REPORT
RECONNAISSANCE LEVEL GEOLOGICAL STUDY
PROPOSED SINGLE LOT KEO HOMESTEAD SUBDIVISION
APPROXIMATELY 5600 EAST HIGHWAY 39
WEBER COUNTY, UTAH

Submitted To:

Mr. David Orchard
2248 Oneida Street
Salt Lake City, Utah

Submitted By:

GSH Geotechnical, Inc.
1596 West 2650 South
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January 6, 2016

Job No. 1675-02N-15

GSH

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Mr. David Orchard
2248 Oneida Street
Salt Lake City, Utah 84109

Mr. Orchard:

Re: Reconnaissance Level Geological Study
Proposed Single-Lot KEO Homestead Subdivision
Approximately 5600 East Highway 39
(Part of Section 14, Township 6 North, Range 1 East, Salt Lake base and meridian)
Weber County, Utah

1. Introduction

In response to your request, GSH Geotechnical, Inc (GSH) has prepared this Reconnaissance Level Geological Study for the proposed single-lot KEO Homestead Subdivision referenced above. The proposed subdivision is located in the vicinity of Huntsville Town, Weber County, Utah (41.2429, -111.7884). The general location of the subdivision is on the south side of Utah SR-39 with access at approximately 5600 East (MP-15.2), and entirely within Section 14, T6N-R1E SLBM, as shown on Figure 1.

The area of the proposed subdivision consists of approximately 21.3 acres of lands zoned by Weber County as FV-3, "Forest Valley Zone." A smaller area of approximately four acres within northeastern part of the subdivision property has been surveyed for single-family residential use, and is shown on Figure 2 as "Homesite Area." Figure 3 presents our geological mapping of the site on both LiDAR and Aerial coverages. A more detailed drawing of proposed improvements for the Homesite Area is provided on Figure 4 and Figure 5, showing the proposed improvements, which are to include: a residence and a detached garage, with both structures to be served by independent septic/drain field systems; a well with a 100-foot protection radius is shown to be located between the residence and the garage; and a paved turn-around area for vehicle access on the northeast side of the site.

A previous Geotechnical Study for this subdivision was conducted by our office for this property in 2014 (GSH Geotechnical, Inc., 2014). Details from this report indicate:

> *Construction for the home will likely consist of reinforced concrete footings and basement foundation walls supporting 1 to 3 wood-framed levels above grade with some stone, brick, or stucco veneer. The detached garage is anticipated to be a single level wood framed level above grade and constructed slab on grade. Projected maximum column and wall loads are on the order of 10 to 20 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 understand that site grading will be minimized on the project to maintain stability of the slopes at the site. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 5 feet. Larger fills and cuts may be required at isolated areas and should be engineered accordingly to maintain stability of the slopes at the site.

As shown on Figure 3 and Figure 5, the general area of the proposed KEO Homestead Subdivision and the Homesite Area includes slopes on the order of 20-pecent to greater than 50-percent.

2. Weber County Natural Hazards Overlay Districts

Because the proposed KEO Homestead Subdivision is located on a sloping hillside area with susceptible expansive soil and rock conditions, Weber County (Planning Commission) has requested that geological studies be conducted to evaluate conformance with development plans.

At this time specific guidelines for these studies have not been specified by the County, however Weber County Chapter 27 Natural Hazards Overlay Districts, Section 104-2B (Weber County Code, 2015), pertaining to Landslide/Tectonic Subsidence provides the following requirements:

> *...any development proposed within a designated landslide hazard area, as delineated on the Sensitive Lands Overlay District maps, shall require the submittal, review and approval by the Planning Commission, of specific site studies, including grading plans, cut/fill, and plans produced by a qualified engineering geologist and a Utah licensed Geotechnical Engineer. The site specific study shall address slope stability (including natural or proposed cut slopes), evaluate slope-failure potential, effects of development and recommendations for mitigative measures. Slope stability analysis shall include potential for movement under static, development-induced and earthquake-induced conditions as well as likely ground water conditions.*

Sensitive Lands Overlay District maps addressing Landslide/Tectonic Subsidence zones for Weber County are not available for the site. A review of site geological mapping prepared by Utah Geological Survey (UGS) geologists (King, et al, 2008) has indicated that the proposed KEO Homestead Subdivision is upon or within mapped Quaternary landslide deposits (Qms and Qmc) or sensitive Tertiary age Norwood Tuff (Tn) formation rocks (King, et al., 2008).

To address the concerns and expectations of the Weber County Planning and Engineering Staff a scoping meeting was held on December 8, 2015 between the KEO Subdivision applicant proponents and Weber County Staff. Based upon our experience with Weber County the purpose of the scoping meeting was to accomplish the following:

> *Scoping Meeting: The developer or consultant should schedule a scoping meeting with the Weber County to evaluate the engineering geologist's/geotechnical engineer's investigative approach. At this meeting, the consultant should present a work plan that*

includes locations of anticipated geologic hazards and locations of proposed exploratory excavations, such as trenches, borings, CPT soundings, etc., which meet the minimum standard of practice. The investigation approach should allow for flexibility due to unexpected site conditions. Field findings may require modifications to the work plan

3. Scoping Meeting, December 8, 2015

The following individuals were present for the December 8 scoping meeting with Weber County Planning and Engineering Staff:

Chad Meyerhoffer (Weber County Engineering)
Dana Schuler PE (Weber County Engineering)
Ben Hatfield (Weber County Engineering)
David Simon PG, (Simon and Associates), Weber County Geological Consultant (teleconference)
Alan Taylor PE (Taylor Geotechnical) Weber County Geotechnical Engineering Consultant.
Greg Schlenker, PG, GSH Geotechnical Inc., Applicant Geological Consultant.
Andrew Harris, PE, GSH Geotechnical Inc., Applicant Geotechnical Engineering Consultant
Andy Hubbard, PE PLS Great Basin Engineering, Applicant Engineering Consultant.

During the December 8 scoping meeting GSH consultants presented the following scope of work (work plan) for the evaluation of the KEO Subdivision site relevant to the Weber County Natural Hazards Overlay District Code:

For the present circumstances, but pending the consent of the scoping meeting, GSH proposes to conduct an engineering geology evaluation of the KEO Homestead Subdivision. A preliminary layout of our, test pit locations and slope geologic cross-sections to be evaluated for this study is show on Figure 2 Proposed Work Plan. Our proposed work plan effort is to include; 1) a search and review of previous relevant documentation of site engineering and geologic studies and including UGS mapping (King, et al, 2008), and previous reports and studies, 2) a field reconnaissance study including the geologic logging of four walk-in test pits on the Homesite Area, and to include field review by the Weber County Geologist, 4) site specific geological mapping and classification to identify critical geological units and exposure of proposed improvements, 5) slope analysis from DEM-LiDAR geoprocessing identifying critical areas of 25-percent or greater across the site, and 6) preparation of summary report presenting results of our analysis including:

- *A vicinity map showing the location of the property relative to site vicinity and topographic features.*

- *A geologic map showing the site specific surficial geology of the KEO Homestead Subdivision and surrounding area.*

- *Aerial photography showing the site and nearby surficial geologic features, site reconnaissance and test pit features, and site development features.*
- *An assessment of potential geologic hazards in the vicinity of the site and the exposure of the site and proposed site improvements to hazards named in the ordinance including but not limited to: landsliding and slope stability; alluvial fan processes including debris-flow; surface fault rupture hazards, strong earthquake ground motion, and liquefaction hazards; rockfall and avalanche hazards, flood hazards, and*
- *Site development recommendations based upon our findings and professional experience.*

Because parts of the KEO Subdivision are mapped by the UGS geologists (King, et al, 2008) as upon or within mapped Quaternary landslide deposits (Qms and Qmc) or sensitive Tertiary age Norwood Tuff (Tn) formation rocks (King, et al., 2008), Weber County Geological Consultant, Mr. David Simon requested that a more detailed geological mapping of the site using currently available LiDAR data/imagery be performed before selecting test pit and/or boring locations for final work plan implementation. The County, following Mr. Simon's recommendation, has requested GHS to prepare geological mapping of the KEO Subdivision vicinity to better ascertain the geological conditions of the site prior to the acceptance test pit and/or boring locations for the subdivision work plan and evaluation. For those reasons this geological study has been prepared without the support of specific subsurface observations.

Minutes of the December 8 meeting were not available at the time of this report.

4. Geological Analysis

4.1 Detailed Geological Mapping and LiDAR Analysis

The previous existing mapping of the site by the UGS geologists (King, et al, 2008), is a 1:24,000 scale U.S. Geological Survey quadrangle based effort that is currently published as an "Interim - Open-File Report." The Utah Geological Survey discloses that *"... open-file release makes information available to the public that may not conform to UGS standards; the report may be incomplete and possible inconsistencies, errors, and omissions have not been resolved. Therefore it may be premature for an individual or group to take action based on its contents."* The UGS mapping effort shows the KEO Subdivision Homesite Area to be largely covered by units classified as **Qms** and **Qmc,** landslide and slump, and colluvial deposits undivided.

Our initial approach for the mapping was to assume the Quaternary landslide deposits (Qms and Qmc) as mapped by the UGS in the vicinity of the KEO Subdivision was correct, and that landslide terrain features such as head scarps (main scarps), minor scarps, transverse cracks and ridges, hummocky surfaces and toe development could be identified in the site vicinity to clarify the areal limits, geometry and mode of movement (Varnes, 1978) of the landsliding mapped in the vicinity of the site (King, et al, 2008).

