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Geologic Hazards Screening Assessment
Lot 70R Summit Eden Phase 1C
8492 East Spring Park Road
Eden, Utah
Parcel # 23-130-0037

GeoStrata Job No. 594-005

July 17, 2018

Prepared for:

Scandinavian LLC
c/o Jake Vainio
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July 17, 2018

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APPENDICES

1.0 EXECUTIVE SUMMARY

The purpose of this investigation and report is to assess the approximately 0.06 acre single family residential lot, Lot 70R Summit Eden Phase 1C, located at 8492 East Spring Park Road in Eden, Utah for the presence of geologic hazards that may impact the planned development of the site. The work performed for this report was performed in accordance with our proposal, dated June 22, 2018.

The subject site is located in Eden, Utah above Ogden Valley and in the Powder Mountain Ski Resort at an elevation of approximately 8,580 feet above sea level. We understand that the project site is currently an undeveloped lot approximately 0.06 acre in size and located on a native hillside. Proposed development, as currently planned, will consist of a single family residential structure as well as associated driveway, utilities and landscape areas. The subject site and the area surrounding the subject site remains in a relatively native condition apart from grading for the roadways. Some parcels along Spring Park Road are currently under development.

The earthquake ground shaking hazard that would potentially impact the subject site was assessed as part of our study. Given our office investigations, it is the opinion of GeoStrata that the earthquake ground shaking hazard within the subject site is considered low. It is the opinion of GeoStrata that earthquake ground shaking hazard should not preclude development at the subject site.

The surface fault rupture hazard that would potentially impact the subject site was assessed as part of our study. No active faults are located near the subject site. Given our field and office investigations, the surface fault rupture hazard within the subject site is considered low and it is considered unlikely that surface fault rupture will impact the proposed development. It is the opinion of GeoStrata that surface fault rupture hazard should not preclude development at the subject lot.

The tectonic deformation hazard that would potentially impact the site was assessed as part of our study. No active faults are reported or mapped within or adjacent to the subject site. It is the opinion of GeoStrata that the tectonic deformation hazard within the subject site is considered low and it is considered unlikely that tectonic deformation will impact the proposed development. It is the opinion of GeoStrata that the tectonic deformation hazard should not preclude development at the subject site.

The liquefaction hazard that would potentially impact the site was assessed as part of our study. The site is located in an area currently designated as having a "Very Low" liquefaction potential. The near-surface soils are not considered to be susceptible to liquefaction. It is the opinion of GeoStrata that liquefaction hazard should not preclude development at the subject site.

The rockfall hazards within the subject site were assessed as part of our study. No rockfall or talus deposits are located within or immediately adjacent to the subject lot. Our field investigation revealed no indications that the subject lot has been subjected to previous rockfall. Therefore, the rockfall hazard within the subject site is considered low and it is considered unlikely that rockfall will impact the proposed development. It is the opinion of GeoStrata that rockfall hazard should not preclude development at the subject site.

The landslide, slump and creep hazards that would potentially impact the site were assessed as part of this study. A landslide deposit (Qms) is mapped immediately south of the subject site. A deposit described as landslide undifferentiated from talus and/or colluvial is mapped south and in the vicinity of the subject site as shown on the Landslide Hazard Maps of Utah (Elliot and Harty, 2010). No landslide deposit is mapped within or immediately adjacent to the subject site on the Geologic Map of the Browns Hole and Huntsville Quadrangles. A trench trending north-northwest to south-southeast through the middle of the subject site and at a depth of approximately 5 to 9 feet below existing site grade was excavated as part of the geotechnical study compiled for the subject site. Geologic observations of the near surface geology in the trench exposure were made during our site visit. It is the opinion of GeoStrata that the soils observed in the trench were observed to comprise of colluvium deposits. No shears or deformation features related to a landslide deposit were observed in the trench. Based on our stereographic aerial photograph interpretation, our review of the hillshades derived from 2016 0.5 meter LiDAR and our field observations, no landslide features such as hummocky topography, slumps or scarps were identified within the subject site or observed in the trench excavation. The subject site was observed to be moderately to steeply sloping and to contain outcroppings of well-rounded quartzite cobbles and boulders that were partially buried. Based on the landslide mapped south of the subject site and the moderate to steep grade within the subject site, it is the opinion of GeoStrata that the landslide hazard within the subject site is considered low to moderate. GeoStrata recommends that a slope stability analysis be performed by a professional engineer as part of a comprehensive site specific geotechnical investigation to assess the potential for slope failure. Slope stability modeling should take landslide deposits and potential landslide deposits into consideration and evaluate all portions of the subject site being considered for development to provide recommendations for construction that will aid in reducing the risk for mass movement within the subject site.

It is the opinion of GeoStrata that landslide hazards should not preclude development at the subject site as long as a slope stability analysis is conducted as a part of a comprehensive site specific geotechnical investigation for the site that indicates that the planned development will not be affected by potential slope failure. All recommendations to reduce the risks of slope stability hazards contained in the site specific geotechnical report should be followed and incorporated in the design of the site. The recommendations contained in the geotechnical report should be incorporated into the grading and drainage design for the lot. Saturated soil conditions should be considered in the slope stability analysis conducted as a part of a comprehensive site specific geotechnical investigation for the site.

Slope stability of the subject site was not assessed as part of this geological hazard assessment. The subject site was observed to be moderately to steeply sloping to the south toward a nearby drainage. The possibility that development of the site could negatively affect slope stability within the subject site is increased if development is planned for areas of the site with slopes steeper than approximately 3 horizontal: 1 vertical. It should be noted that grading or development adjacent to the subject site could potentially impact the stability of the area within the subject site and assessment of that hazard is out of the scope of this assessment.

The snow avalanche hazard that would potentially impact the site was assessed as part of this study. No evidence of prior snow avalanche was observed within the subject site. It is the opinion of GeoStrata that the snow avalanche hazard within the subject site is considered low and it is considered unlikely that this hazard will impact the proposed development. It is the opinion of GeoStrata that snow avalanche hazard should not preclude development at the subject site.

The alluvial-fan flooding hazard that would potentially impact the site was assessed as part of this study. No Holocene age alluvial fan deposit is mapped within or adjacent to the subject site. Given our field and office investigations, the alluvial fan flooding hazards within subject site is considered low and it is considered unlikely that debris flows will impact the proposed development. It is the opinion of GeoStrata that alluvial fan flooding hazard should not preclude development at the subject lot.

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The shallow groundwater hazard that would potentially impact the site is out of the scope of this study. Seasonal fluctuations in precipitation, rapid snowmelt, surface runoff from adjacent properties, or other on or offsite sources may increase moisture conditions; groundwater conditions can be expected to rise several feet seasonally depending on the time of year. A trench was excavated within the subject site and to a depth of approximately 9 feet below existing grade. No water was observed at the time of our site visit. Groundwater potential will be evaluated and discussed further in the geotechnical study compiled for the subject site.

The stream flooding hazard that would potentially impact the site was assessed as part of this study. A drainage is located in the downslope and southwest of the subject site. Given our field and office investigations, the stream flooding hazard within the subject lot is considered low and it is considered unlikely that stream flooding will impact the proposed development. It is the opinion of GeoStrata that stream flooding hazard should not preclude development at the subject site. Proper site grading and drainage plans should be developed for the subject site as a part of the civil engineering design for the site to mitigate the potential for stream flooding to impact and damage planned structures or other planned associated infrastructure.

The canal flooding hazard that would potentially impact the site was assessed as part of this study. No canals were observed or are mapped within or adjacent to the subject site. Given our field and office investigations, the canal flooding hazard within the subject lot is considered low and it is considered unlikely that canal flooding will impact the proposed development. It is the opinion of GeoStrata that canal flooding hazard should not preclude development at the subject lot.

The dam failure hazard that would potentially impact the site was assessed as part of this study. No dams or reservoirs are located up-gradient of the subject site. Given our field and office investigations, the dam failure hazard within the subject lot is considered low and it is considered unlikely that dam failure will impact the proposed development. It is the opinion of GeoStrata that dam failure hazard should not preclude development at the subject lot.

