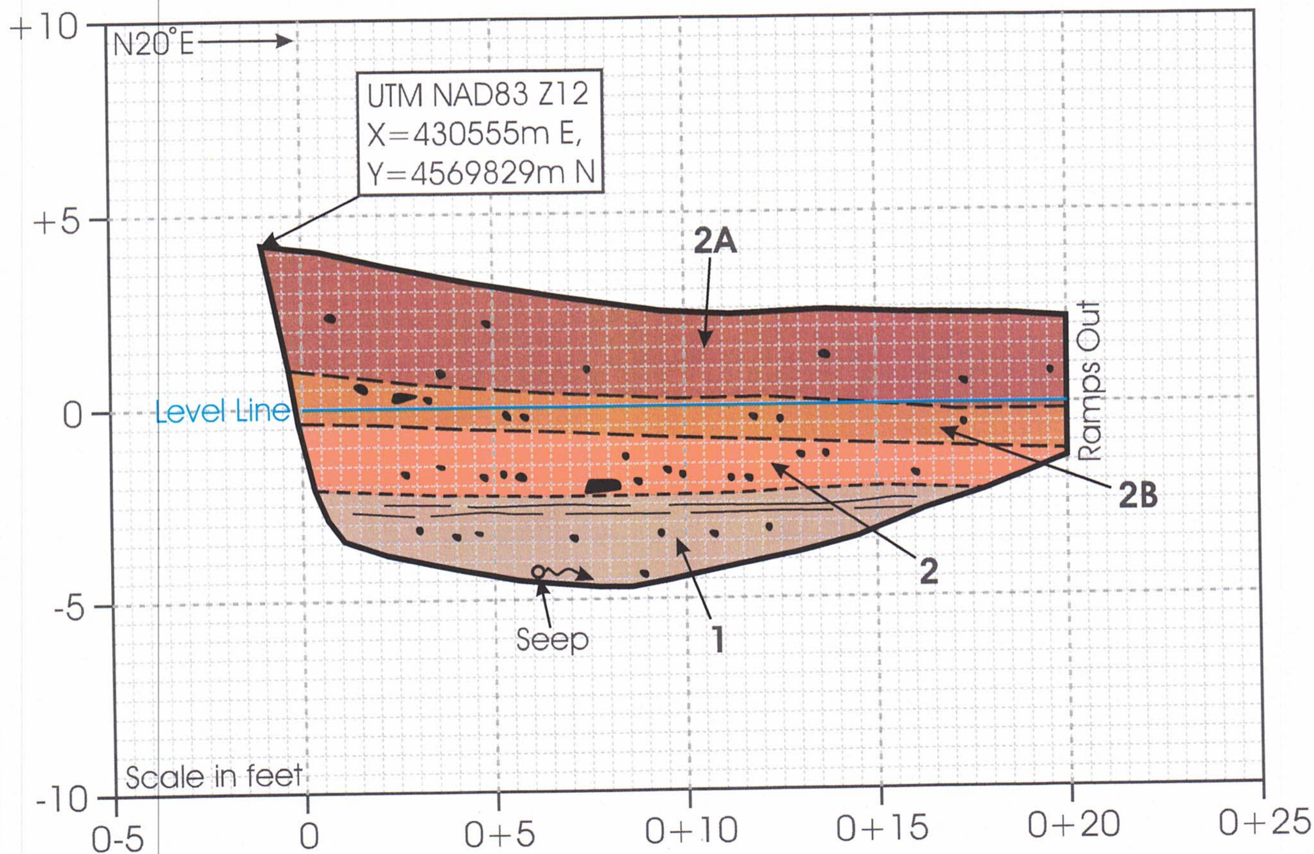
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on June 1-2, 2016

TRENCH LOG, SHEET 4

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 5D



UNIT DESCRIPTIONS

Unit 1. *Latest Pleistocene to Holocene Alluvium and Colluvium* - Reddish-brown to gray, moderate to high density, poorly bedded to massive, bedded, sandy clay (CL) with gravel; topset lean to fat clay lense; likely shallow slump deposits.

Unit 2. *Holocene Alluvium and Colluvium* - Reddish-brown to dark-brown, moderate density, massive, sandy clay with gravel and trace cobbles (CL); likely slope colluvium.

2A. Organic-rich, very-dark-grayish-brown, root penetrated, A-horizon soil formed in unit.

2B. B-horizon soil formed in unit.