Our geological mapping effort included reviews of previous mapping and literature pertaining to site geology including Sorensen and Crittenden (1979), Bryant (1988) Coogan and King (2001) and King, et al. (2008); an analysis of vertical and stereoscopic aerial photography for the site including a 1946 1:20,000 stereoscopic sequence, a 2014 1.0 meter digital NAIP coverage, and a 2012 5.0 inch digital HRO coverage of the site; and a GIS analysis using the QGIS® GIS platform to geoprocess and analyze 2006 2.0 meter LiDAR digital elevation data 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, Roughness, Ruggedness Index utilities, the GRASS® (Geographic Resources Analysis Support System, 2013) r.slope and r.shaded.relief modules, and the LiDAR First Return Intensity models, where features related to landslide morphology in the site vicinity were explored for detection and mapping. A summary and results of these analyses is included in Appendix A LiDAR Analyses of this report. The particular GIS analyses used in this study are outlined as follows:

GDAL Contour Utility - Extracts contour lines from any GDAL-supported elevation raster.

GDAL Roughness Utility - Outputs a single-band raster with values computed from the elevation. Roughness is the degree of irregularity of the surface. It's calculated by the largest inter-cell difference of a central pixel and its surrounding cell. The determination of the roughness plays a role in the analysis of terrain elevation data, it's useful for calculations of the river morphology, in climatology and physical geography in general

GDAL Ruggedness Index Utility - This command outputs a single-band raster with values computed from the elevation. TRI stands for Terrain Ruggedness Index, which is defined as the mean difference between a central pixel and its surrounding cells

GRASS r.slope Utility - Generates raster maps of slope, where slope is the angle of inclination to the horizontal. User has the option of specifying the type of slope value you want: degrees or percent slope.

GRASS r.shaded.relief Utility - Creates a raster shaded relief map based on current resolution settings and on sun altitude, azimuth, and z-exaggeration values entered by the user. Cardinal sun angle azimuths of 300º, 30º, 120º and 210º respectively are shown on Appendix A Figure 2.

LiDAR First Return Intensity - Returns point-cloud intensity values of first return pulse. The intensity value is a measure of the return signal strength. Intensity values vary with altitude, atmospheric conditions, directional reflectance properties, and the reflectivity of the target. First-return values intensity values can be used to detect spectral edges on the imaged surface.

4.2 Surface

A surface reconnaissance of the Homesite Area was conducted on December 9, 2015, however no subsurface observations have been made specifically for this reporting.

As shown on Figure 1 and 2, the site consists of an area of 21.3 acres that is currently vacant and undeveloped. Surface vegetation consists of open areas of grasses, weeds and sage brush on ridgelines, with a predominant wooded cover of scrub oak, alder and maple trees. The topography of the site consists of foothill slopes with the property occupying generally north facing slopes facing downward toward the north toward Ogden Valley. A small unnamed intermittent drainage passes from southwest to northeast across the Homesite area.

Topographically the site is located on base foothills on the northeast side of Mount Ogden, and overlooks Ogden Valley and the South Fork of the Ogden River floodplain, which is inundated by Pineview Reservoir waters, to the north of the site. The site, as shown on Figure 2, is bordered on the south, and west by vacant undeveloped lands, and on the north and west and by similar residential estate property land uses.

4.3 Geologic Setting

The site is located on the eastern flank of Mount Ogden which western flank comprises the Wasatch Front. The Wasatch Front is marked by the Wasatch fault, which is 5.8 miles west of the site, and provides the basis of division between the Middle Rocky Mountain Physiographic on the east and the Basin and Range Physiographic Province on the west. The Basin and Range Physiographic Province is characterized by approximately north-south trending valleys and mountain ranges that have been formed by extensional tectonics and displacement along normal faults, and extends from the Wasatch Range on the east to the Sierra Nevada Range on the west (Hunt, 1967).

The Middle Rocky Mountain province covers parts of Utah, Colorado, Wyoming, Idaho, and Montana. The geology of the province is an assemblage of sedimentary, igneous, and metamorphic rocks that have been folded, faulted, and uplifted. Mountain building (tectonic) activity commenced about 30 million years ago (Cretaceous time) and continues to the present. The province is characterized by mountainous terrain with deep canyons and broad intervening basins, with temperate semi-arid to mesic climatic conditions (Hunt, 1967).

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 east of the site. This exposure was the result of movement along high-angle faults during late Tertiary and Quaternary age (Bryant, 1988).

Bounding the east foothill flank of Mount Ogden are mid Teritary units of the Norwood Tuff Formation that ramp along the base of the mountains south and west of the Ogden Valley floor. The Norwood Tuff Formation is described as "light-gray to light brown, altered tuff (claystone), tuffaceous siltstone, sandstone, and conglomerate" derived from volcanic ash deposition (King, et al., 2008), and has been measured to be as much as 7,000 feet thick in the vicinity of the site. The claystone, siltstone and sandstone occurrences of the formation are primarily a result of lacustrine (lake processes) redisposition of the volcanic ash. The site location is believed to be largely underlain by Norwood Tuff Formation lacustrine rock units which beds appear to slope gently down to the northeast across the site (King et. al, 2008). The existing surface of the site appears to have been modified by Quaternary age erosion, and localized late-Quaternary stream, lacustrine (Currey and Oviatt, 1985), residual soil weathering and development, and mass movement processes (King, et al., 2008).

4.4 Site Engineering Geology

Our interpretation of the site engineering geology is presented on Figure 3 Aerial and LiDAR Geologic Mapping. The engineering geologic mapping shown on Figure 3 is largely based on previous mapping prepared by King, et al., (2008), with amendments to the mapping drawn on the basis of the findings of this study including our LiDAR analysis incorporated in Appendix A of this report. A summary of the mapping units identified on the KEO Subdivision Property are listed below in relative age sequence (youngest-top to oldest bottom):

Qac; Alluvium and colluvium - Includes stream and fan alluvium...
Qc; Colluvium - Includes materials moved by slopewash and soil creep.
Qms; Landslide and slump, and colluvial deposits undivided.
Qmc; Landslide and slump, and colluvial deposits, undivided
Qlf/Tn; Lake Bonneville fine-grained deposits over Norwood Formation - Typically light-gray to light brown, altered tuff.
Qmso/Tn; Landslide and slump, and colluvial deposits, over Norwood Formation.
Qmso?Tn; Landslide and slump, and colluvial deposits, likely over Norwood Formation.
Tn; Norwood "Tuff" Formation.

In addition to the areal distribution of the geological deposits shown on Figure 3, a wave-cut shoreline attributed to the "Bonneville" highstand of ancient Lake Bonneville that was cut approximately 15,000 years ago (Currey and Oviatt, 1985), is shown to cross on the northwest corner of the property along the uppermost margins of the deposits mapped as **Qlf/Tn**.

Areas shown on the Homesite Area on Figure 3 mapped as **Qc** Colluvium and **Tn** Norwood "Tuff" Formation, were previously mapped by King et al. (2008) as consisting of **Qms and Qmc** Landslide and slump and colluvial deposits undivided (shown on Appendix A Figure 1). Our revision of the mapping in this area reflects the results of our LiDAR analysis included in Appendix A, where landslide terrain features such as; head scarps (main scarps), minor scarps, transverse cracks and ridges, hummocky surfaces and toe development were not detected. However, terrain features such as these were observed on mapped **Qms** regions on the southwest and south margins of the property as shown on the Figures included in Appendix A.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

5.1.1 Subsurface Observations:

Previous subsurface observations were made during our Geotechnical Study conducted in 2014 (GSH Geothchnical Inc., 2014), where four vertical test pits were excavated on the Homesite area. The discussions pertaining to the site soils observed during our 2014 study are paraphrased below:

> *At the test pit locations, topsoil and disturbed soils were encountered at the surface of the site to about 3 to 12 inches below existing grades. Natural soils consisting of lean to fat clay with varying amounts of sand, gravel, and cobbles were encountered beneath the topsoil and disturbed soils within test pits TP-1, TP-2 and TP-3 to depths of about 8.0 to 10.0 feet (full depth penetrated in TP-1 and TP-3) below existing grades. Clayey fine to coarse sand with fine and coarse gravel and cobbles comprised of volcanic ash was observed below the clay soils in TP-2 and extended to the maximum depth explored of 10.0 feet below existing grades. Excavating in TP-2 was terminated at about 10.0 feet due to practical equipment refusal in the weakly cemented clayey sands with gravel and cobbles.*

A verbal driller's report was provided by Mr. Bob Sutton (Well Driller) regarding well drilling progress on the site for the Water Well Location shown on Figure 4 and 5. On December, 2015 Mr. Sutton indicated that:

> *Well drilling activities at the site are being completed with a cable-tool (wire-line) drill rig. Drilling for the well became difficult at about 5 feet below the ground surface. At this depth they encountered a "shale" bedrock that generated a clayey gravel cutting. At about 32 to 40 feet, the bedrock material generated more gravelly cuttings with less clay content. Below 40 feet to the current depth of 280 feet, the bedrock material was relatively consistent and consisted of "shale." Minor groundwater was encountered at about 275 feet; however the flow rate was estimated at less than 2 gallons per minute. The well is anticipated to extend about 100 feet further (TD at about 380 to 400 feet). Mr. Sutton indicated that the drilling rates through this material were very slow by comparison to the rates achieved on wells in the Mountain Green area and other parts of the Ogden Valley. Drilling was limited to about 3 to 9 feet per day in the bedrock on this well, where wells in the Mountain Green area and other parts of the Ogden Valley average about 20 feet per day in bedrock.*

No subsurface observations specific to this current report have been made.

