# GCS Geoscience

**Report Professional Geologist Site**
**Reconnaissance and Review**
**4.72 Acre Parcel #21-082-0002**
**Lot #107, Green Hills Estates Phase 6**
**1088 Maple Street**
**Huntsville, Weber County, Utah**

For:

Randy and Deanna Aadland
14274 122nd Ave NE
Kirkland Washington
98034

By:

GCS Geoscience
554 South 7700 East Street
Huntsville, Utah 84317

September 11, 2017
GCS File No: 2017.30

**GCS Geoscience**

*554 South 7700 East Street*
*Huntsville, Utah 84317*
*d| 801 745 0262*
*m| 801 458 0207*


September 11, 2017
File No: 2017.30

Randy and Deanna Aadland
14274 122nd Ave NE
Kirkland Washington
98034

Attn: Mr. and Mrs. Aadland

**Subject: Report**
**Professional Geologist Site Reconnaissance and Review**
**4.72 Acre Parcel #21-082-0002**
**Lot #107, Green Hills Estates Phase 6**
**1088 Maple Street**
**Huntsville, Weber County, Utah**

## INTRODUCTION

In response to your request, GCS Geoscience (GCS) has prepared this Professional Geologist site reconnaissance review report for the above referenced site. The subject parcel consists of an approximately 4.72 acre building lot located in the Huntsville Area of Ogden Valley in Weber County, Utah, as shown on attached Figure 1. Figure 2 provides aerial coverage of the site and detail of the current (2014) layout of the site vicinity.

The property is a presently undeveloped, and is part of the Green Hills Estates Phase 6 subdivision project. The Green Hills Estates Phase 6 subdivision is a cluster type project consisting of 35 homesite development lots ranging form 1.1 to 4.9 acres in size. The Phase 6 area encompasses 362.8 acres, of which 224 acres are common area, and 138 acres are used for development lots. The subdivision is accessed by private homeowner access roads, including Maple Street. The location of the lot is within the Weber County Forrest F-5 zoning designation, of which single family residences and accessory buildings are permitted uses. According to the Weber County Code of Ordinances *the intent of the Forest Zones is to protect and preserve the natural environment of those areas of the County that are characterized by mountainous, forest or naturalistic land, and to permit development compatible to the preservation of these areas.*

It is our understanding that you intend to purchase the property and construct a single-family residence on the site. We expect that the proposed construction will consist of a single-family residence structure, likely to be constructed with a basement level and supported on conventional spread and strip footings. Above grade levels will consist of wood frame construction one to three levels in height. Projected site grading is anticipated to consist primarily of cutting into the existing ground to construct the residence and driveway, with very little fill projected for the site.

Because the proposed site appears to be located on a hillslope area in the vicinity of mapped landslide hazards, marginal soils, and FEMA floodplain areas, Weber County is requesting that a geological site reconnaissance be performed to asses whether all or parts of the site are exposed to the hazards that are included in the Weber County Code, Section 108-22 Natural Hazard Areas. These hazards include, but are not limited to: Surface-Fault Ruptures, Landslide, Tectonic Subsidence, Rock Fall, Debris Flows, Liquefaction Areas, Flood, or other Hazardous Areas.

The purpose of this Professional Geologist Site Reconnaissance Review is to evaluate if the proposed development is outside or within areas identified as Natural Hazards Area, and if within a hazard area, to recommend appropriate additional studies that comply with the purpose and intent of the Weber County Natural Hazards Area guidelines and standards in order to be "cleared" for building permit issuance by the county, as outlined by the Weber County Development Process packet provided by the Weber County Building Inspection Department (2017).

Based upon findings made during this study and discussed herein, a Proposed Building Area covering a 0.94 acre part of the property was delineated for the proposed residence structure placement. This Proposed Building Area is shown on Figure 2, and is also included on Figure 3 and Figure 4.

## LITERATURE AND RESOURCE REVIEW

To evaluate the potential exposure of sites to geological hazards that impact sites or site improvements, Weber County has compiled a series of Geographic Information Systems (GIS) data mapping layers of geological hazard related information. These data may be queried on-line using the Weber County Geo-Gizmo web server application at http://www.co.weber.ut.us/gis/maps/gizmo/. Using the Geo-Gizmo application, under the Engineering Layers category, is listed geological hazard related layers that may be toggled on and off to determine potential hazards exposure to sites in the county. These mapping layers include the following categories; *Quake Epicenters, FEMA Flood Zone Line, FEMA Base Flood Elevation, Wasatch Faults, Landslide Scarps, Geologic Faults, Faults, Quaternary Faults, FEMA Flood Zone, FEMA LOMR, Engineering Problems; Liquefaction Potential, Landslide, FEMA Letters of Map Change, and FEMA Flood Zones.* These layers have been compiled from the respective agencies including the Federal Emergency Management Agency (FEMA), the Utah Geological Survey (UGS), and the U.S. Geological Survey (USGS). These mapping layers consist of regional compilation hazards data, but are not compiled at scales that are necessarily applicable for site specific usage and planning. When hazard layer data on the Geo-Gizmo are found to interact with Permit Applicant site improvement locations, Weber County Engineers and Planners will request that the

Permit Applicant have a Professional Geologist Site Reconnaissance Review, such as presented herein, conducted for the site.