The problem soils hazard is out of the scope of this study. Based on our review of published geologic maps and our field observations, the subject site is underlain by granular soils. No laboratory testing was performed on these soils as part of this study and therefore this hazard was not assessed as part of this study. A geotechnical study will be completed for the subject site in order to understand soil properties for use in the design of footing, foundation elements and grading.

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The radon gas hazard is out of the scope of this study. No published data that covers the area of the subject sites currently exists. Indoor testing following construction is recommended for determining radon gas levels and mitigation methods needed.

The karst and sink holes hazards is out of the scope of this study. The karst and sink holes hazards within the subject site are considered low and it is unlikely that karst and sink holes hazards will impact the proposed development.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions for the proposed development. This executive summary is not intended to replace the report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

The purpose of this investigation and report is to assess the approximately 0.06 acre single family residential lot, Lot 70R Summit Eden Phase 1C, located at 8492 East Spring Park Road in Eden, Utah for the presence of geologic hazards that may impact the planned development of the site. The geologic hazards considered for this site are presented in Table 2 of this report. The work performed for this report was performed in accordance with our proposal, dated June 22, 2018. Our scope of services included the following:

- Review of available references and maps of the area.
- Stereographic aerial photograph interpretation of aerial photographs covering the site area.
- Review of 2016 0.5 meter LiDAR obtained from the State of Utah AGRC.
- Geologic reconnaissance and field mapping of the site by an engineering geologist to observe and document pertinent surface features indicative of geologic hazards.
- Evaluation of our observations combined with existing information and preparation of this written report with conclusions and recommendations regarding possible surface rupture hazards or any other geologic hazards observed to affect the site.

The recommendations contained in this report are subject to the limitations presented in the Limitations section of this report.

2.2 PROJECT DESCRIPTION

The subject site is located in Eden, Utah above Ogden Valley and in the Powder Mountain Ski Resort at an elevation of approximately 8,580 feet above sea level. We understand that the project site is currently an undeveloped lot approximately 0.06 acre in size and located on a native hillside. Proposed development, as currently planned, will consist of a single family residential structure as well as associated driveway, utilities and landscape areas. The hillside in the area of the subject lot slopes moderately to steeply to the south toward a nearby drainage. It is our understanding that the general area of the subject lot was first developed within the last few years. The subject site and the area surrounding the subject site remains in a relatively native condition apart from grading for the roadways. Some parcels along Spring Park Road are currently under development. The subject site is shown on the Site Vicinity Map and Topographic Map included in the Appendix of this report (Plate 1; Plate 2).

3.0 METHODS OF STUDY

3.1 OFFICE INVESTIGATION

To prepare for the investigation, GeoStrata reviewed pertinent literature and maps listed in the references section of this report, which provided background information on the local geologic history of the area and the locations of suspected or known geologic hazards (Elliot and Harty, 2010; Black and others, 2016; Coogan and King, 2016; Crittenden, 1972; Sorensen and Crittenden, 1979). A stereographic aerial photograph interpretation was performed for the subject site using two sets of stereo aerial photographs obtained from the UGS as shown in Table 1.

Source	Photo Number	Date	Scale
ASCS	AAI_4K-35	September 14, 1952	1:20,000
ASCS	AAI_4K-36	September 14, 1952	1:20,000

Table 1: Aerial Stereosets.

GeoStrata also conducted a review of hillshades derived from 2016 0.5 meter LiDAR obtained from the State of Utah AGRC to assess the subject site for visible alluvial fan deposits, scarps associated with landslide geomorphology and lineations related to stream flooding hazards or surface fault rupture related geomorphology. The LiDAR elevation data was used to create hillshade imagery that could be reviewed for assessment of geomorphic features related to geologic hazards (Plate 3 Hillshade Map).

3.2 FIELD INVESTIGATION

An engineering geologist investigated the geologic conditions within the general site area. A field geologic reconnaissance was conducted to observe existing geologic conditions and to assess existing geomorphology for surficial evidence of geologic hazards. During our fieldwork we conducted site observations to assess geologic hazards that might impact the lot. We used our field observations to confirm the observations made during our office research and to observe any evidence of geologic hazards that were not evident in our office research, but which could be observed in the field.

4.0 GEOLOGIC CONDITIONS

4.1 GEOLOGIC SETTING

The site is located in the mountains of the Powder Mountain Ski Resort located in Eden, Utah and in the eastern region of Ogden Valley at approximately 8,580 feet above sea level. The Ogden Valley is a northwest trending deep, lacustrine sediment-filled structural basin of Cenozoic age bounded on the northeast and southwest by two normal faults that dip towards the center of the valley. The Ogden Valley is a fault graben flanked by two uplifted blocks, the Wasatch Range on the west and unnamed flat-topped mountains to the east (King and others 2008). The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah (Stokes, 1986). The Willard Thrust, one of the largest faults in the Sevier mountain belt, bounds the western side of Ogden Valley which uplifted and exposed Proterozoic age sedimentary bedrock.

The near-surface geology of the Ogden Valley is dominated by lake sediments with a maximum thickness of 70 feet which were deposited within the last 30,000 years during the high stand of the Lake Bonneville Cycle when water inundated Ogden Canyon and formed a small lake in Ogden Valley up to an approximate altitude of 4,900 feet (Scott and others, 1983; Hintze, 1993; Leggette and Taylor, 1937; King and others, 2008). As the lake receded, streams began to incise large deltas that had formed at the mouths of major canyons along the Wasatch Range and the unnamed flat-topped mountains bounding the eastern margins of Ogden Valley. The eroded material was then deposited in shallow lakes and marshes in the basin and at the base of nearby canyons and in a series of recessional deltas and alluvial fans that extended into the Ogden Valley and nearby canyons. Sediments toward the center of the valley are predominately deep-water deposits of clay, silt and fine sand whereas sediments closer to the mountain fronts are shallow-water deposits of coarse sand and gravel. However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover. Proterozoic age sedimentary bedrock is dominant in the northern portion of Ogden Valley where Tertiary age volcanics are prevalent in the southern portion of Ogden Valley and along knolls or foothills in the central portion of the valley.

4.2 SITE GEOLOGY

The surficial deposits within the subject site are shown on Plate 4 Site Vicinity Geologic Map and Plate 5 Site Vicinity 30x60 Geologic Map. On Plate 4, the geology within the subject site is mapped as Eocene, Paleocene and Upper Cretaceous(?) Wasatch and Evanston(?) Formations, Undivided (Twe) bedrock and is described as unconsolidated pale-reddish-brown Precambrian quartzite pebble, cobble and boulder conglomerate with a matrix of sand and silt (Sorensen and Crittenden, 1979 and Crittenden, 1972). Plate 5 also indicates that the subject site is underlain Eocene and upper Paleocene Wasatch Formation (Coogan and King, 2016). Coogan and King (2016) indicate a Holocene and upper and middle(?) Pleistocene age landslide deposit (Qms) located immediately south of the subject site.

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

As stated previously, the project site is located in the eastern mountains above Ogden Valley and within the Powder Mountain Ski Resort. The subject site is located on a moderately to steeply sloping hillside. The hillside slopes at approximately 13° south toward a nearby drainage. A trench was excavated as part of the geotechnical study compiled on the subject site and observed during our site visit. The surficial deposits exposed within the trench were observed to consist of subrounded to rounded gravel, cobbles and boulders in a matrix of silt and sand. Numerous well-rounded quartzite cobbles and boulders up to 2 feet in diameter were observed in the trench and partially buried near the surface. The majority of the cobbles and boulders were observed to be partially buried. The site remains in a relatively natural state and is vegetated with low lying brush, wildflowers, weeds and grasses. No structures were observed on the subject property. Some parcels in the surrounding area of the subject site are under development. The properties bordering the subject site are currently undeveloped.

6.0 GEOLOGIC HAZARDS

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. These hazards must be considered before development of the site. There are several hazards that if present at the site should be considered in the design of habitable structures and other critical infrastructure. The hazards considered for this site are presented on Table 2 and discussed in the following sections of this report.