5.1.2 Sloping Surfaces. The surface of site slopes developed from our LiDAR analysis range from level to over 55-percent as shown on Figure 5, Homesite LiDAR Geology and Slope. For the Homesite Area, the slope areas averaged 30.3-percent, and for overall the Property area the slopes averaged 33.0-percent. As previously discussed in the Slope Analysis section of this report, the critical gradient for slope development considerations according to the Weber County Code is 25-percent.

5.1.3 Site Engineering Geology And Mapping. The engineering geology mapping of the site presented on Figure 3 reveals two issues pertinent to site development planning for the Homesite Area. These issues include: (1) **Colluvium deposits (Qc)** - the presence of materials moved by slopewash and soil creep; (2) **Norwood "Tuff" Formation (Tn)** - the presence of Norwood Tuff Formation **Tn** underlying much of the area of the property including the Homesite Area. These issues are addressed in order importance below:

1. **Colluvium deposits (Qc):** Presence of **Qc** Colluvium deposits on the site is based upon reconnaissance field observations and the analysis of aerial imagery and the LiDAR Analysis included in Appendix A. The engineering geology significance of the Colluvium deposits **(Qc)** is the propensity of deposits of this genera to experience slope creep. Slope creep is described by Varnes (1978) as:

   ...the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress sufficient to produce permanent deformation, but too small to produce shear failure. There are generally three types of creep: (1) seasonal, where movement is within the depth of soil affected by seasonal changes in soil moisture and soil temperature; (2) continuous, where shear stress continuously exceeds the strength of the material; and (3) progressive, where slopes are reaching the point of failure as other types of mass movements. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

   Because specific subsurface exploration has not been conducted for the Homesite Area, we cannot discuss the presence or severity of the slope creep phenomenon at this time.

2. **Norwood Tuff Formation (Tn):** The Norwood Tuff Formation has a notoriety of poor stability performance and geotechnically challenging soils throughout Northern Utah. Based upon our past experience with areas underlain by Norwood Tuff Formation rock and soil, we believe that appropriate geological/geotechnical studies should be conducted before structural improvements are made in those areas.

5.1.5 Geoseismic Setting: 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 (Peterson, et al., 2008). The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

Based on probabilistic estimates (Peterson, et al., 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 0.16*g*, and for a two-percent probability of exceedance in 50 years is as high as 0.33*g* for the site. Ground accelerations greater than these are possible but will have a lower probability of occurrence.

5.1.6 Active Earthquake Faults: Based upon our review of available literature, no active faults are known to pass through or immediately adjacent to the site. The nearest active (Holocene) fault is the Weber Segment of the Wasatch fault, located 5.8 miles west of the site (Black et al., 2004). . The Wasatch Fault Zone is considered capable of generating earthquakes as large as magnitude 7.3 (Arabasz, et al., 1992).

5.1.7 Liquefaction Potential Hazards: In conjunction with the ground shaking 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 commonly occurs in saturated non-cohesive soils such as alluvium, thus no areas of the subject site appear to be susceptible to liquefaction processes.

5.1.8 Alluvial Fan Deposits: Alluvial fan deposits indicative of processes including flash flooding and debris flow hazard do not occur on the site: The nearest active alluvial fan deposits to the site, mapped as Qaf by king, et al., (2008), are located on a small fan surface (<1.2 acres in area) approximately 1400 feet northwest of the site, and do not appear to represent a potential impact the site.

5.1.9 Flooding Hazards: 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 has not been prepared at this time.

5.1.10 Rockfall and Avalanche Hazards: The site is located roughly a mile from steep slope areas where such hazards may originate.

6. CONCLUSIONS

Based upon our geological studies herein, we believe that the proposed KEO Subdivision is suitable for development as discussed in Section 1 of this report, pending the results of our proposed subsurface evaluation. At this time we speculate that the Homesite Area is generally covered with an approximately 10-foot thick mantle of Colluvial deposits (Qc) and is not exposed to deep-seated landslide movement. The proposed locations of our Test Pits/Trenches are provided on Figure 6. We believe these locations will provide suitable subsurface exposure

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to evaluate geological and stability concerns expressed for the proposed improvements. Additionally, a geological cross-section based on observed conditions will be generated which can be utilized in further geotechnical engineering evaluations of the slope stability at the proposed site improvements.

CLOSURE

If you have any questions or would like to discuss the results of this study further, please feel free to contact us at (801) 393 2012.

Respectfully submitted,

GSH Geotechnical, Inc.

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Encl. Figure 1, Vicinity Map
Figure 2, Aerial Coverage
Figure 3, Aerial and LiDAR Geologic Mapping
Figure 4, Homesite Aerial Geologic Mapping
Figure 5 Homesite LiDAR Geology and Slope
Figure 6 Proposed Subsurface Evaluation Locations

Appendix A LiDAR Analyses
Figure 1 Contour and Shaded Relief Analysis
Figure 2 Shaded Relief Analysis
Figure 3 Slope Percent Analysis
Figure 4 Roughness Index
Figure 5 Ruggedness Index
Figure 6 LiDAR First Return Intensity

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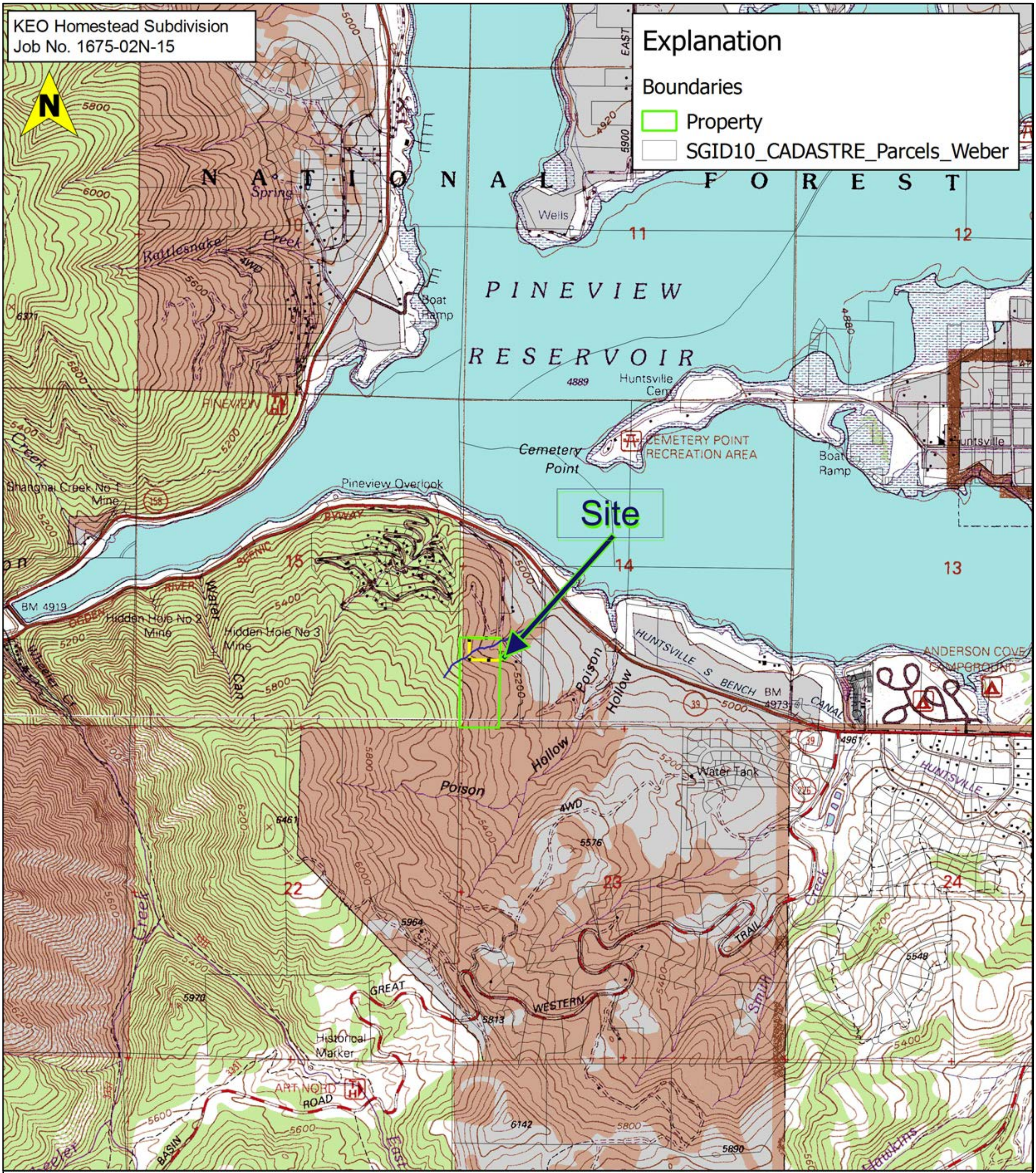