Our preliminary review of the Geo-Gizmo mapping layers indicated that the Lot #107 property was partly within an area classified as "*Landslide undifferentiated*" by UGS database layers (Elliott and Harty, 2010), otherwise the location did not show exposure to any of the other aforementioned hazard layer areas, including; *Expansive soil or rock* (Mulvey, 1992), *Quaternary Faults* (USGS and UGS, 2006), and *FEMA Flood Zone* (FEMA, 2015).

Our site specific review consisted of a GIS data integration effort that included:

1. Reviews of previous mapping, literature and reports pertaining to site geology including Crittenden (1972); AGEC (1996); King and McDonald (2014); and Coogan and King (2016).

2. An analysis of vertical and stereoscopic aerial photography for the site including; a historical 1946 1:20,000 stereoscopic sequence; a 2006 1.0 foot digital HRO coverage; and a 2014 1.0 meter digital NAIP coverage of the site.

3. A GIS analysis using the QGIS® GIS platform to geoprocess and analyze 2006 5.0 meter digital elevation data (DEM), auto-correlated from 1m NAIP imagery, made available for the site by the Utah Automated Geographic Reference Center (AGRC). The GIS analysis included using the QGIS® platform Geospatial Data Abstraction Library (GDAL, 2013) Contour; the GRASS® (Geographic Resources Analysis Support System, 2013) r.slope and r.shaded.relief modules.

For the best site specific documentation for this review we relied on geologic mapping by Coogan and King (2016), which provided the most up to date rendering of geological mapping for the site location. Mapping by King and McDonald (2014) was also used to support this review. The geological mapping for this review is provided on Figure 3, Geologic Mapping. Topographic, slope, and elevation data for this review was supported through the aforementioned DEM analysis which is presented on Figure 4, DEM/Slope Analysis.

## REVIEW FINDINGS

The site is located on the eastern margin Ogden Valley on the southwestern flank of abroad plateau that rises above the valley on the east. The valley is a northwest trending fault bounded graben structure, with the Wasatch Range comprising the western flank of the valley and the Bear River Range the eastern flank (Avery, 1995). The surficial geology of the site vicinity is the result of the uplift and exposure of older pre-Cambrian rocks which forms the crest of Mount Ogden (9572 feet), located west of the valley and the broad plateau located on the east side of the valley. This exposure was the result of movement along locally high-angle faults during late Tertiary and Quaternary age (Bryant, 1988). The older Precambrian rocks that underlie the site are parts of eastward thrusted plates including the Willard thrust sheet, which is believed to have moved onto the vicinity during the Cretaceous Sevier orogeny, occurring approximately 140 million years ago. The older Precambrian rocks have since been exposed by uplift along the valley bounding faults that has been occurring over the past 10 million years.

During the most recent stage of geologic time, the Quaternary Period, which includes the past one million years, permanent (year-round) ice and glaciers have periodically occupied the higher elevation summits surrounding the site, and waters of Lake Bonneville have risen to near the elevation of the site approximately 15,000 years ago (Currey and Oviatt, 1985).

The site location occupies valley-margin slopes that are believed to be largely underlain by eroded Precambrian rocks (Crittenden, 1972), Quaternary age valley-fill sediments (Avery, 1994), and mantled on the surface with Quaternary age soils placed by alluvial and mass movement processes and modified by erosion and soil development processes (King and McDonald, 2014; Coogan and King, 2016). Current geological mapping (Coogan and King, 2016) of the site is shown on Figure 3, Geologic Mapping.

Figure 3, Geologic Mapping, shows the location of the site relative to GIS overlays including geological mapping prepared by Coogan and King (2016). A summary of the geological mapping of the site vicinity by Coogan and King (2016) is paraphrased as follows:

> **Qmc** - Landslide and colluvial deposits, undivided (Holocene and Pleistocene) – Poorly sorted to unsorted clay- to boulder-sized material...(slopewash and soil creep)...These deposits are as unstable as other landslide units...
>
> **Qms** - Landslide deposits(Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods...
>
> **Qafp?** - Lake Bonneville-age alluvial-fan deposits (upper Pleistocene) –Mostly sand, silt, gravel, cobbles and boulders...
>
> **Zmcc** - Maple Canyon Formation bedrock; Upper unit (conglomerate) member(Neoproterozoic) – At top...light-gray coarse-grained, quartzite to pebble and small cobble meta-conglomerate with local tan-weathering, darkgray, meta-graywacke matrix; thin olive-gray, laminated, weakly resistant argillite in middle...
>
> **Zmcg** - Maple Canyon Formation bedrock; Lower unit (green arkose) member(Neoproterozoic) – Grayish-green, fine-grained arkosic (feldspathic) meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses...is prone to slope failures...

> **Zpu** - Formation of Perry Canyon bedrock; 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”...This unit is prone to slope failures...

Summarily, the mapping scene on Figure 3 presents older highly deformed Neoproterozoic rocks (**Zmcc, Zmcg** and **Zpu**), covered with unconsolidated Quaternary (Holocene and Pleistocene) alluvium (**Qafp?**), and landslide and colluvial deposits (**Qms** and **Qmc**). The site is located upon **Qms** landslide deposits, that are believed to have moved prehistorically, and since the upper to middle Pleistocene, a time period extending approximately 30,000 years ago to the present. Based upon our limited experience and experience of others (AGEC, 1996), the soils in the site vicinity have demonstrated isolated failures where the slopes have been over-steepened by site development grading.

Thrust faulting and anticlinal warping associated with the Cretaceous Willard thrust is shown near the site on Figure 3, however this faulting and folding is ancient and is not associated with presently active movement.