Hazard	Hazard Rating*					Further Study Recommended
	Not Applicable	Not Assessed	Low	Moderate	High	
Ground Shaking			X			
Surface Fault Rupture			X			
Tectonic Deformation			X			
Liquefaction			X			
Rock Fall and Topple			X			
Landslide			X	X		E
Slump			X	X		E
Creep			X	X		E
Avalanche			X			
Debris Flow			X			
Hyperconcentrated Flow			X			
Stream Flow			X			
Shallow Groundwater		X				E
Stream Flooding			X			
Canal Flooding	X					
Dam Failure			X			
Problem Soils		X				E
Radon		X				
Karst and Sink Hole		X				

Table 2: Summary of Geologic Hazards.

Table 2 shows the summary of the geologic hazards assessed and not assessed at the study area. The hazard rating as shown on Table 2 is intended to assess the probability that the hazard could have an impact on the site and not the severity of the hazard. A hazard rating of "Not Assessed" are hazards this report does not consider and no inference is made as to the presence or absence of the hazard at the site. A hazard rating of "Low" indicates that no evidence was found to indicate that the hazard is present and has a low probability of impacting the site, hazard not known or suspect to be present. A hazard rating of "Moderate" indicates that the hazard has a moderate probability of impacting the site, but the evidence is equivocal, based only on theoretical studies, or was not observed and further study is necessary as noted. A hazard rating of "High" indicates that that evidence is strong and suggests that there is a high probability of impacting the site and mitigation measures should be taken. If a hazard is assessed to potentially impact the site then further studies may be recommended. The following are the recommended studies and the letter designation associated with those studies: "E" – geotechnical/engineering, "H" – hydrologic, "A" – avalanche, "G" – additional detailed geologic hazard study out of the scope of this study.

6.1 EARTHQUAKE GROUND SHAKING HAZARD

During the event of an earthquake, seismic waves radiate outward from the initial point of rupture and dissipate with distance. The ground shakes as the seismic waves displace the ground both vertically and horizontally. Ground shaking can cause significant damage to and potentially collapse structures and can also trigger landslides, avalanches and liquefaction. The type of soil a seismic wave travels through can amplify or dampen the effects of ground shaking.

Seismic hazard maps depicting probabilistic ground motions and spectral response have been developed for the United States by the U.S. Geological Survey as part of NEHRP/NSHMP (Frankel et al, 1996). These maps have been incorporated into both *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (FEMA, 1997) and the *International Building Code* (IBC) (International Code Council, 2015). Spectral responses for the Maximum Considered Earthquake (MCE_R) are shown in the table below. These values generally correspond to a two percent probability of exceedance in 50 years (2PE50) for a "firm rock" site. To account for site effects, site coefficients which vary with the magnitude of spectral acceleration are used. Based on our field and office investigations, it is our opinion that this location is best described as a Site Class C which represents a "Very Dense Soil and Soft Rock" profile. The spectral accelerations are shown in the table below. The spectral accelerations are calculated based on the site's approximate latitude and longitude of 41.362942° and

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-111.746329° respectively and the United States Geological Survey U.S. Seismic Design Maps web-based application. Based on the IBC, the site coefficients are F_a=1.08 and F_v= 1.54. From this procedure the peak ground acceleration (PGA) is estimated to be 0.35g.

Site Location: **Latitude = 41.362942 N** **Longitude = -111.746329 W**	**Site Class C Site Coefficients:** **F_a = 1.08** **F_v = 1.54**
Spectral Period (sec)	**Response Spectrum Spectral Acceleration (g)**
0.2	S_{MS}=(F_a*S_S=1.08*0.812) = 0.87
1.0	S_{M1}=(F_v*S_1=1.54*0.269) = 0.41
[a] IBC 1613.3.4 recommends scaling the MCE_R values by 2/3 to obtain the design spectral response acceleration values; values reported in the table above have not been reduced.	

Table 3: MCE_R Seismic Response Spectrum Spectral Acceleration Values for IBC Site Class C[a].

Based on the above information, it is the opinion of GeoStrata that the earthquake ground shaking hazard within the subject site is considered low. It is the opinion of GeoStrata that earthquake ground shaking hazard should not preclude development at the subject site.

6.2 SURFACE FAULT RUPTURE HAZARD

Movement along faults within the crustal rocks beneath the ground surface generates earthquakes. During large magnitude earthquakes (Richter magnitude 6.5 or greater) along the normal faults in the intermountain region, fault ruptures can propagate to the ground surface resulting in a surface fault rupture (Smith and Arabasz, 1991). The fault scarp formed during a surface fault rupture event along a normal fault is generally nearly vertical. A surface rupture fault may be comprised of a larger single surface rupture or several smaller surface ruptures across a fault zone. For all structures designed for human occupancy, a surface rupturing fault is considered active if it has experienced movement in approximately the past 10,000 years (Christenson and others, 2003).

Based on review of published geologic maps, our stereographic aerial photograph interpretation, our review of the hillshades derived from 2016 0.5 meter LiDAR and our field observations, no active faults are located near the subject site (Plate 6 UGS Quaternary Fault Map). The nearest fault is the Ogden Valley Northeastern Margin Fault which is between 0.75 and 2.6 million years old with an undetermined reoccurrence interval and a slip rate of less than 0.2 mm/yr (Black and others, 2003). This fault is trending northwest approximately 3 miles southwest of the subject site. Given our field and office investigations, the surface fault rupture hazard within the subject site is considered low and it is considered unlikely that surface fault rupture will impact the proposed development. It is the opinion of GeoStrata that surface fault rupture hazard should not preclude development at the subject lot.

6.3 TECTONIC DEFORMATION

Subsidence is a hazard associated with warping, lowering and tilting of a valley floor accompanying surface ruptures on normal faults (Robinson, 1993). Inundation along the shores of lakes and reservoirs and the rise of groundwater levels are the main hazards associated with subsidence. Structures that require gentle gradients or horizontal floors such as waste water treatment plants and sewer lines may be adversely affected by tectonic subsidence. Because subsidence may occur over very large areas, it is not generally practical to avoid the use of potentially affected land except in narrow areas of hazard due to lakeshore inundation (Keaton, 1987; Robison, 1993). According to Gary Christenson (UGS, personal communication 2001), tectonic subsidence is not typically assessed for subdivision development unless the development is located within an area of potential lake flooding.

Based on published geological maps, no active faults are reported or mapped within or adjacent to the subject site. It is the opinion of GeoStrata that the tectonic deformation hazard within the subject site is considered low and it is considered unlikely that tectonic deformation will impact the proposed development. It is the opinion of GeoStrata that the tectonic deformation hazard should not preclude development at the subject site.

6.4 LIQUEFACTION

Certain areas within the intermountain region possess a potential for liquefaction during seismic events. Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. The primary factors affecting liquefaction potential of a soil deposit are: (1) level and duration of seismic ground motions; (2) soil type and consistency; and (3) depth to groundwater.

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Based on our review of the *Liquefaction Special Study Areas, Wasatch Front and Nearby Areas, Utah* compiled by Christenson and others, 2008, the site is located in an area currently designated as having a "Very Low" liquefaction potential. "Very Low" liquefaction potential indicates that there is less than a 5 percent probability of having an earthquake within a 100-year period that will be strong enough to cause liquefaction. The surface soils we observed during our field investigation are not considered to be susceptible to liquefaction. A liquefaction analysis was beyond the scope of this geologic hazards assessment; however, if the owner wishes to have greater understanding of the liquefaction potential of the soils at greater depths, a liquefaction analysis should be completed at the site. It is the opinion of GeoStrata that liquefaction hazard should not preclude development at the subject site.

6.5 ROCKFALL AND TOPPLE

Rockfalls are the fastest moving mass movement that predominantly occurs in mountains where a rock source exists along steep slopes and cliffs greater than 35 degrees. Rockfalls are a result of a loss of support from beneath the rock mass that can be caused by freeze/thaw action, rainfall, weathering and erosion, and/or strong ground shaking resulting from seismic activity. Rockfalls result in the collection of rock fall material, referred to as talus, at the base of the slope. The presence of talus indicates that a rockfall hazard has occurred and may still be present at the site.