WESTERN GEOLOGIC

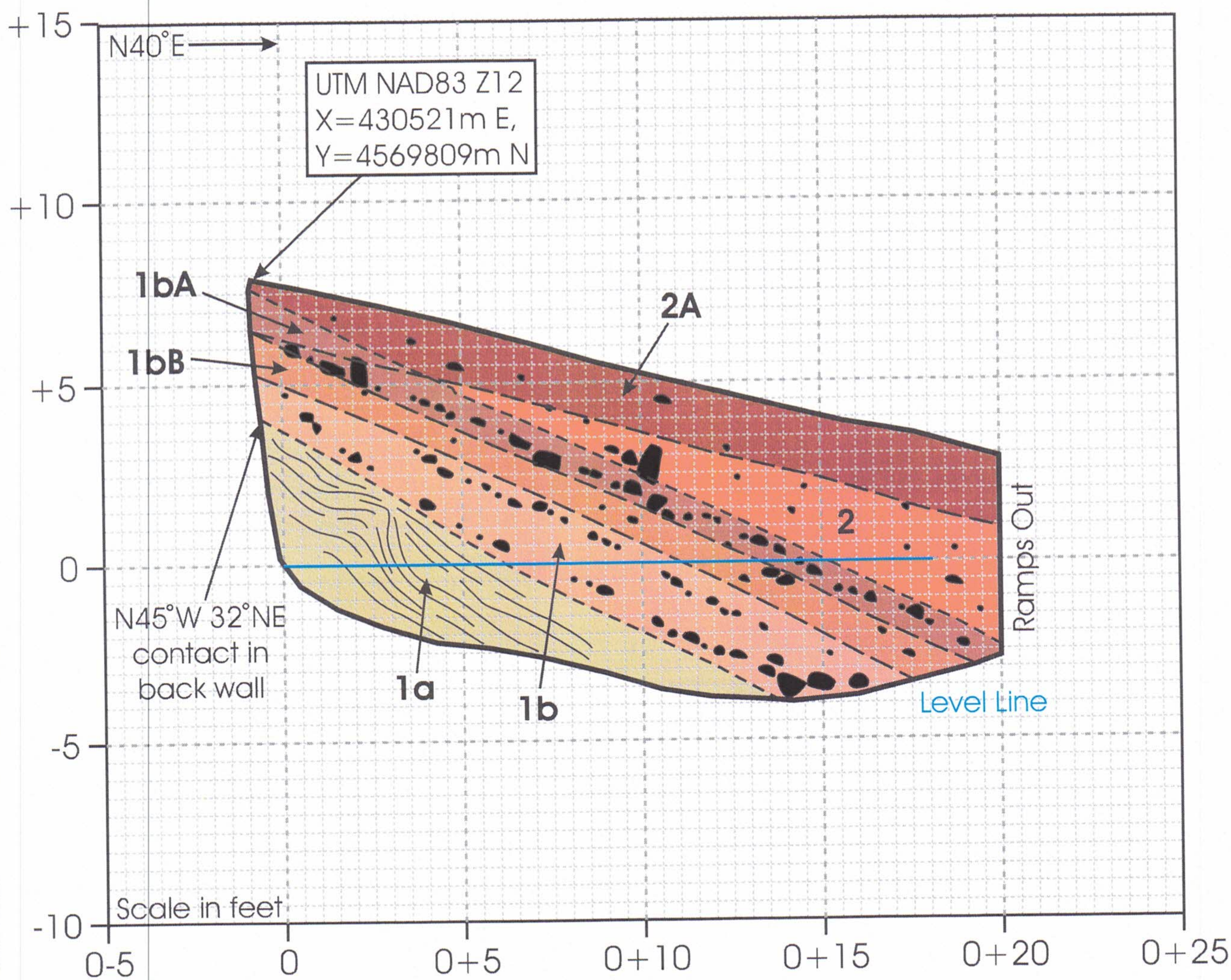
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on May 31, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 1 LOG

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 6A



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - Sequence of weathered, poorly to well-bedded, moderate to high density, tuffaceous claystone, sandstone, and conglomerate.

1a. Claystone to sandstone comprised of sandy clay to clayey sand (CL-CH/SC), iron-oxide staining along bedding; likely corresponds to unit 1h in trench (Figure 5).

1b. Conglomerate comprised of reddish-brown clayey sand with gravel, cobbles, and trace boulders (SC).

1bA. Paleosol A horizon formed in unit.

1bB. B-horizon soil formed in unit.