## Geologic/Natural Hazards

In addition to the review and location query we searched for nearby or proximal classifications or conditions that could possibly present hazardous conditions to the site. A summary of this search is provided as follows:

1. **Landsliding:** On the basis of mapping by Coogan and King (2016), the nearest landslide units are mapped as **Qms** deposits that are located western third of the Lot #107 property. The slope and apparent movement of this unit is toward the southwest, away from the Proposed Building Area shown on Figure 3. This unit (**Qms**) appears to have moved or "creeped" downslope on the past in response to inherent weak and expansive soil characteristics coupled with high soil moisture conditions, and the moderately steep slope conditions in this area, and has complex earth-flow/soil creep morphology (Varnes, 1978). Based upon our, and others (AGEC, 1996), understanding of the slopes in this area, we believe that movement of the **Qms** unit is presently inactive, but possibly near threshold conditions, such that site development cuts and fills should be conservatively applied.

2. **Alluvial fan debris flow processes** including flash flooding and debris flow hazard: The nearest alluvial fan debris flow process deposits to the site, are mapped as **Qafy,** and occur approximately 2700 feet southwest of the Lot #107 site, and are not shown on Figure 3. These deposits and the location of these potential processes do not appear to be a potential impact to the Lot #107 site.

3. **Surface fault rupture hazards, strong earthquake ground motion, tectonic Subsidence and liquefaction:**

**Surface fault rupture hazards:** The nearest active (Holocene) earthquake fault to the site is the Weber segment of the Wasatch fault zone (UT2351E) which is located 11.0 miles west of the site (Black and others, 2004). Accordingly, fault rupture hazards are not considered present on the site. The Ogden Valley northeastern margin fault (UT2379) is located much closer to the site, approximately 3300 feet to the southwest, however the most recent movement along this fault is estimated to be pre-Holocene (>15,000 ybp), and presently is not considered an active risk (Black and others, 1999).

**Strong earthquake ground motion:** Strong ground motion originating from the Wasatch fault or other near-by seismic sources is capable of impacting the site. The Wasatch fault zone is considered active and capable of generating earthquakes as large as magnitude 7.3 (Arabasz and others, 1992). Based on probabilistic estimates (Peterson, and others, 2008) queried for the site, the expected peak horizontal ground acceleration on rock from a large earthquake with a ten-percent probability of exceedance in 50 years is as high as 0.15*g,* and for a two-percent probability of exceedance in 50 years is as high as 0.30*g* for the Site.

The a ten-percent probability of exceedance in 50 years event has a return period of 475 years, and the 0.15*g* acceleration for this event corresponds "strong" perceived shaking with "light" potential damage based on instrument intensity correlations. The two-percent probability of exceedance in 50 years event has a return period of 2475 years, and the 0.30*g* acceleration for this event corresponds "very strong" perceived shaking with "moderate" potential damage based on instrument intensity correlations (Wald and others, 1999).

Future ground accelerations greater than these are possible but will have a lower probability of occurrence.

**Tectonic Subsidence** is surface tilting subsidence that occurs along the boundaries of normal faults in response to surface-faulting earthquakes (Keaton, 1986). Because the site is not located in near proximity to active earthquake faults, tectonic subsidence hazards are not considered a risk to the site.

**Liquefaction potential hazards:** In conjunction with strong earthquake ground motion potential of large magnitude seismic events as discussed previously, certain soil units may also possess a potential for liquefaction during a large magnitude event. Liquefaction is a phenomenon whereby loose, saturated, granular soil units 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. Horizontally continuous liquefied layers may also have a potential to spread laterally where sufficient slope or free-face conditions exist. The primary factors affecting liquefaction potential of a soil deposit are: (1) magnitude and duration of seismic ground motions; (2) soil type and consistency; and (3) occurrence and depth to groundwater.

Liquefaction potential condtions have not been studied or mapped for the Ogden Valley area, as has occurred in other parts of northern Utah (Anderson and others 1994). Liquefaction commonly occurs in saturated non-cohesive soils such as alluvium, which is not found on the property, consequently the conditions susceptible to liquefaction do not appear to be present at the site.

4. **Rockfall and avalanche hazards:** The site is over a mile from steep slope areas where such hazards may originate.

5. **Flooding:** No significant water ways pass in the vicinity of the site and flood insurance rate mapping by Federal Emergency Management Agency for the site vicinity indicates that the site is outside the 100-yearFlood Zone (FEMA, 2015). Local sheet flow, slope wash, and seasonally perched soil water typical of sloping areas should be anticipated for the site, and site improvements.

6. **Sloping surfaces:** Elevations on the site are shown on Figure 4 to range from 5422 feet on the southwest side of the site, to 5640 feet on the northeast side of the site. The surface of site slopes developed from our DEM analysis and shown on Figure 4 range from level to over 100-percent. For the 0.94 acre Proposed Building Area the slope gradients averaged 24.9 percent, for the overall 4.72 acre parcel area the slope gradients averaged 32.7 percent.

   The threshold gradient for slope development considerations and hillside review according to the Weber County Section 108-14-3 includes slopes greater than 25-percent (Weber County Code, 2017).