Based on review of published geologic maps, our stereographic aerial photograph interpretation and our field observations, no rockfall or talus deposits are located within or immediately adjacent to the subject lot. Boulders observed within the subject site were well rounded, partially buried and are in our opinion not indicative of recent rockfall events. Furthermore, no rockfall sources such as talus deposits or bedrock outcroppings were observed upslope from the subject site. Our field investigation revealed no indications that the subject lot has been subjected to previous rockfall. Therefore, the rockfall hazard within the subject site is considered low and it is considered unlikely that rockfall will impact the proposed development. It is the opinion of GeoStrata that rock fall hazard should not preclude development at the subject site.

6.6 LANDSLIDE, SLUMP, CREEP

There are several types of landslides that should be considered when evaluating geologic hazards at a site with moderately to steeply sloping terrain. These include shallow debris slides, deep-seated earth or rock slumps and earth flows. Landslides, slumps, creep and other mass movements can develop on moderate to steep slopes where the slope has been altered or disturbed. Movement can occur at the top of a slope that has been loaded by fill placement, at the base of a slope that has been undercut, or where local groundwater rises resulting in increased pore pressures within the slope. Slopes that exhibit prior failures and large landslide deposits are particularly susceptible to instability and reactivation.

Based on review of the Interim Geologic Map of the Ogden 30x60 Quadrangle, a landslide deposit (Qms) is mapped immediately south of the subject site (Plate 5 Site Vicinity 30x60 Geologic Map). A deposit described as landslide undifferentiated from talus and/or colluvial is mapped south and in the vicinity of the subject site as shown on Plate 7 Landslide Hazard Map. No landslide deposit is mapped within or immediately adjacent to the subject site on the Geologic Map of the Browns Hole and Huntsville Quadrangles as indicated on and Plate 4 Site Vicinity Geologic Map. A trench trending north-northwest to south-southeast through the middle of the subject site and at a depth of approximately 5 to 9 feet below existing site grade was excavated as part of the geotechnical study compiled for the subject site. Geologic observations of the near surface geology in the trench exposure were made during our site visit. It is the opinion of GeoStrata that the soils observed in the trench were observed to comprise of colluvium deposits. No shears or deformation features related to a landslide deposit were observed in the trench. Based on our stereographic aerial photograph interpretation, our review of the hillshades derived from 2016 0.5 meter LiDAR and our field observations, no landslide features such as hummocky topography, slumps or scarps were identified within the subject site or observed in the trench excavation. The subject site was observed to be moderately to steeply sloping and to contain outcroppings of well-rounded quartzite cobbles and boulders that were partially buried. Based on the landslide mapped south of the subject site and the moderate to steep grade within the subject site, it is the opinion of GeoStrata that the landslide hazard within the subject site is considered low to moderate. GeoStrata recommends that a slope stability analysis be performed by a professional engineer as part of a comprehensive site specific geotechnical investigation to assess the potential for slope failure. Slope stability modeling should take landslide deposits and potential landslide deposits into consideration and evaluate all portions of the subject site being considered for development to provide recommendations for construction that will aid in reducing the risk for mass movement within the subject site.

Due to the presence of a mapped landslide deposit near the subject site and the steep grade observed within the subject site, GeoStrata recommends that a geotechnical report that evaluates the slope stability within the subject site is conducted prior to any development. It is the opinion of GeoStrata that landslide hazards should not preclude development at the subject site as long as a slope stability analysis is conducted as a part of a comprehensive site specific geotechnical investigation for the site that indicates that the planned development will not be affected by potential slope failure. All recommendations to reduce the risks of slope stability hazards contained in the site specific geotechnical report should be followed and incorporated in the design of the site. The recommendations contained in the geotechnical report should be incorporated into the grading and drainage design for the lot. Saturated soil conditions should be considered in the slope stability analysis conducted as a part of a comprehensive site specific geotechnical investigation for the site.

Slope stability of the subject site was not assessed as part of this geological hazard assessment. The subject site was observed to be moderately to steeply sloping to the south toward a nearby drainage (Plate 2 Topographic Map). The possibility that development of the site could negatively affect slope stability within the subject site is increased if development is planned for areas of the site with slopes steeper than approximately 3 horizontal: 1 vertical. It should be noted that grading or development adjacent to the subject site could potentially impact the stability of the area within the subject site and assessment of that hazard is out of the scope of this assessment.

6.7 AVALANCHE

An avalanche is a rapid flow of snow down a hill or mountainside. A snow avalanche can be a hazard in high alpine settings with slopes generally between 35 degrees and 45 degrees that accumulate appreciable amounts of snow. There are three types of avalanches: slough, dry slab and wet slab. Sloughs typically occur right after a heavy snowfall event. This type of slide occurs from a single point and accumulates snow as it moves downslope. Dry slabs are the most common type of avalanche and are the result of a fracture that occurs along a weak layer within the snowpack. Dry slabs can travel upwards of 80 mph removing trees and structures in its path. Wet slabs are triggered when percolating water dissolves bonds and decreases the strength of the weak snow layer. This type of slab can travel up to 20 mph. Several factors that influence a snow avalanche include weather, temperature, slope steepness, slope orientation, wind direction and wind loading, terrain, vegetation, and snowpack conditions. Snow avalanche hazard could affect access and snow removal on roads as well as the safety of habitable structures and critical facilities.

Based on review of our stereographic aerial photograph interpretation, our field observations, the slope within and above the subject site is less than 35 degrees as well as avalanche control work conducted by the Powder Mountain Ski Resort, it is the opinion of GeoStrata that the avalanche hazard within the subject site and it is considered unlikely that a snow avalanche will impact the proposed developed. It is the opinion of GeoStrata that snow avalanche hazards should not preclude development within the subject lot.

6.8 ALLUVIAL FAN FLOODING

Alluvial fan flooding is a potential hazard that may exist in areas containing Holocene alluvial fan deposits. This type of flooding typically occurs as a stream flows, hyperconcentrated flows and debris flows consisting of a mixture of water, soil, organic material, and rock debris with variations in sediment-water concentrations transported by fast-moving water flows. Stream flows contains approximately less than 20% sediment by volume and involves sediment transport by entrained and suspended sediment load (Bowman and Lund, 2016). Unconfined stream flows are referred to as sheetfloods which are spread over and occur in the distal areas of the alluvial fan. Hyperconcentrated flows are alluvial fan flows with 20 to 60% sediment by volume whereas debris flows contain greater than 60% sediment by volume.

Alluvial fan flooding can be a hazard on or below alluvial fans or in stream channels above alluvial fans. Precipitation (rainfall and snowmelt) is generally viewed as an alluvial fan flood “trigger”, but this represents only one of the many factors that contribute to alluvial fan flooding hazard. Vegetation, root depth, soil gradation, antecedent moisture conditions and long term climatic cycles all contribute to the generation of debris and initiation of alluvial fan flooding. Events of relatively short duration, such as a fire, can significantly alter a basin’s absorption of storm water and snowmelt runoff and natural resistance to sediment mobilization for an extended period of time. These factors are difficult to quantify or predict and vary not only between different watersheds, but also within each sub-area of a drainage basin. In general, there are two methods by which alluvial fan flooding can be mobilized: 1) when shallow landslides from channel side-slopes are conveyed in existing channels when mixed with water and 2) channel scour where debris is initially mobilized by moving water in a channel and then the mobilized debris continues to assemble and transport downstream sediments.

Based on review of published geologic maps, review of stereographic aerial photographs and hillshades derived from 2016 0.5 meter LiDAR, no Holocene age alluvial fan deposit is mapped within or adjacent to the subject site (Plate 4 Site Vicinity Geologic Map; Plate 5 Site Vicinity 30’ X 60’ Geologic Map). Given our field and office investigations, the alluvial fan flooding hazards within subject site is considered low and it is considered unlikely that debris flows will impact the proposed development. It is the opinion of GeoStrata that alluvial fan flooding hazard should not preclude development at the subject lot.