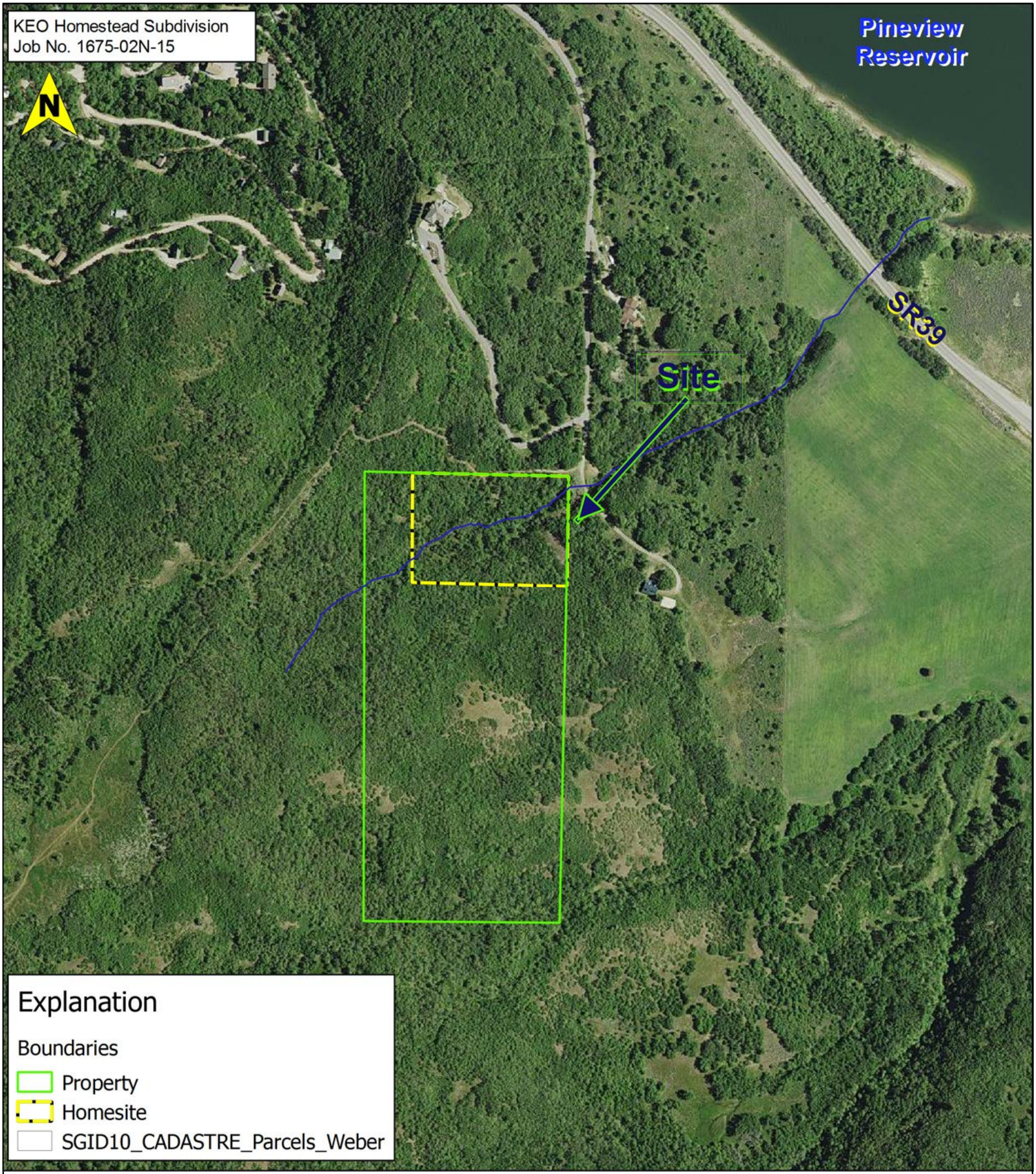
Base:
1998 7.5 Minute USGS Toporgraphic Maps Titled Snowbasin, Utah, and Huntsville, Utah.

0 1000 2000 3000 4000 ft

1:24,000

FIGURE 1
VICINITY MAP

GSH



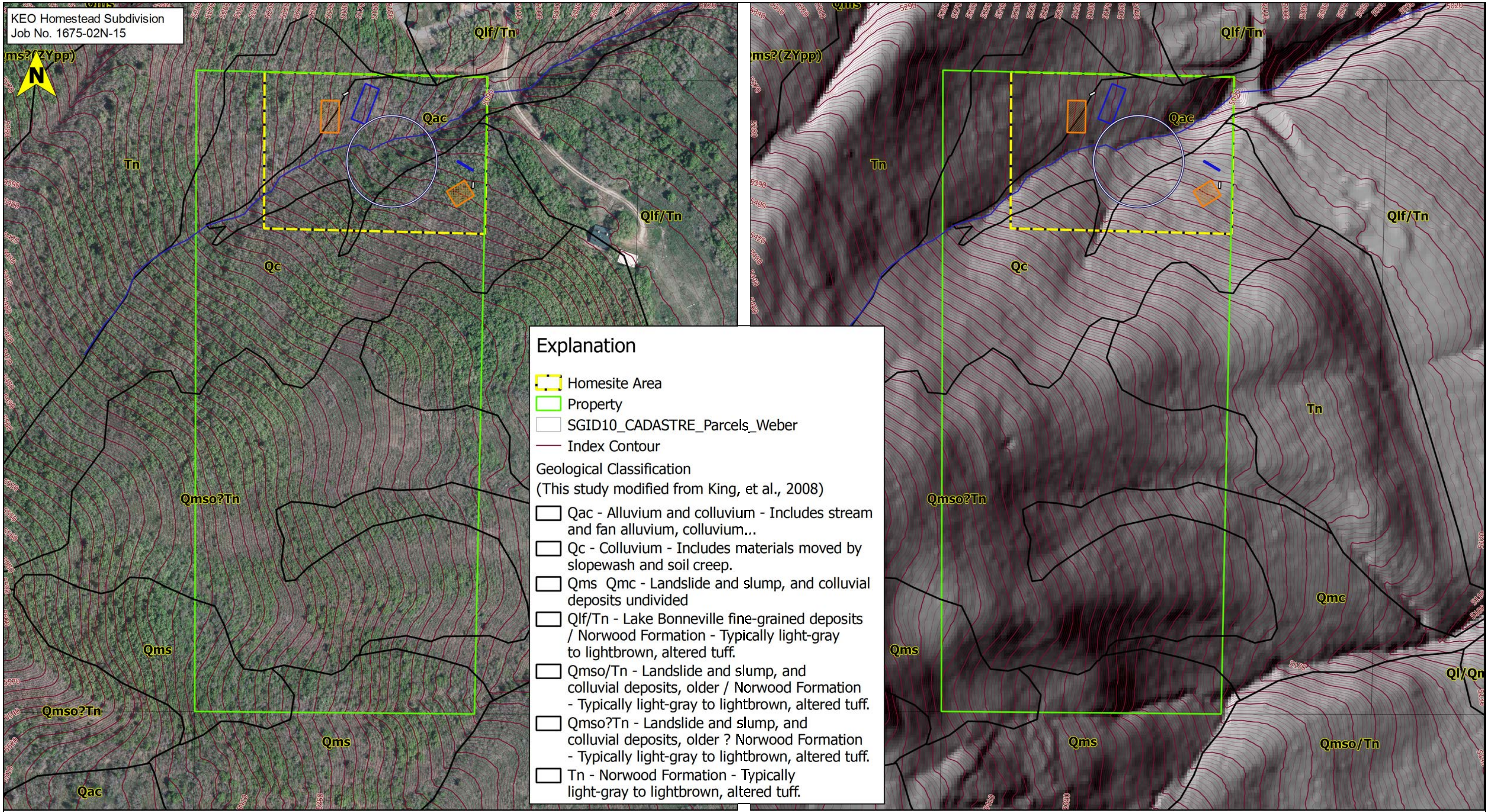
Base:
1998 7.5 Minute USGS Toporgraphic Maps Titled Snowbasin, Utah, and Huntsville, Utah.