7. **Radon exposure:** Radon is a naturally occurring radioactive gas that has no smell, taste, or color, and comes from the natural decay of uranium that is found in nearly all rock and soil. Radon and has been found occur in the Ogden Valley area, and can be a hazard in buildings because the gas collects in enclosed spaces. Indoor testing following construction to detect and determine radon hazard exposure should be conducted to determine if radon reduction measures are necessary for new construction. The radon-hazard potential mapping has been prepared for most of Ogden Valley by the Utah Geological Survey (Solomon, 1996), however that mapping does not extend far enough to the east to include the site, but is classified as "Moderate" potential within about 950 feet south of the site (Solomon, 1996). For new structures radon-resistant construction techniques as provided by the EPA (EPA 2016) should be considered.

### Site Reconnaissance

The site was reconnoitered on September 4, 2017. The access roadways for the subdivision including Maple Street were paved and in place, as were electrical, community sewer and water connections. The site is a mostly rectangular shaped property occupying approximately 350 feet southwest to northeast, and 620 feet southeast to northwest in plan dimensions. From the west side property frontage on Maple Street, the site surface slopes moderately up to the east, becoming a less-steep grade toward the center of the site where the Proposed Building Area is to be located. The eastern third of the site slopes steeply upward to east. At the time of our visit, cover on the lot consisted of tall fescue grasses, dried mule ear, and sagebrush, and individual maple trees. The surficial soils on the site appeared to consist of gravelly clays with sub-angular cobble and boulder sized particles.

Established and recently constructed single-family homesites were observed on near-by properties; however adjacent properties surrounding the site were presently undeveloped at the time of our reconnaissance.

During the reconnaissance no conditions of active geologic hazards or ongoing processes were observed at the Lot #107 site.

## CONCLUSIONS

Based upon the findings of this review we believe that Proposed Building Area identified in this report on Lot #107, Green Hills Estates Phase 6 is not adversely exposed to the geological hazards specified in the Section 108-22 Natural Hazard Areas of the Weber County Code (2017). With this finding we point out that the Proposed Building Area delineated for this study specifically avoids the parts the property that include **Qms** - Landslide deposits shown on Figure 3, and excessively steep slopes areas shown on Figure 4.

Because groundwater and subsurface soils conditions for the site are presently unevaluated, and because the site is partly upon Landslide deposits (**Qms**), we optionally suggest that site specific geotechnical engineering soils and groundwater study be considered for homesite design and construction and site grading, and minimally we recommend that a licensed Geotechnical Engineer observe the foundation excavation prior to the setting of the footings of proposed structures, to confirm the suitability of the foundation soils for the proposed homesite construction.

Although not addressed by the Weber County ordinances, we optionally advise that radon exposure be evaluated to determine if radon reduction measures may be necessary for the new construction. It is our understanding that new construction in Ogden Valley area often includes radon remedial measures as part of final design.

## LIMITATIONS

Our services were limited to the scope of work discussed in the introduction section of this report. The results provided by this study are limited to geological hazards included as "potential hazards" in Section 108-22 Natural Hazard Areas of the Weber County Code (2017). The reporting provided here is not based upon any subsurface observations, and should in no way preclude the results of a geotechnical engineering soils and groundwater studies for foundations, earthwork, and geoseismic design prepared by a professional engineer licensed in the State of Utah.

Although risk can never be eliminated, more detailed and extensive studies yield more information, which may help understand and manage the level of risk. The recommendations contained in this report are based on our site observations, available data, probabilities, and our understanding of the facilities investigated. This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, express or implied, is made.

This report may be used only by the client and only for the purposes stated within a reasonable time from its issuance. The regulatory requirements and the "state of practice" can and do change from time to time, and the conclusions presented herein may not remain current. Based on the intended use of the report, or future changes to design, GCS Geoscience may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else, unless specifically agreed to in advance by GCS Geoscience in writing will release GCS Geoscience from any liability resulting from the use of this report by any unauthorized party.

## REFERENCES

Applied Geotechnical Engineering Consultants (AGEC) , 1996, Geotechnical and Landslide study, Green Hill Country Estates Phase VI, Sections 4 and 9 T6N, R2E SLB&M, Weber County Utah: Unpublished consultants report, 21p.

Anderson, L.R., Keaton, J.R., and Bay, J.A., 1994, Liquefaction potential map for the northern Wasatch Front, Utah, complete technical report: Utah Geological Survey Contract Report 94-6, 150 p., 6 plates, scale 1:48,000.

Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and the evaluation of earthquake hazards and risk in the Wasatch Front area, Utah, in Gori, P.L., and Hays, W.W., (eds.), Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah: U.S. Geological Survey Professional Paper 1500-D, 36 p.

Avery, C., 1994, Ground-water hydrology of Ogden Valley and surrounding area , eastern Weber County, Utah, and simulation of ground-water floor in the valley-fill aquifer system; Utah Department of Natural Resources, Technical Publication no. 99, 84 p.

Black, B.D., DuRoss, C.B., Hylland, M.D., McDonald, G.N., and Hecker, S., compilers, 2004, Fault number 2351e, Wasatch fault zone, Weber section, in Quaternary fault and fold database of the United States: U.S. Geological Survey *website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 06/20/2016 02:49 PM.*

Black, B.D., and Hecker, S., compilers, 1999, Fault number 2379, Ogden Valley northeastern margin fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults

Bryant, B.B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: USGS Professional Paper 1476, 54 p., 1 scale 1:50,000

Coogan, J.C., and King, J.K., 2016, Interim geologic map of the Ogden 30' x 60' quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open File Report 653DM, for use at 1:62,500 scale, 3 plates, 147 p.