6.9 SHALLOW GROUNDWATER

Shallow groundwater flooding is a hazard that can cause the flooding of excavated areas where the depth of excavation exceeds the depth of the local water table. Shallow groundwater flooding should be considered when designing habitable structures that require excavation that may exceed the depth to the shallow groundwater.

Shallow groundwater assessment is out of the scope of this study. Seasonal fluctuations in precipitation, rapid snowmelt, surface runoff from adjacent properties, or other on or offsite sources may increase moisture conditions; groundwater conditions can be expected to rise several feet seasonally depending on the time of year. A trench was excavated within the subject site and to a depth of approximately 9 feet below existing grade. No water was observed at the time of our site visit. Groundwater potential will be evaluated and discussed further in the geotechnical study compiled for the subject site.

6.10 STREAM FLOODING HAZARD

Stream flooding can be caused by precipitation, snowmelt or a combination of both. Throughout most of Utah floods are most common in spring during the snowmelt. High flows in drainages can last for a few hours to several weeks. Factors that affect the potential for flooding at a site include surface water drainage patterns and hydrology, site grading and drainage design, and seasonal runoff.

Based on review of our stereographic aerial photograph interpretation, our review of the hillshades derived from 2016 0.5 meter LiDAR and our field observations, a drainage is located in the downslope and southwest of the subject site (Plate 8 Hydrology Map). Given our field and office investigations, the stream flooding hazard within the subject lot is considered low and it is considered unlikely that stream flooding will impact the proposed development. It is the opinion of GeoStrata that stream flooding hazard should not preclude development at the subject site. Proper site grading and drainage plans should be developed for the subject site as a part of the civil engineering design for the site to mitigate the potential for stream flooding to impact and damage planned structures or other planned associated infrastructure.

6.11 CANAL FLOODING

High runoff in a short period of time can lead to canal water breaching their banks and flooding the surrounding area. Failure of the canal embankments or a blockage in the canal could also lead to flooding surrounding the canal.

Based on review of published topographic maps, our stereographic aerial photograph interpretation, our review of the hillshades derived from 2016 0.5 meter LiDAR and our field observations, no canals were observed or are mapped within or adjacent to the subject site. Given our field and office investigations, the canal flooding hazard within the subject lot is considered low and it is considered unlikely that canal flooding will impact the proposed development. It is the opinion of GeoStrata that canal flooding hazard should not preclude development at the subject lot.

6.12 DAM FAILURE

Dams are structures that store water and diverge and impound water upstream. Most dams have a spillway where water flow from the reservoir is controlled and hydroelectric power is produced. Failure in dams can occur from a collapse or a breach in the structure most commonly due to extended periods of high runoff.

Based on our review of the Mantua, James Peak, Sharp Mountain and Huntsville topographic quadrangles and our field investigation, no dams or reservoirs are located up-gradient of the subject site (Plate 1 Site Vicinity Map; Plate 2 Topographic Map). Given our field and office investigations, the dam failure hazard within the subject lot is considered low and it is considered unlikely that dam failure will impact the proposed development. It is the opinion of GeoStrata that dam failure hazard should not preclude development at the subject lot.

6.13 PROBLEM SOILS

Problem soils include collapsible soils and expansive soils. Collapsible soils are low density and typically dry soils that decrease in volume when exposed to water. This type of problem soil typically occurs in alluvial fan flooding deposits, dry loess or eolian deposits or unconsolidated colluvium deposits (Owens and Rollins, 1990). Expansive soils are soils that undergo an increase in volume upon wetting and typically include fine grained soils such as clay.

The problem soils hazard is out of the scope of this study. Based on our review of published geologic maps and our field observations, the subject site is underlain by granular soils. No laboratory testing was performed on these soils as part of this study and therefore this hazard was not assessed as part of this study. A geotechnical study will be completed for the subject site in order to understand soil properties for use in the design of footing, foundation elements and grading.

6.14 RADON

Radon is a naturally occurring odorless, tasteless and colorless gas that is released during the breakdown of uranium in well drained permeable soils and uranium rich rocks which include granite, metamorphic rocks, black shales, and some volcanic rocks (Sprinkel and Solomon, 1990). Radon gas moves freely in the air and can also dissolve in water which can potentially migrate through cracks and open spaces in rock, soils, and foundations as well as utility pipes.

The radon gas hazard is out of the scope of this study. No published data that covers the area of the subject sites currently exists. Indoor testing following construction is recommended for determining radon gas levels and mitigation methods needed.

6.15 KARST AND SINK HOLES

A karst is a type of underground drainage terrain that is the result of dissolution of soluble bedrock such as limestone, carbonate rock, salt beds or other types of rocks that are easily dissolved by groundwater circulating through them. The most common type of hazard that forms within a karst terrain is subsidence or collapse of soils, these are referred to as sink holes. Sink holes can be a few feet to hundreds of acres wide and 1 to 100 feet deep and can form slowly or collapse suddenly.

Based on our review of published geologic maps, the karst and sink holes hazards within the subject site are considered low and it is unlikely that karst and sink holes hazards will impact the proposed development. It is the opinion of GeoStrata that karst and sink hole hazards should not preclude development at the subject lot.

7.0 GEOLOGIC HAZARDS SUMMARY AND CONCLUSIONS

It is the opinion of GeoStrata that the geologic hazards that we assessed in this study that could impact the subject site or that have not been assessed as a part of this study, but which could impact the subject site include: landslide, shallow groundwater, problem soils and radon gas. Below is a summary of each geologic hazard and GeoStrata's recommendation for mitigation:

- Landslide, slump and creep hazard within the subject site was assessed as part of this study. It is the opinion of GeoStrata that the landslide hazard within the subject site is considered low to moderate. GeoStrata recommends that a slope stability analysis is performed by a professional engineer as part of a comprehensive site specific geotechnical investigation to assess the potential for slope failure. Slope stability modeling should take landslide deposits and potential landslide deposits into consideration and evaluate all portions of the subject site being considered for development to provide recommendations for construction that will aid in reducing the risk for mass movement within the subject site.

  It is the opinion of GeoStrata that landslide hazards should not preclude development at the subject site as long as a slope stability analysis is conducted as a part of a comprehensive site specific geotechnical investigation for the site and that indicates that the planned development will not be affected by potential slope failure and that all recommendations to reduce the risks of slope stability hazards contained in the site specific geotechnical report are followed. Saturated soil conditions should be considered in the slope stability analysis conducted as a part of a comprehensive site specific geotechnical investigation for the site.

  Slope stability of the subject site was not assessed as part of this geological hazard assessment. The subject site was observed to be moderately to steeply sloping to the south toward a nearby drainage (Plate 2 Topographic Map). The possibility that development of the site could negatively affect slope stability within the subject site is increased if development is planned for areas of the site with slopes steeper than approximately 3 horizontal: 1 vertical. It should be noted that grading or development adjacent to the subject site could potentially impact the stability of the area within the subject site and is out of the scope of this assessment. Due to the presence of mapped landslide deposits near the subject site and the steep grade observed within the subject site, GeoStrata recommends that a geotechnical report that evaluates the slope stability within the subject site is conducted prior to any development and the recommendations contained in the geotechnical report be followed as a part of the grading and drainage design for the lot.

- Shallow groundwater hazard within the subject site was not assessed as part of this study. Seasonal fluctuations in precipitation, rapid snowmelt, surface runoff from adjacent properties, or other on or offsite sources may increase moisture conditions; groundwater conditions can be expected to rise several feet seasonally depending on the time of year. A trench was excavated within the subject site and to a depth of approximately 9 feet below existing grade. No water was observed at the time of our site visit. Groundwater potential will be evaluated and discussed further in the geotechnical study compiled for the subject site.

- Problem soils hazard within the subject site was not assessed as part of this study. The subject site is underlain by gravel, cobbles and boulders in a matrix of silt and sand. No laboratory testing was performed on these soils as part of this study and therefore this hazard was not assessed as part of this study. A geotechnical study will be completed for the subject site in order to understand soil properties for use in the design of footing, foundation elements and grading.