Unit 2. *Holocene Alluvium and Colluvium* - Reddish-brown to dark-brown, moderate density, massive, sandy clay with gravel and trace cobbles (CL); clasts with stage II carbonate, mainly quartzite.

2A. Organic-rich, very-dark-grayish-brown, root penetrated, A-horizon soil formed in unit.

WESTERN GEOLOGIC

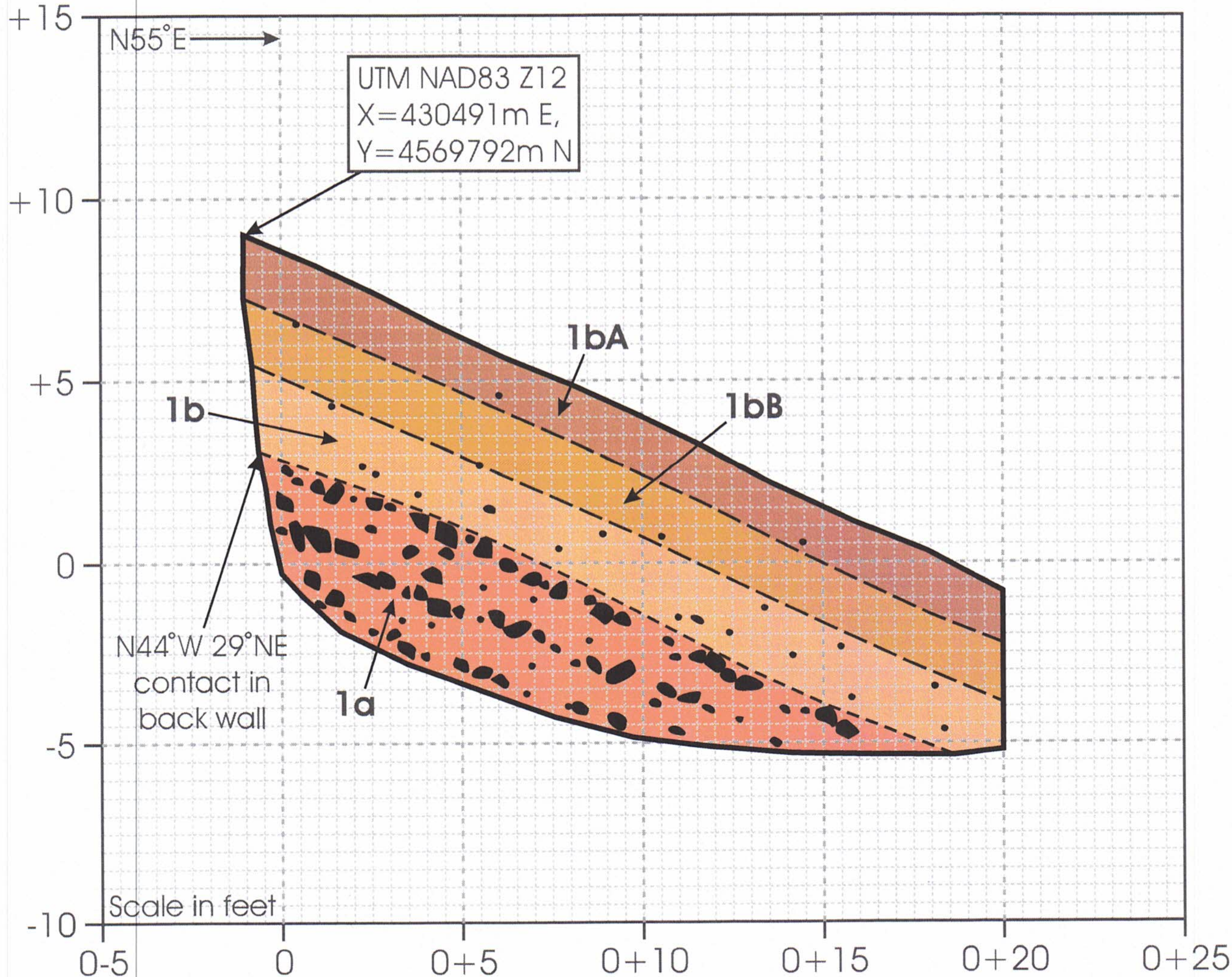
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on May 31, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 2 LOG

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 6B



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - Sequence of weathered, moderate density, poorly bedded, tuffaceous conglomerate and sandstone.

1a. Tuffaceous conglomerate comprised of reddish-brown clayey gravelly sand to sandy gravel (SC/GW) with cobbles and trace boulders.