Currey, D.R., and Oviatt, C.G., 1985, Durations, average rates, and probable causes of Lake Bonneville expansion, still-stands, and contractions during the last deep-lake cycle, 32,000 to 10,000 years ago, in Kay, P.A., and Diaz, H.F., (eds.), Problems of and prospects for predicting Great Salt Lake levels - Processing of a NOAA Conference, March 26-28, 1985: Salt Lake City, Utah.

Crittenden, M. D. 1972, Geologic map of the Brown's Hole quadrangle, Utah: US. Geological Survey Geologic Quadrangle map. Map GQ-968, scale 1:24,000

Elliott, A.H., and Harty, K.M., 2010, Landslide Maps of Utah, Utah Geological Survey Map 246DM, 14 p., 46 plates, 1:100,000 scale

EPA 2016, Radon-Resistant Construction Basics and Techniques: Environmental Protection Agency website, https://www.epa.gov/radon/radon-resistant-construction-basics-and-techniques accessed 07/20/2016

FEMA, 2015, Flood Insurance Rate Map, 2015 Weber County, Utah, Panel 49057C0263F, Scale 1 inch equals 1000 feet.

GDAL-SOFTWARE-SUITE, 2013, Geospatial data abstraction library. http://www.gdal.org.

GRASS-PROJECT, 2013. Geographic resource analysis support system. http://grass.osgeo.org.

Keaton, J.R., 1986, Potential consequences of tectonic deformation along the Wasatch fault: Utah State University, Final Technical Report to the U.S. Geological Survey for the National Earthquake Hazards Reduction Program, Grant 14-08-0001-G0074, 23 p.

King, J.K., and McDonald, G.N., 2014, Progress report geologic map of the Browns Hole quadrangle, Weber and Cache Counties, Utah: Utah Geological Survey files, scale 1:24,000.

Mulvey, W.E., 1992, Soil and rock causing engineering geologic problems in Utah: Utah Geological Survey Special Study 80, 23 p., scale 1:500,000.

Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p.

Solomon, B.J., 1996, Radon-hazard potential in Ogden Valley, Weber County, Utah: Utah Geological Survey Public Information Series 36, 2 p., 1 figure, approximate scale 1:83,300.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, from USGS web site: http//earthquakes.usgs.gov/hazards/qfaults/

Varnes, D.J., 1978, Slope movement types and processes, in Schuster, R.L., and Krizek, R.J., eds., Landslides—Analysis and control: National Research Council, Washington, D.C., Transportation Research Board, Special Report 176, p. 11–33

Wald, D.J., Quitoriano, V., Heaton, T.H., and Kanamori, H., 1999, Relationship between Peak Ground Acceleration, Peak Ground Velocity, and Modified Mercalli Intensity in California: Earthquake Spectra, v. 15, no. 3, p. 557-564

Weber County Code (2017), retrieved from: https://www.municode.com/library/ut/weber_county/codes/code_of_ordinances

Weber County Inspection (2017), retrieved from: http://www.webercountyutah.gov/inspection/documents/Development Process Packet.pdf

We appreciate the opportunity to work with you on this project and look forward to assisting with you in the future. If you have any questions or need additional information on this or other reporting, please contact the undersigned at (801) 745-0262 or (801) 458-0207.