- The radon gas hazard is out of the scope of this study. No published data that covers the area of the subject sites currently exists. Indoor testing following construction is recommended for determining radon gas levels and mitigation methods needed.

It is the opinion of GeoStrata that these hazards should not preclude the development of the subject site, assuming that these recommendations given above will be followed.

8.0 CLOSURE

8.1 LIMITATIONS

The conclusions and recommendations contained in this report, which include professional opinions and judgments, are based on the information available to us at the time of our evaluation, the results of our field observations and our understanding of the proposed site development. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed development changes from that described in this report, our firm should also be notified.

All services were completed in accordance with the current standard of care and generally accepted standard of practice at the time and in the place our services were completed. No other warranty, expressed or implied, is made. Development of property in the immediate vicinity of geologic hazards involves a certain level of inherent risk. It is impossible to predict where geologic hazards will occur. New geologic hazards may develop and existing geologic hazards may expand beyond their current limits.

All services were performed for the exclusive use and benefit of the above addressee. No other person is entitled to rely on GeoStrata's services or use the information contained in this letter without the express written consent of GeoStrata. We are not responsible for the technical interpretations by others of the information described or documented in this report. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

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Appendix

Legend

Approximate Site Boundary

0 1,500 3,000 6,000 9,000 12,000
Feet

1 inch = 4,000 feet

Base Map:
2009 1 meter NAIP aerial imagery and hillshades derived from 5 meter digital elevation model (DEM) provided by the State of Utah AGRC.

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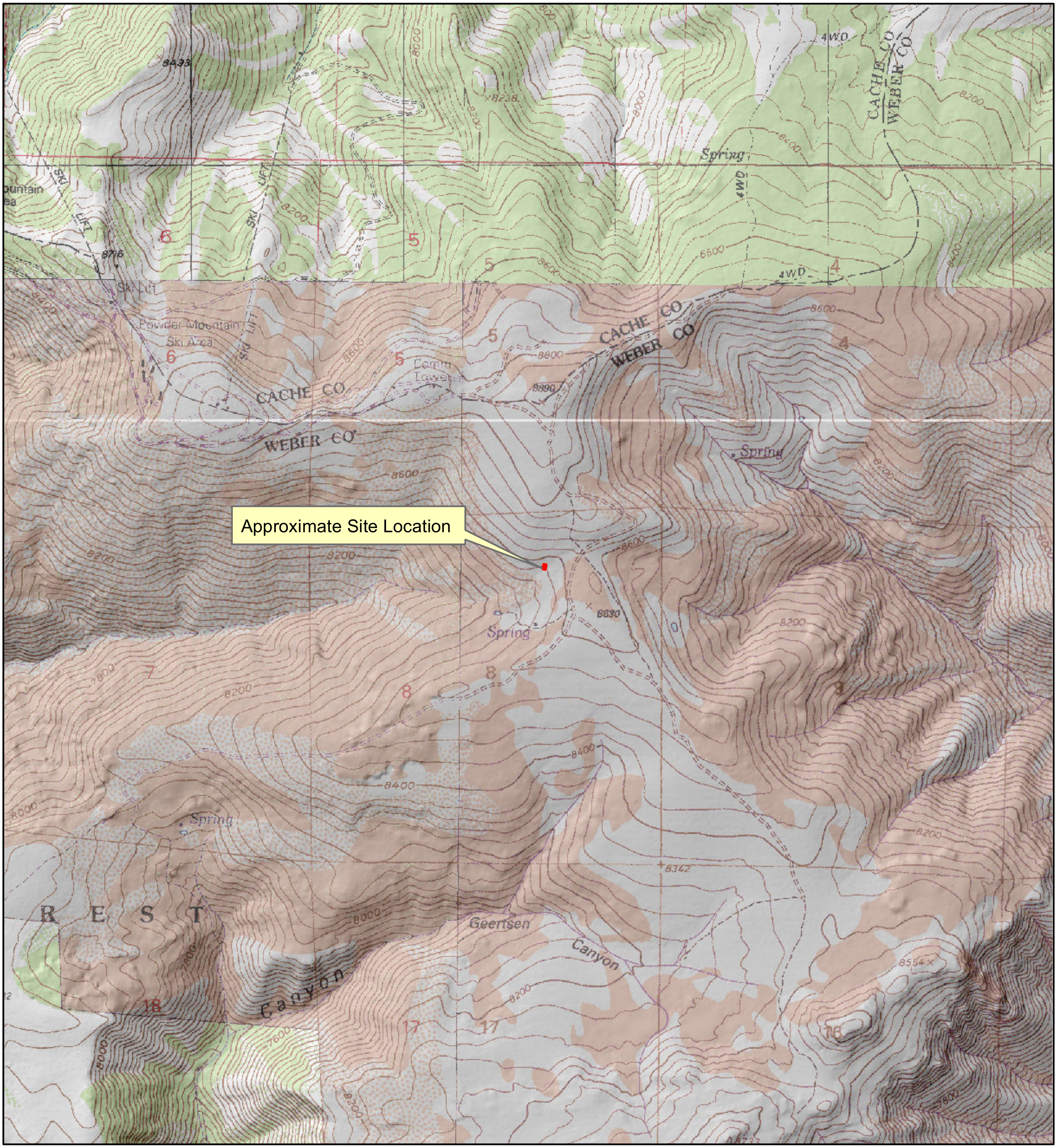
8492 East Spring Park Road
Eden, Utah
Project Number: 594-005

Site Vicinity Map

Plate 1



Legend

Approximate Site Boundary

0 750 1,500 3,000 4,500 6,000 Feet

1 inch = 2,000 feet
Base Map:
Browns Hole, Huntsville, James Peak and Sharp Mountain Quadrangles, Utah 7.5 Minute Series (Topographic), USGS and hillshades derived from 5 meter DEM provided by the State of Utah AGRC.

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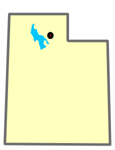

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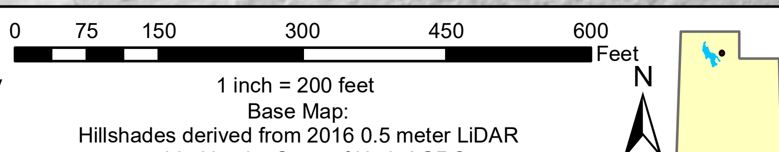
Project Number: 594-005

Topographic Map

Plate 2

Legend

Approximate Site Boundary



1 inch = 200 feet
Base Map:
Hillshades derived from 2016 0.5 meter LiDAR
provided by the State of Utah AGRC.