1b. Highly weathered tuffaceous sandstone (?) comprised of clayey sand with gravel (SC).

1bA. Modern A-horizon soil formed in unit.

1bB. B-horizon soil formed in unit.

WESTERN GEOLOGIC

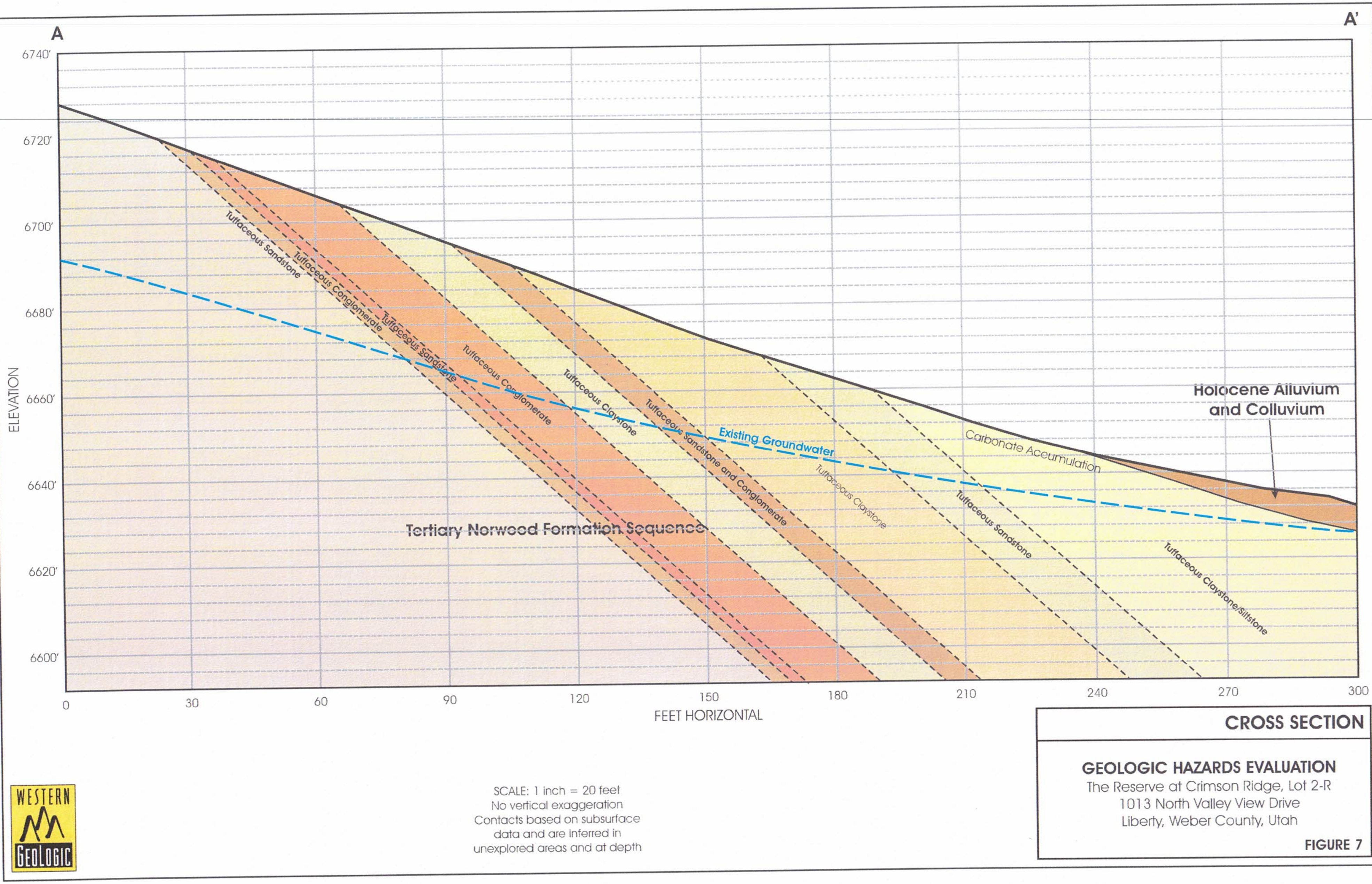
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on May 31, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 3 LOG

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 6C



CROSS SECTION

GEOLOGIC HAZARDS EVALUATION
The Reserve at Crimson Ridge, Lot 2-R
1013 North Valley View Drive
Liberty, Weber County, Utah

FIGURE 7