Respectfully submitted,

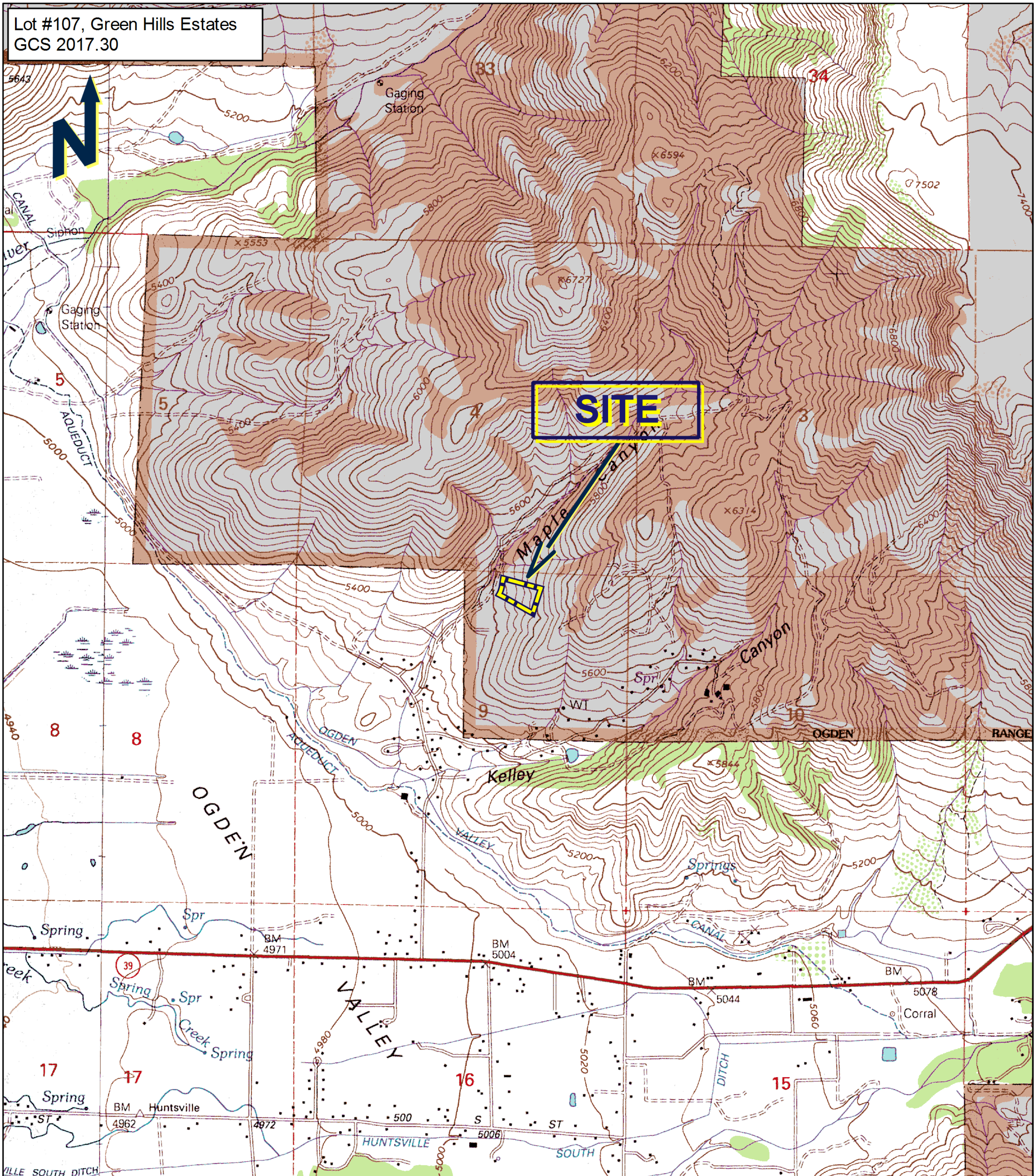
**GCS Geoscience**

Gregory C. Schlenker, PhD, PG
State of Utah No. 5224720-2250
Principal Geologist

GCS Geoscience
554 South 7700 East Street
Huntsville, Utah 84317

Encl. Figure 1, Vicinity Map
Figure 2, Aerial Coverage
Figure 3, Geologic Map
Figure 4, LiDAR Analysis