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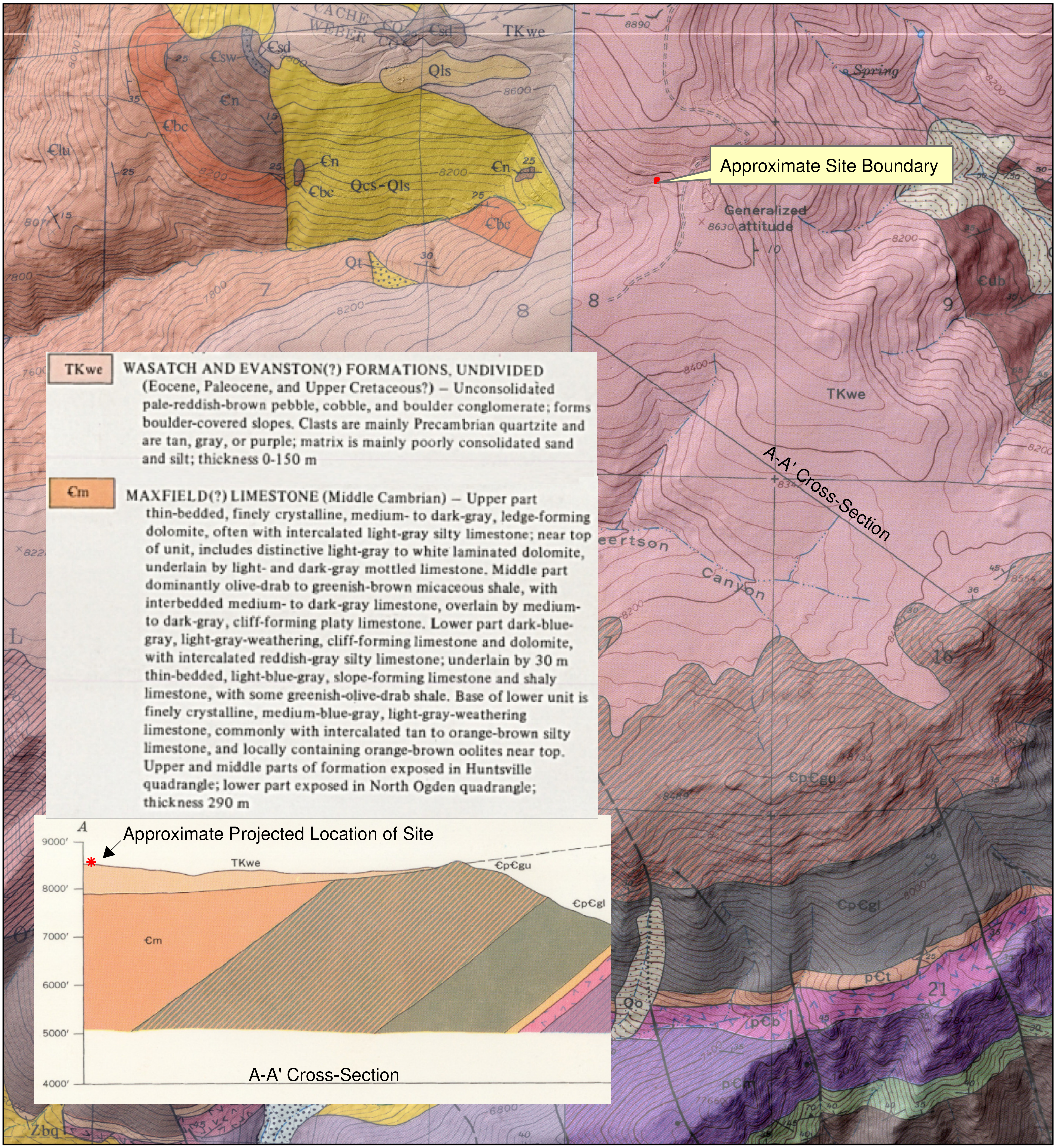
HIllshade Map

Plate 3



Legend

Approximate Site Boundary

0 750 1,500 3,000 4,500 6,000 Feet

1 inch = 2,000 feet

Base Map:
Geologic Map of the Browns Hole Quadrangle, Utah, Crittenden, 1972. Geologic Map of the Huntsville Qudrangle, Weber and Cache Counties, Utah, Sorensen and Crittenden,1970. Hillshades derived from 2016 0.5 meter LiDAR provided by the State of Utah AGRC.

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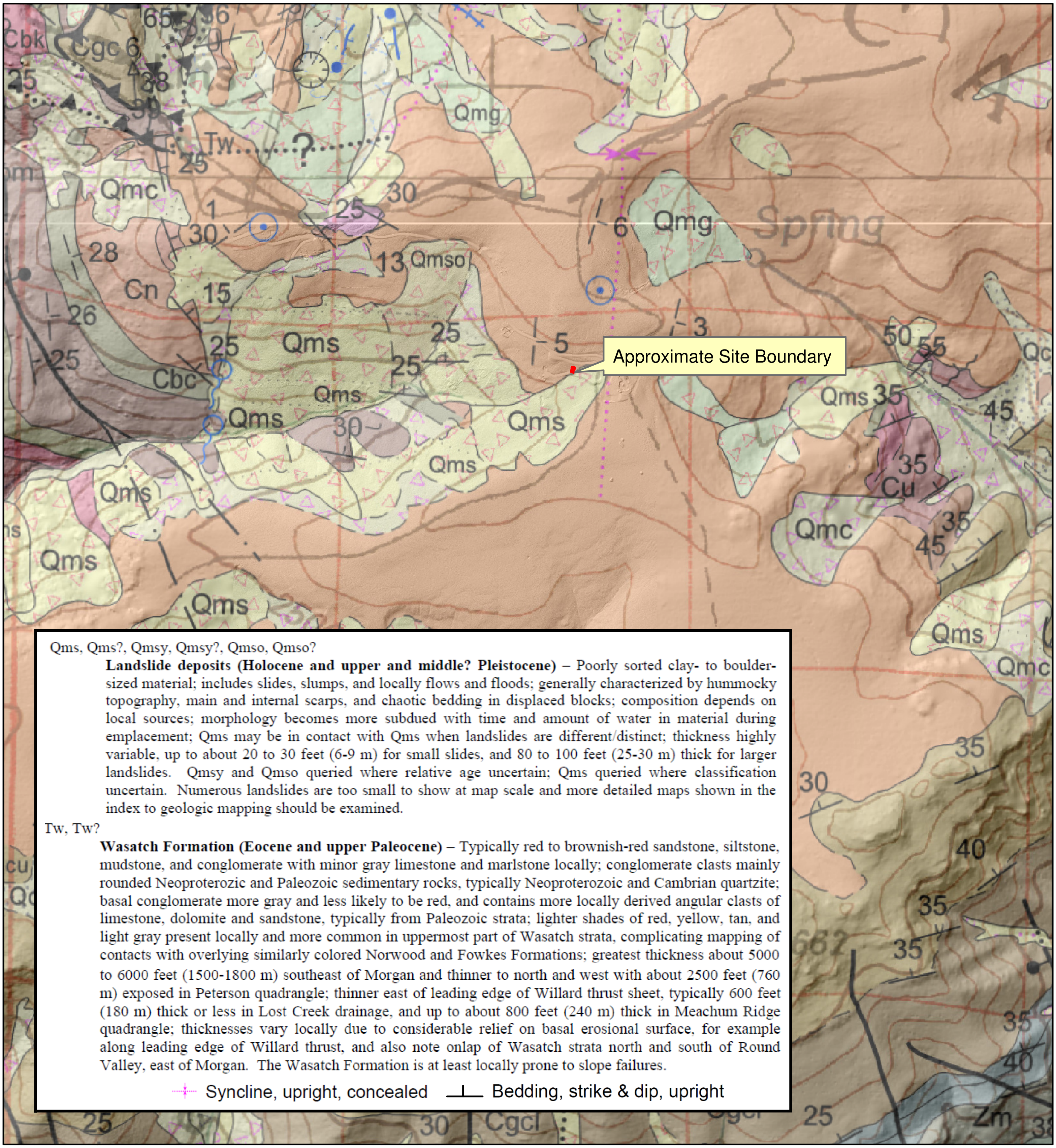
Site Vicinity Geologic Map

Plate 4



Legend

Approximate Site Boundary

0 750 1,500 3,000 4,500 6,000 Feet

1 inch = 2,000 feet

N

Base Map:
Interim Geologic Map of the Ogden 30' x 60' Quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah and Uinta County, Wyoming, Coogan and King, 2016. Hillshades derived from 5 meter DEM provided by the State of Utah AGRC.