0 200 400 600 800 ft

1:4,800

FIGURE 2
AERIAL COVERAGE

GSH



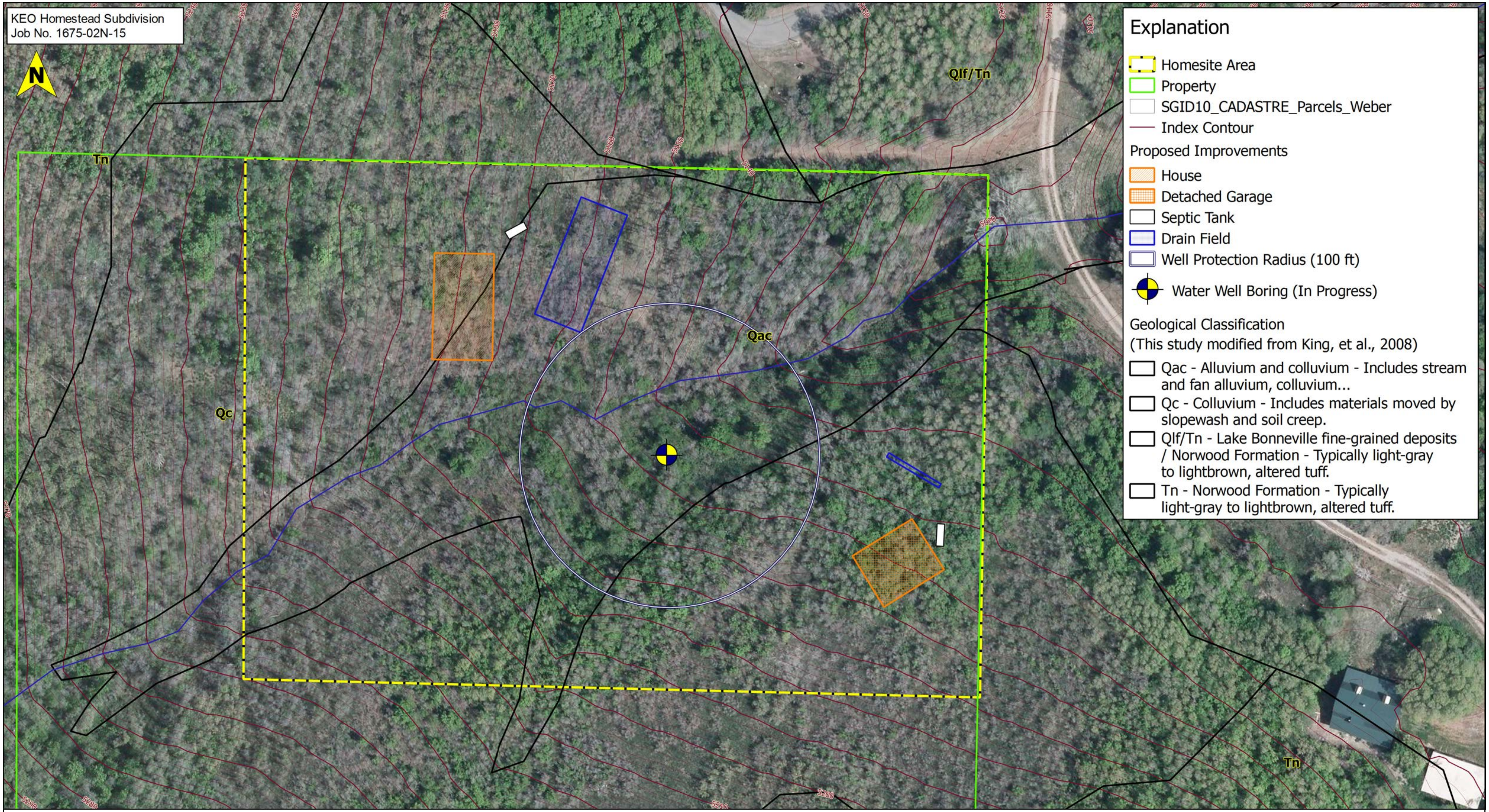
Base: 2012 5.0 inch Color HRO Orthoimagery, from Utah AGRC; http://gis.utah.gov/
Elevation: 2006 2.0m Geoprocessed LiDARfrom Utah AGRC; http://gis.utah.gov/
Geology: Modified from King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000

0 100 200 300 400 500 600 ft

1:2,400

FIGURE 3
AERIAL AND LiDAR GEOLOGIC MAPPING

GSH



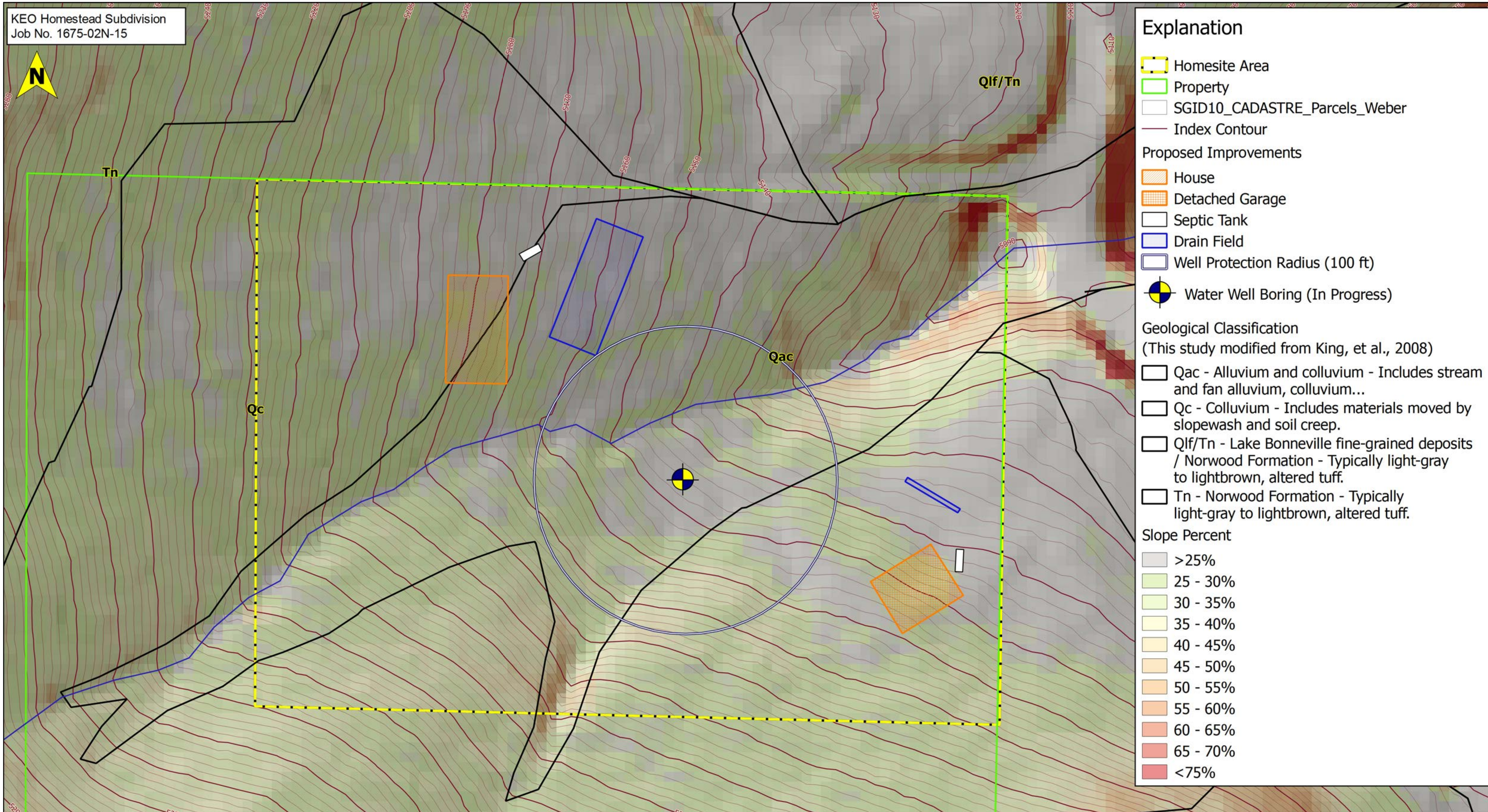
Base: 2012 5.0 inch Color HRO Orthoimagery, from Utah AGRC; http://gis.utah.gov/
Elevation: 2006 2.0m Geoprocessed LiDARfrom Utah AGRC; http://gis.utah.gov/
Geology: Modified from King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000