Lot #107, Green Hills Estates
GCS 2017.30



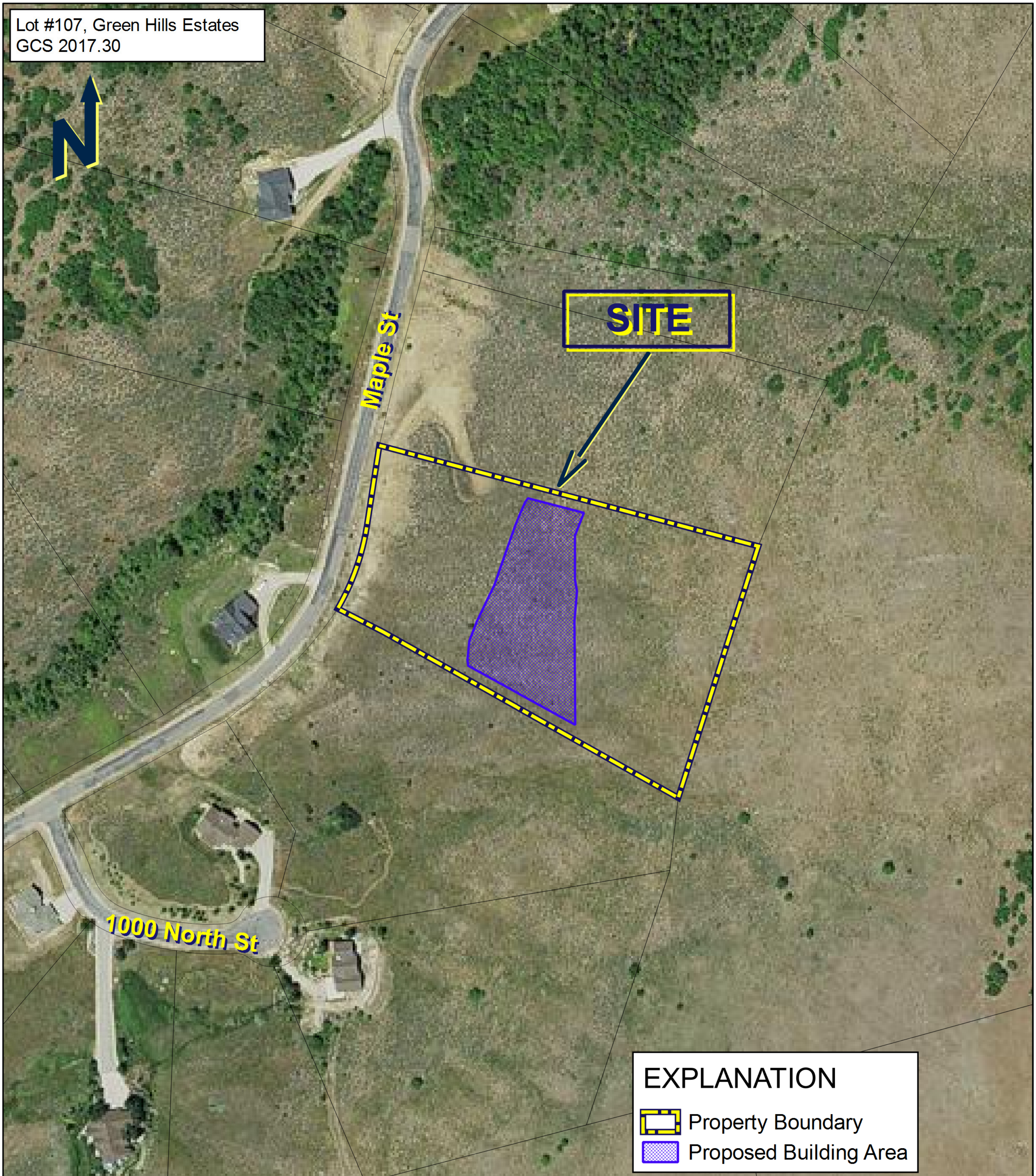

Base:
USGS 7.5 Minute topographic maps titled "Browns Hole, UT 1998; and Huntsville, UT 1998;from Utah AGRC; http://gis.utah.gov/

0 2000 4000 ft

1:24,000

**FIGURE 1**
**VICINITY MAP**

**GCS Geoscience**



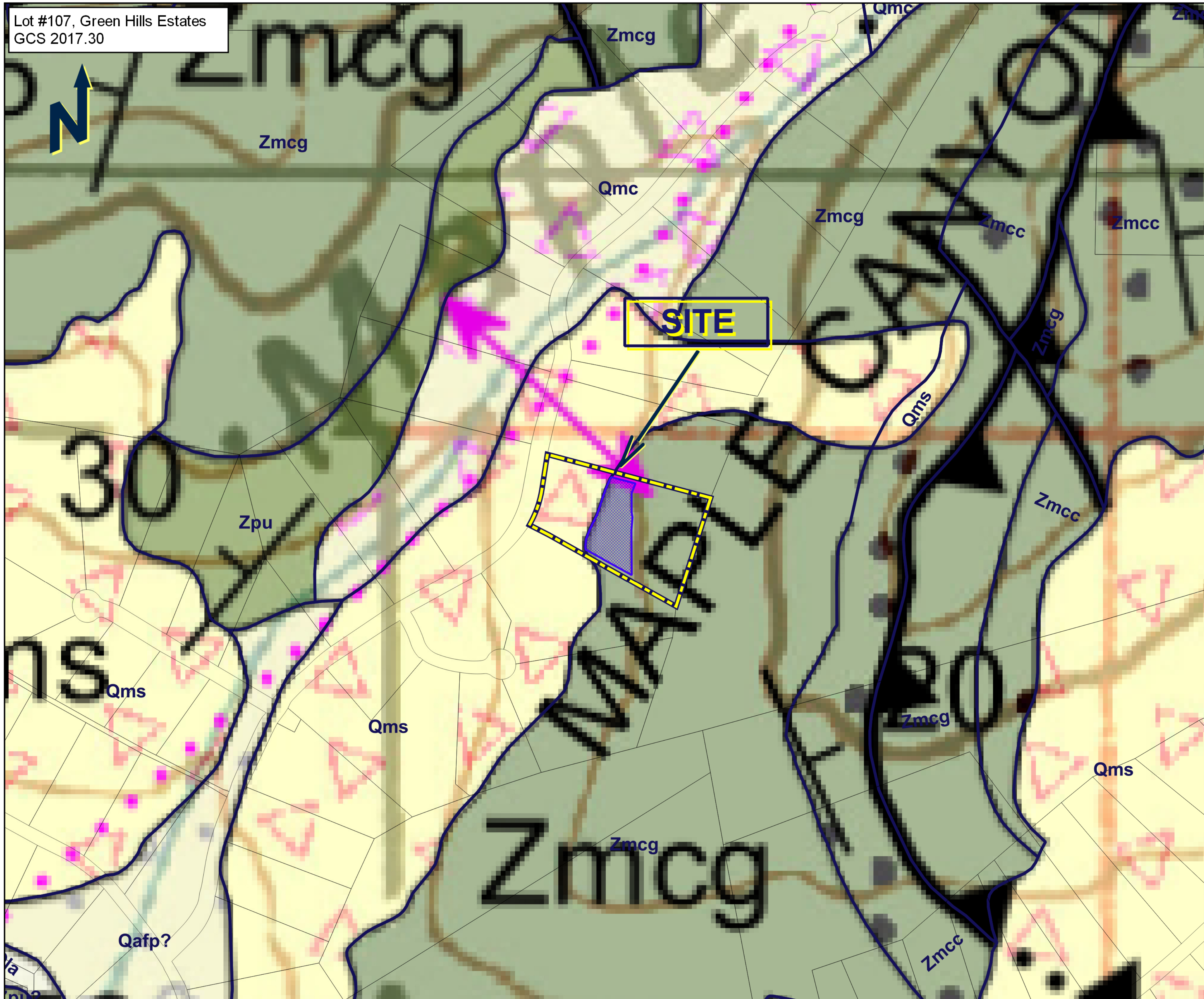

Base:
2014 1.0m Color NAIP Orthoimagery,
from Utah AGRC; http://gis.utah.gov/

0 200 400 ft

1:2,400

**FIGURE 2**
**AERIAL COVERAGE**

**GCS Geoscience**




Base:
Coogan and King, 2016

0 400 800 ft

1:4,800

## Geology (after Coogan and King, 2016)

**Qmc - Landslide and colluvial deposits, undivided** (Holocene and Pleistocene) – Poorly sorted to unsorted clay- to boulder-sized material...(slopewash and soil creep)...These deposits are as unstable as other landslide units...