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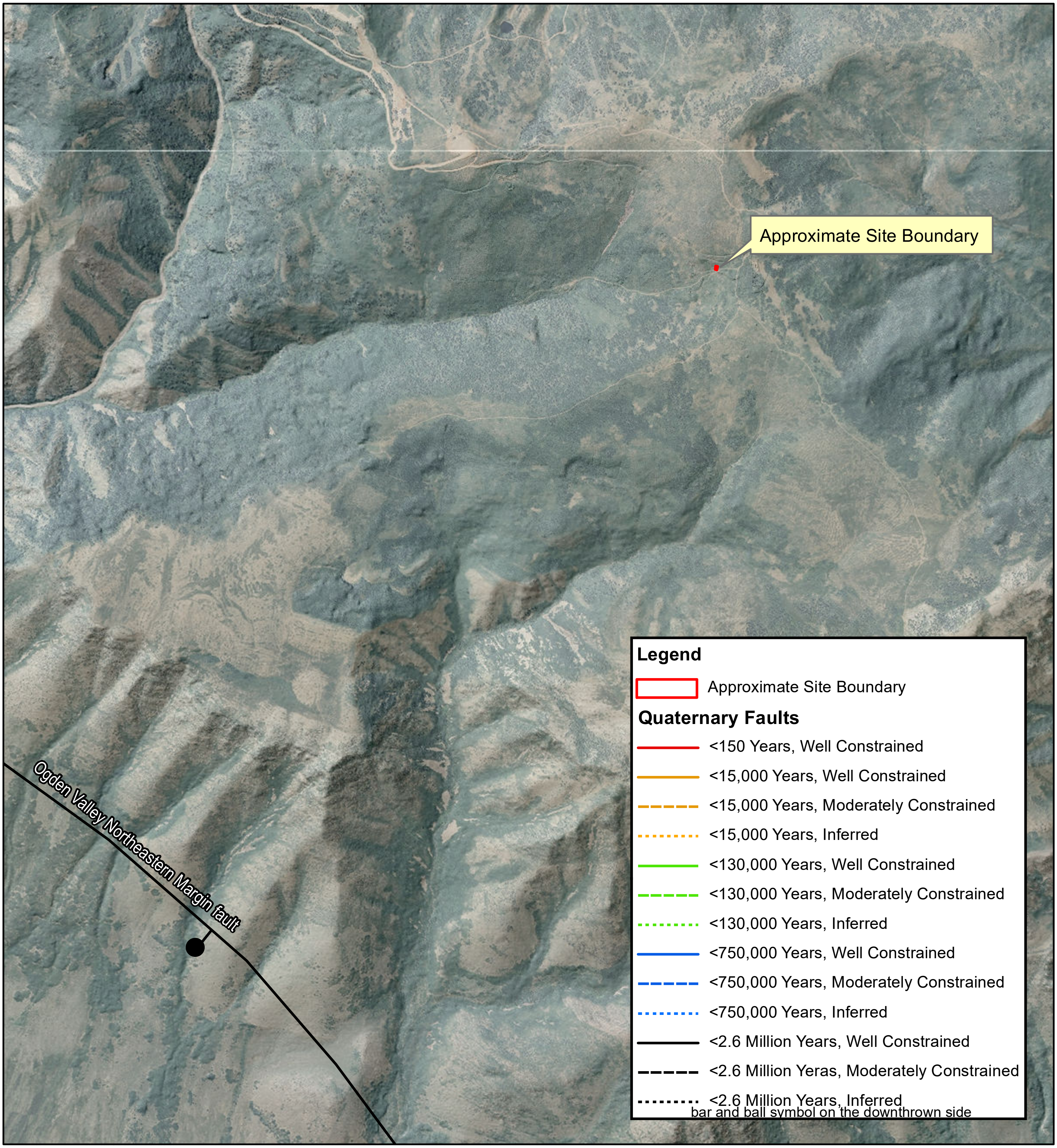
Site Vicinity 30x60 Geologic Map

Plate 5



0 900 1,800 3,600 5,400 7,200 Feet

1 inch = 2,500 feet

Base Map:
UGS Quaternary Fold and Fault Database. 2009 1 meter NAIP aerial imagery and hillshades derived from 5 meter DEM provided by the State of Utah AGRC.

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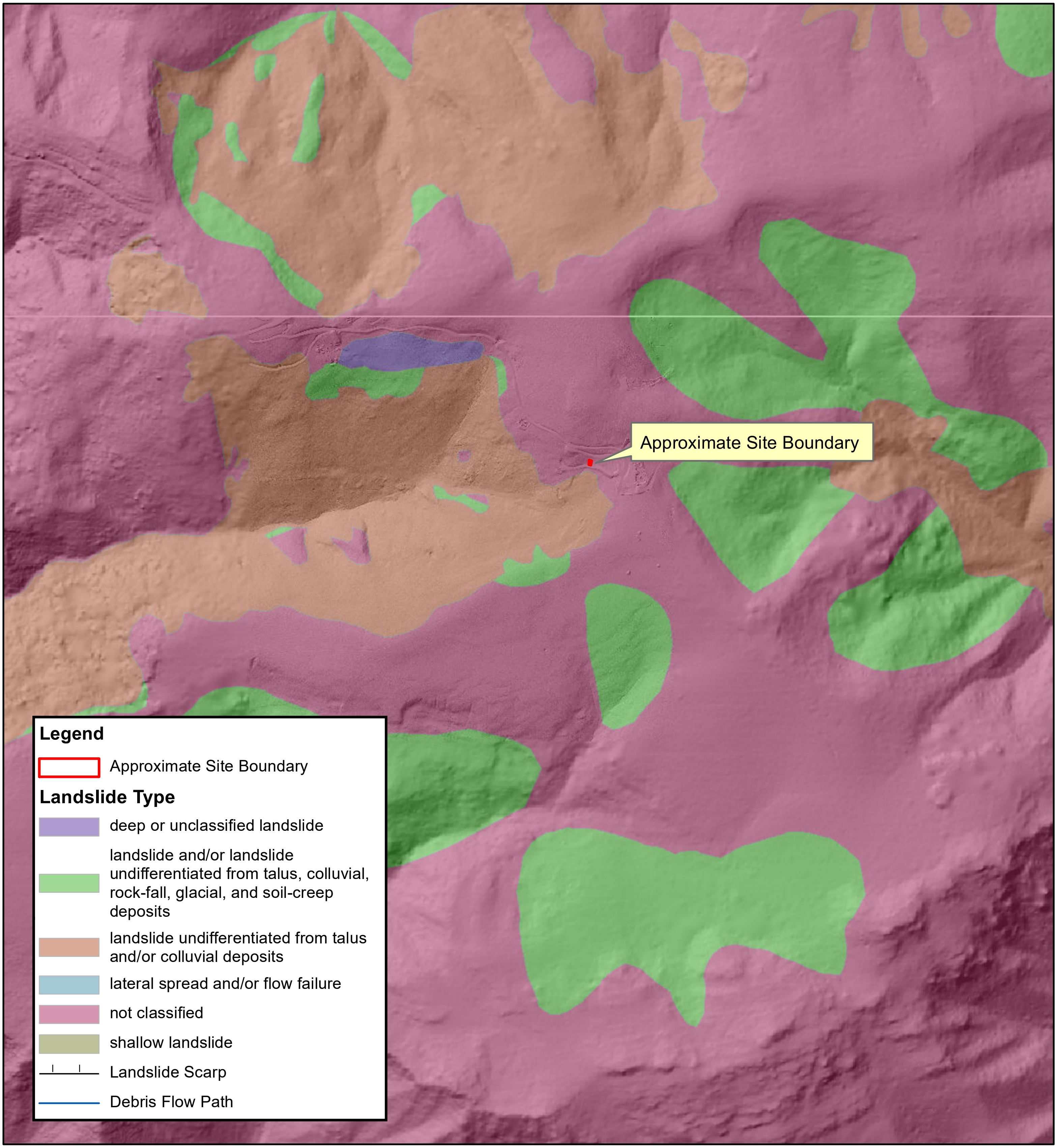
Quaternary Fault Map

Plate 6



1 inch = 2,000 feet
Base Map:
UGS Quaternary Fold and Fault Database. Hillshades derived from 5 meter DEM provided by the State of Utah AGRC.

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Landslide Hazard Map

Plate 7

Legend

Approximate Site Boundary

Stream (National Hydrology Dataset)

0 750 1,500 3,000 4,500 6,000 Feet

1 inch = 2,000 feet

Base Map:
National Hydrology Dataset, 2009 1 meter NAIP aerial imagery and hillshades derived from 5 meter DEM provided by the State of Utah AGRC.

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Hydrology Map

Plate 8