0 60 120 180 ft

1:720

FIGURE 4
HOMESITE AERIAL GEOLOGIC MAPPING

GSH



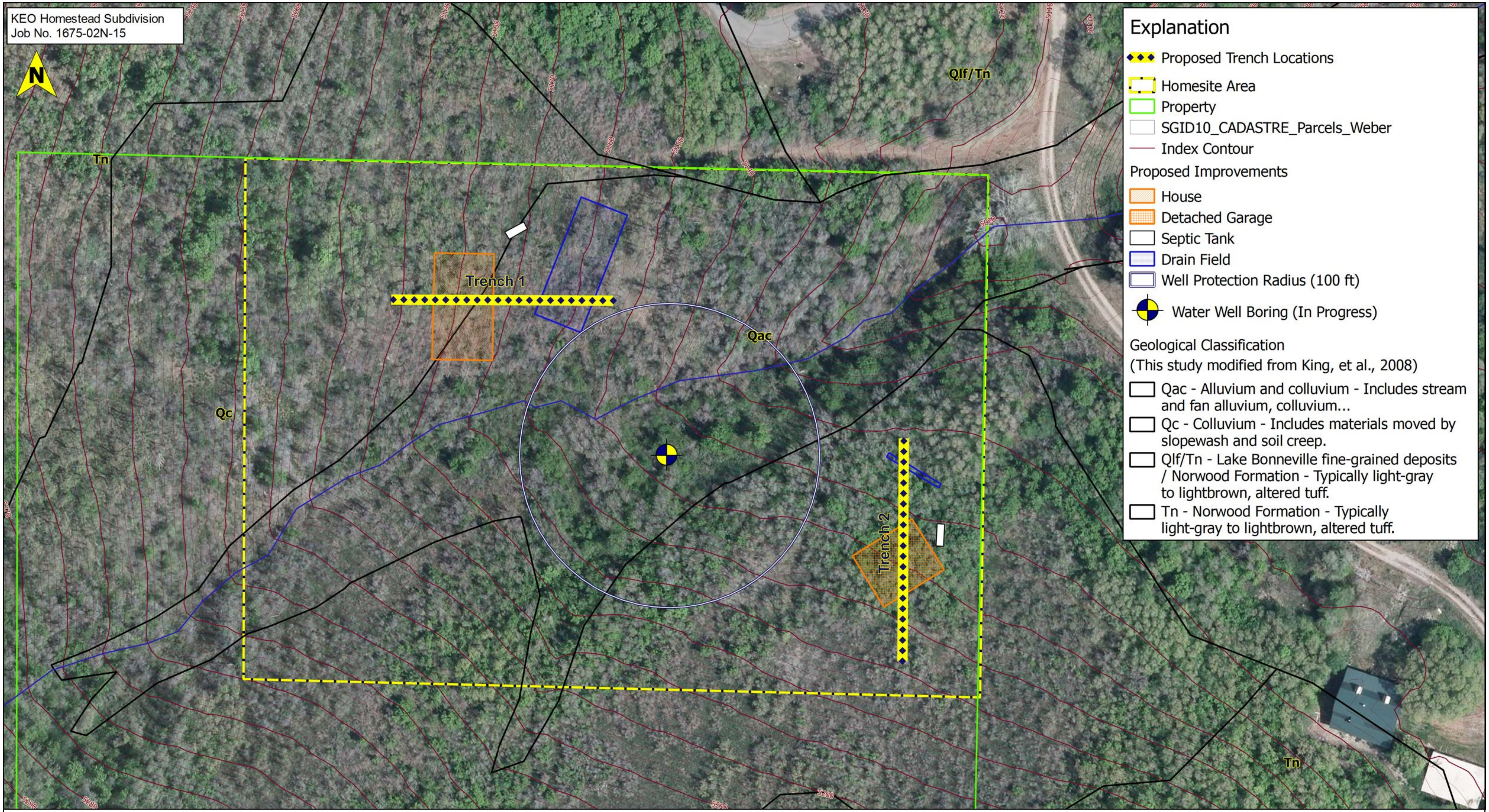
Base & Elevation: 2006 2.0m Geoprocessed LiDAR from Utah AGRC; http://gis.utah.gov/
Geology: Modified from King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000

0 60 120 180 ft

1:720

FIGURE 5
HOMESITE LiDAR GEOLOGY AND SLOPE

GSH

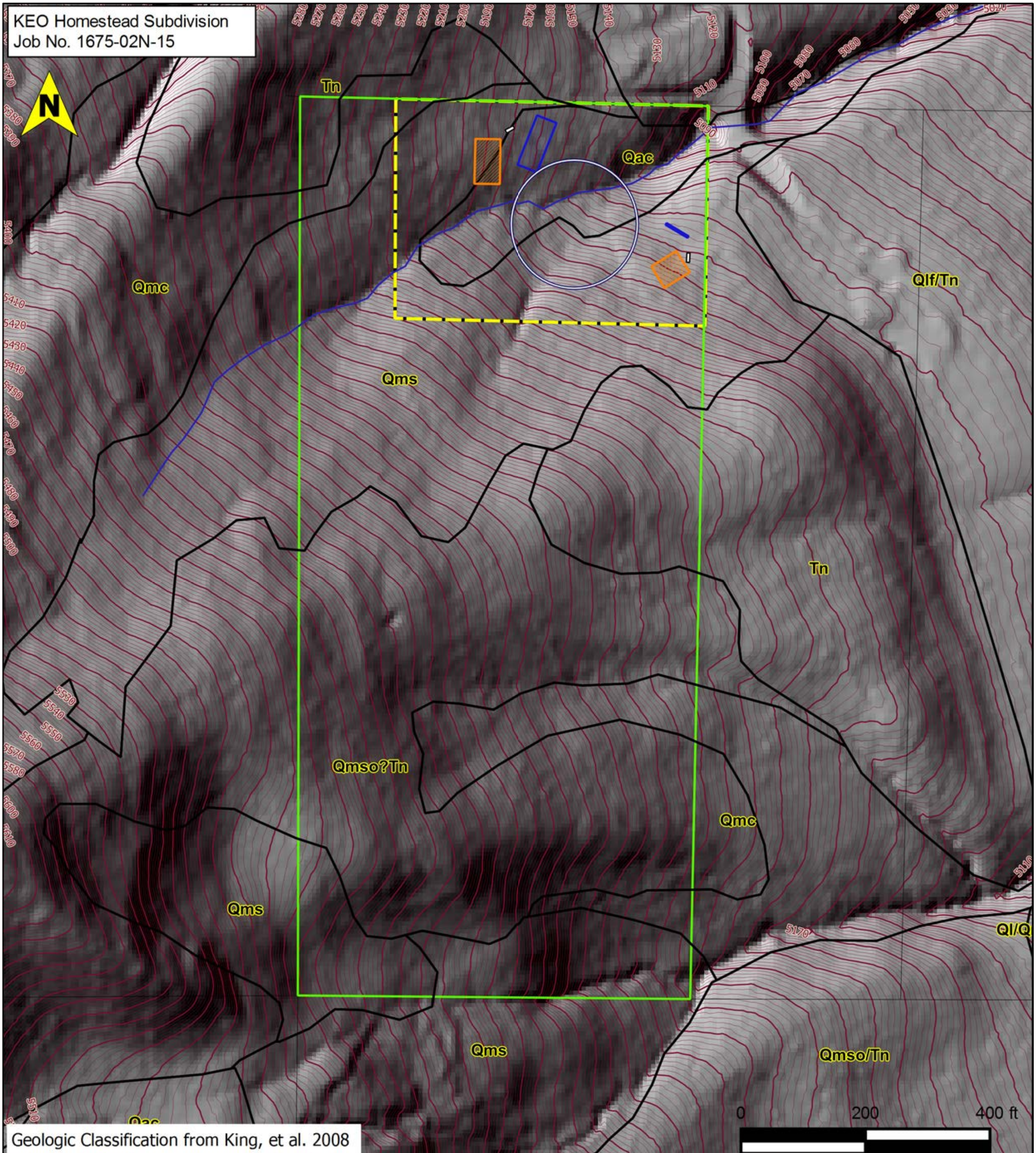


Base: 2012 5.0 inch Color HRO Orthoimagery, from Utah AGRC; http://gis.utah.gov/
Elevation: 2006 2.0m Geoprocessed LiDARfrom Utah AGRC; http://gis.utah.gov/
Geology: Modified from King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000

FIGURE 6
PROPOSED SUBSURFACE EVALUATION LOCATIONS

GSH

APPENDIX

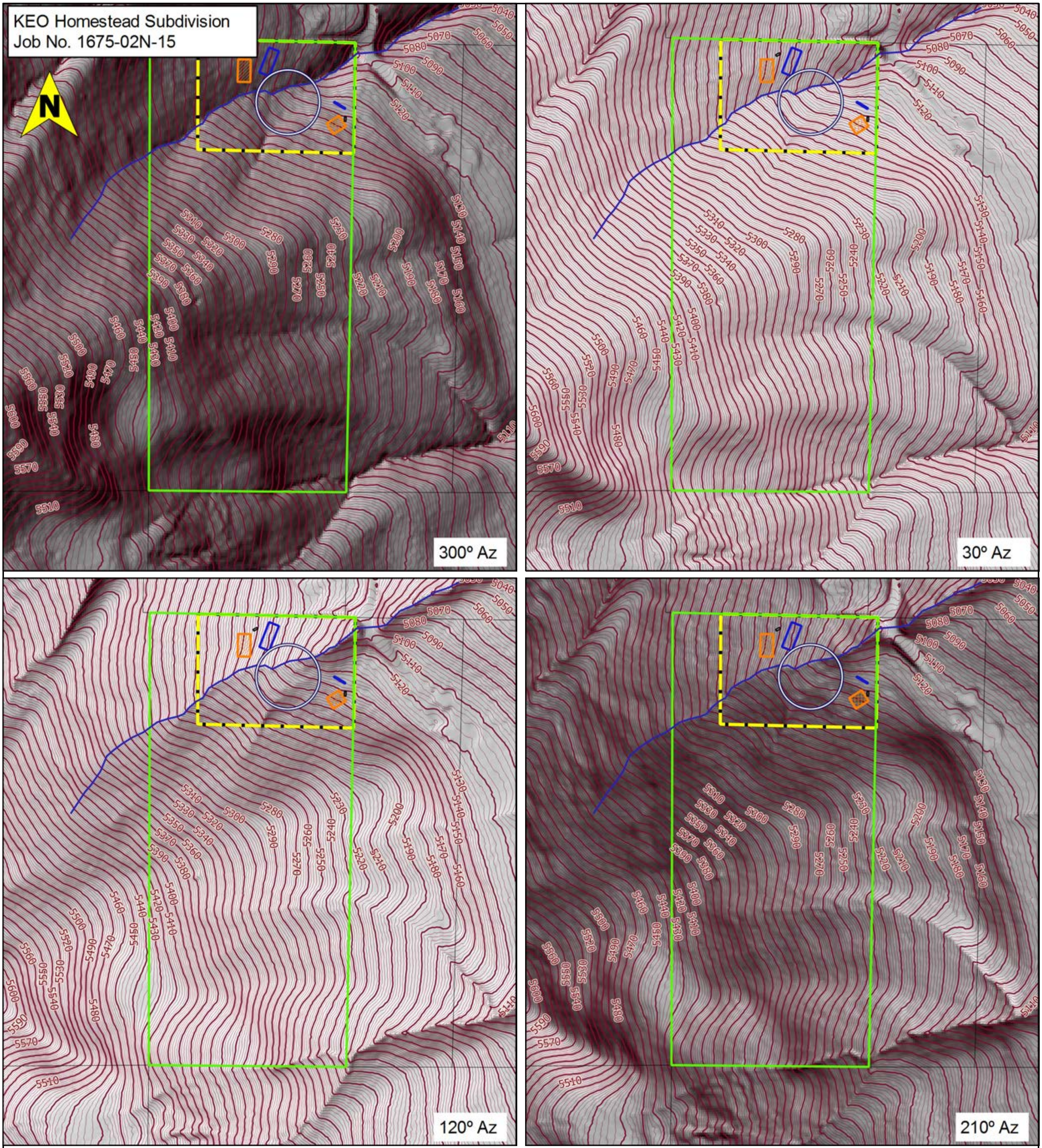


GDAL Contour Utility - Extracts contour lines from any GDAL-supported elevation raster.