**Qms - Landslide deposits** (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods...

**Qafp? - Lake Bonneville-age alluvial-fan deposits** (upper Pleistocene) –Mostly sand, silt, gravel, cobbles and boulders...

**Zmcc - Maple Canyon Formation bedrock; Upper unit (conglomerate) member** (Neoproterozoic) – At top...light-gray coarse-grained, quartzite to pebble and small cobble meta-conglomerate with local tan-weathering, darkgray, meta-graywacke matrix; thin olive-gray, laminated, weakly resistant argillite in middle...

**Zmcg - Maple Canyon Formation bedrock; Lower unit (green arkose) member** (Neoproterozoic) – Grayish-green, fine-grained arkosic (feldspathic) meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses...is prone to slope failures...

**Zpu - Formation of Perry Canyon bedrock; 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”...This unit is prone to slope failures...

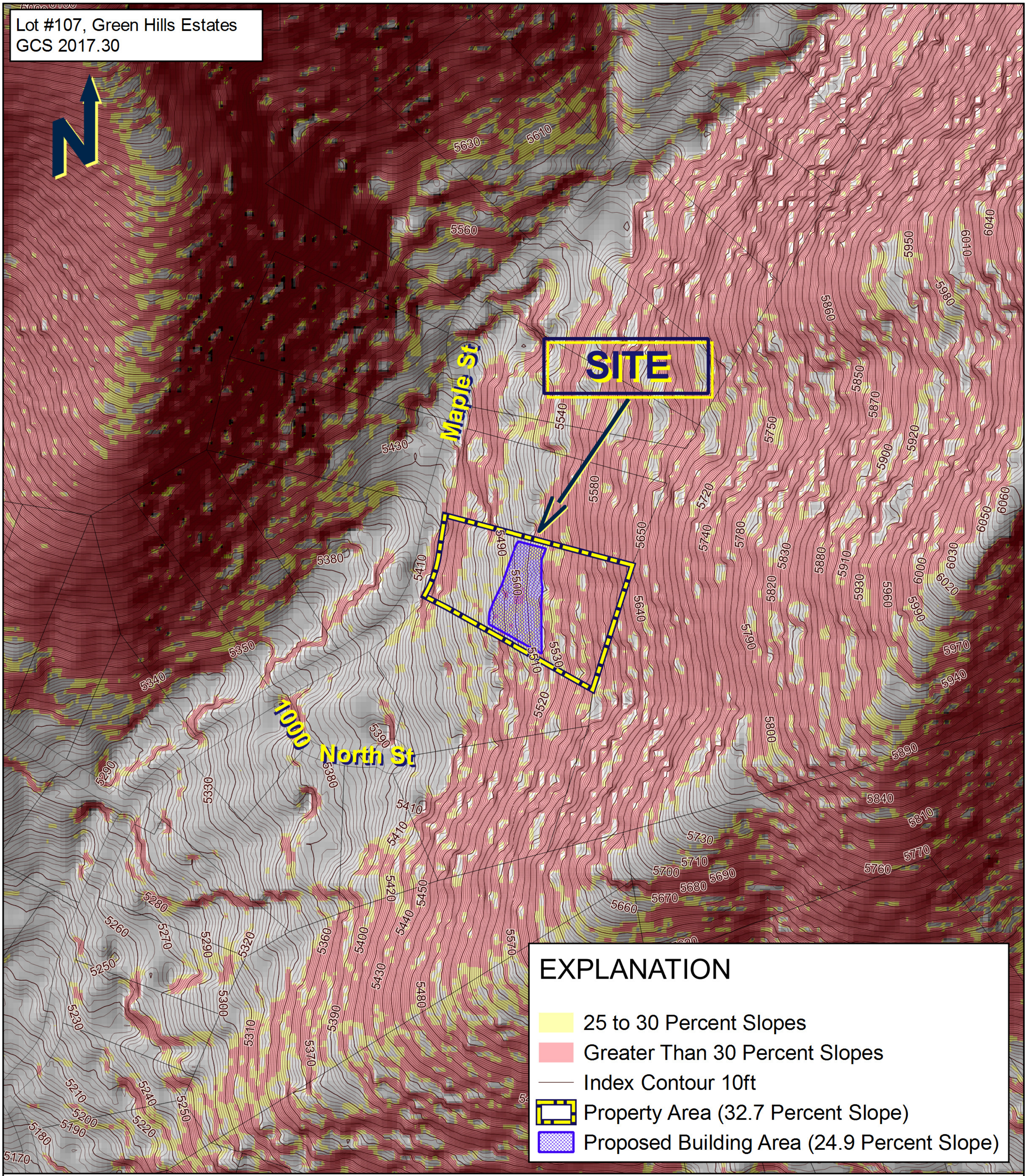
**Thrust Fault** Dashed where covered - Paleozoic rocks and older

**Anticline** Concealed axis

**Strike and Dip** Long bar represents strike axis, numerical value equals dip angle

**FIGURE 3**
**GEOLOGIC MAPPING**

**GCS Geoscience**




Base:
5.0 Meter Auto-Correlated DEM from 1m NAIP 2006 Orthophotography, geoprocessed and resampled to 1.0 m; from Utah AGRC; http://gis.utah.gov/

0 400 800 ft

1:4,800

**FIGURE 4**
**DEM/SLOPE ANALYSIS**

**GCS Geoscience**