GRASS r.shaded.relief Utility Creates a raster shaded relief map based on current resolution settings and on sun altitude, azimuth, and z-exaggeration values entered by the user.

APPENDIX A FIGURE 1
CONTOUR AND SHADED RELIEF ANALYSIS

GSH



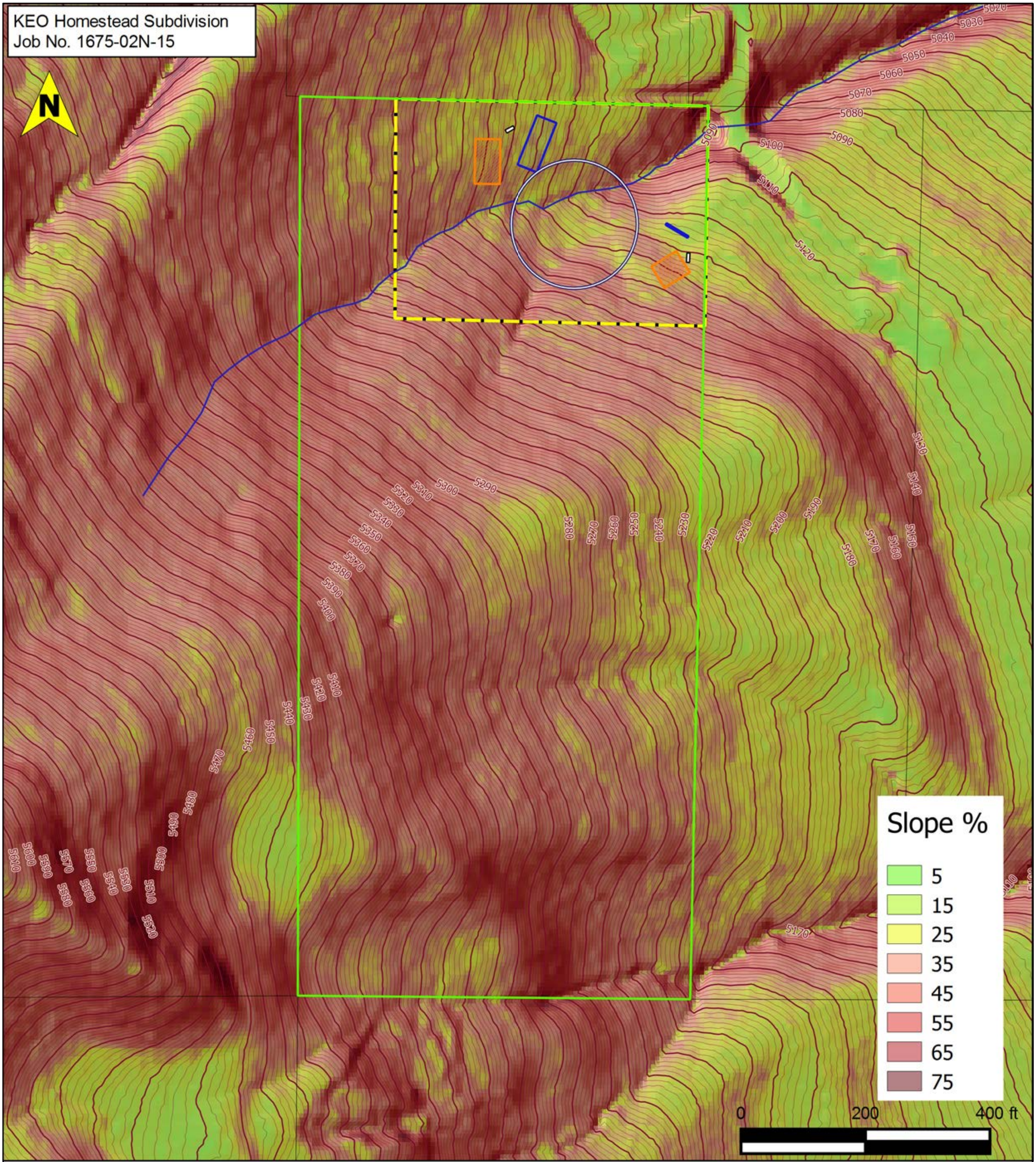
GDAL Contour Utility - Extracts contour lines from any GDAL-supported elevation raster.

GRASS r.shaded.relief Utility Creates a raster shaded relief map based on current resolution settings and on sun altitude, azimuth, and z-exaggeration values entered by the user. Top left to lower right, sun angle azimuth 300º, 30º, 120º and 210º respectively.

0 200 400 ft

APPENDIX A FIGURE 2
SHADED
RELIEF ANALYSIS

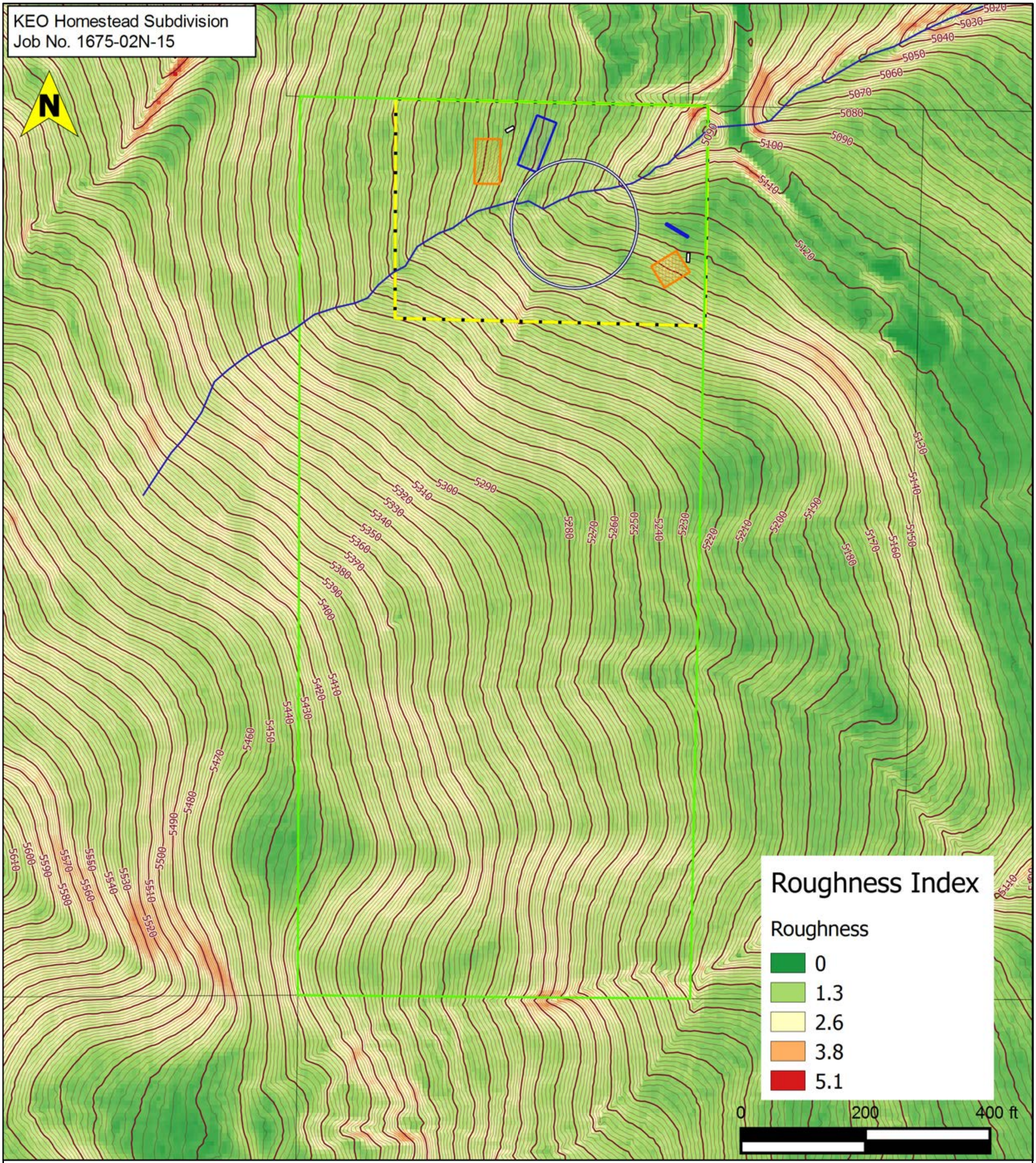
GSH



GRASS r.slope Utility - Generates raster maps of slope, slope is the angle of inclination to the horizontal. You have the option of specifying the type of slope value you want: degrees or percent slope.

APPENDIX A FIGURE 3
SLOPE PERCENT ANALYSIS

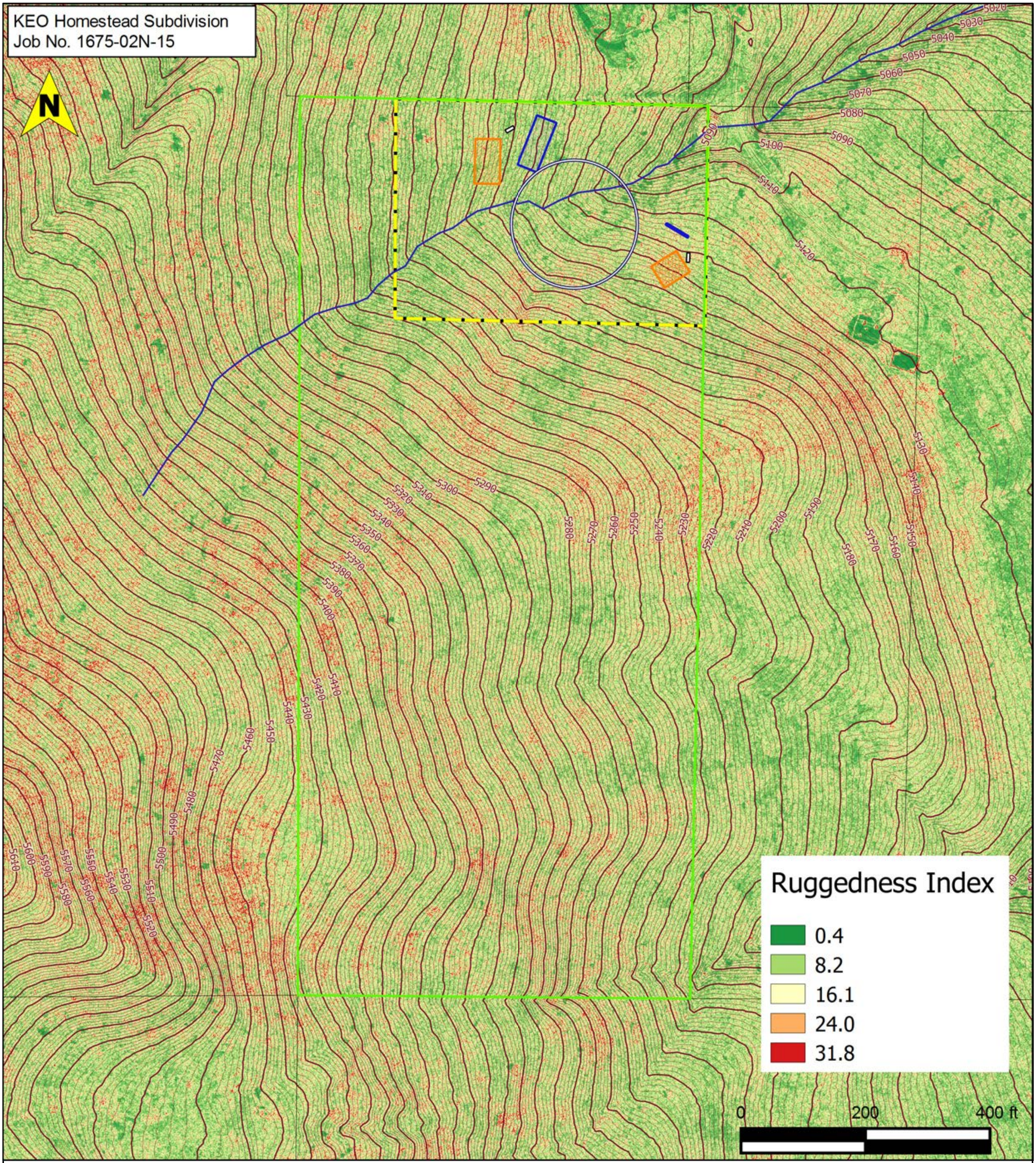
GSH



GDAL Roughness Utility - Outputs a single-band raster with values computed from the elevation. Roughness is the degree of irregularity of the surface. It's calculated by the largest inter-cell difference of a central pixel and its surrounding cell. The determination of the roughness plays a role in the analysis of terrain.

APPENDIX A FIGURE 4
ROUGHNESS INDEX

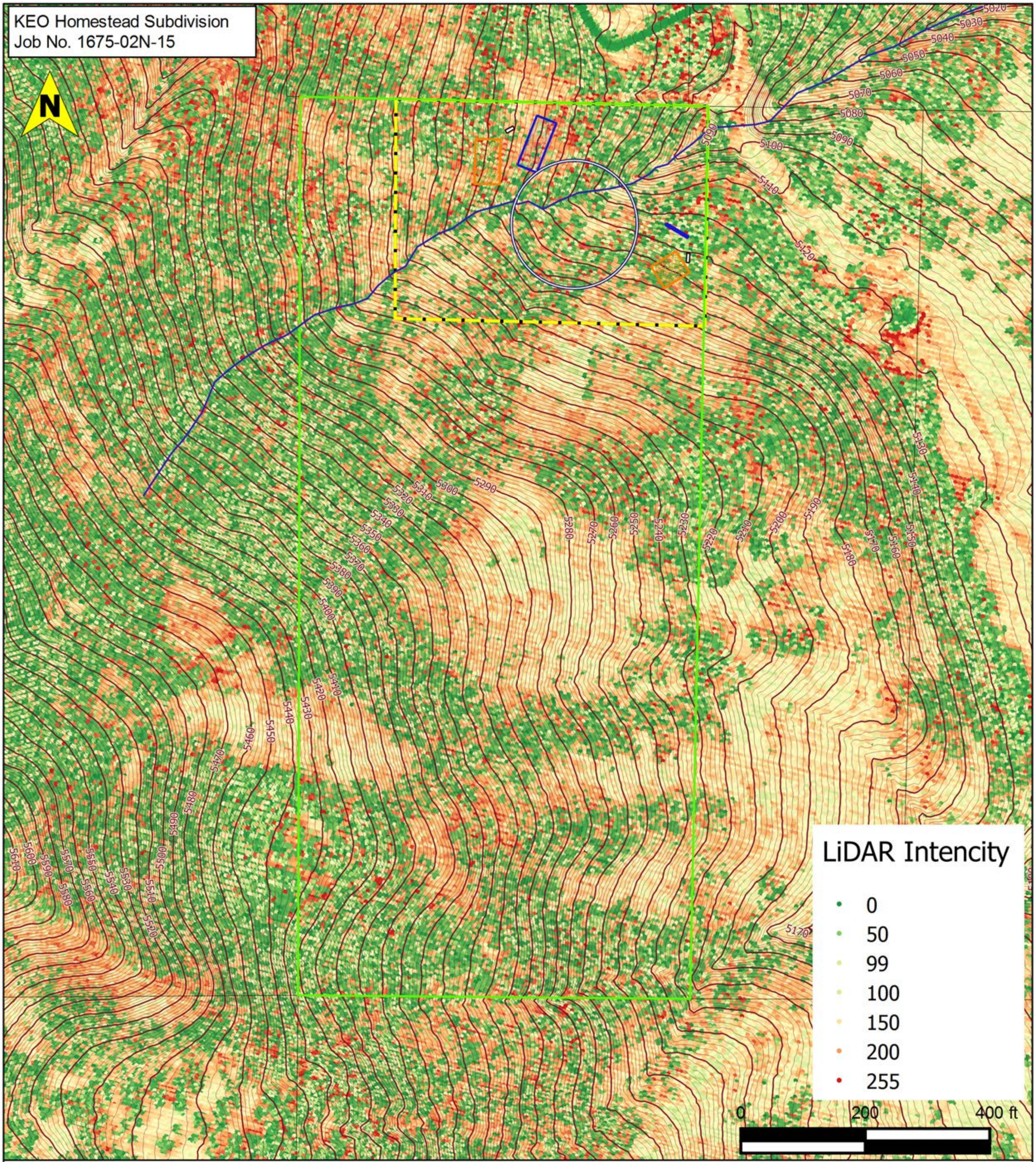
GSH



GDAL Ruggedness Index Utility - This command outputs a single-band raster with values computed from the elevation. TRI stands for Terrain Ruggedness Index, which is defined as the mean difference between a central pixel and its surrounding cells

APPENDIX A FIGURE 5
RUGGEDNESS INDEX

GSH



LiDAR First Return Intensity - Returns point-cloud intensity values of first return pulse. The intensity value is a measure of the return signal strength. Intensity values vary with altitude, atmospheric conditions, directional reflectance properties, and the reflectivity of the target. First-return values intensity values can be used to detect spectral edges on the imaged surface.

APPENDIX A FIGURE 6
LiDAR FIRST
RETURN INTENSITY

GSH