REPORT
PRELIMINARY ENGINEERING GEOLOGY STUDY
THE BRIDGES AT WOLF CREEK MASTER PLAN
EDEN AREA
OGDEN TOWNSHIP,
UNINCORPORATED WEBER COUNTY, UTAH

Submitted To:

Lewis Homes
Attention: Mr. Eric Householder
3718 North Wolf Creek Drive
Eden, Utah

Submitted By:

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

April 25, 2016

Job No. 1661-07N-16

GSH

April 25, 2016
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Mr. Eric Householder
Lewis Homes
3718 North Wolf Creek Drive
Eden, Utah 84310

Mr. Eric Householder

Re: Report
Preliminary Engineering Geology Study
The Bridges at Wolf Creek Master Plan
Parts of Sections 15, 16 and 22 Township 7 North, Range 1 East SLBM
Eden area, Ogden Valley Township, Unincorporated Weber County, Utah
(41.3389 N, 111.8323 W)

1. Introduction

The proposed Bridges at Wolf Creek project (the Project) consists of subdividing and constructing an approximately 357-lot residential subdivision on an approximately 195-acre parcel located northwest of Fairway Drive near Eden, Utah. The present Master Plan concept includes single-family residential lots with utility service and sanitary sewer connections, and associated roadways and pavements. Site development will require a moderate amount of earthwork in the form of site grading. Individual lots will be for single-family residences and will be approximately one-quarter acre in size.

A geotechnical engineering study for the Project was completed by GSH Geotechnical Inc., (GSH) on January 21, 2016. The geotechnical study was performed to evaluate the Project site conditions and soils relevant to site development engineering, earthwork and foundation requirements.

During site development review for the Project, Weber County Planning and Engineering staff identified areas of potential geological hazards on the proposed Project area. A meeting was held at the Weber County offices January 29, 2016 to discuss the proposed Project improvements and exposure to potential geological hazards identified during the site development review.

The following individuals were present at the January 29 meeting:

Ronda Kippen (Weber County Planning)
Dana Schuler, PE (Weber County Engineering)
Jim Gentry (Weber County Planning)
David Simon, PG, (Simon and Associates), Weber County Geological Consultant
Alan Taylor, PE (Taylor Geotechnical) Weber County Geotechnical Engineering Consultant.

Greg Schlenker, PG, (GSH Geotechnical Inc.,) Proponent Geological Consultant.
Andrew Harris, PE, (GSH Geotechnical Inc.,) Proponent Geotechnical Engineering Consultant.
Ryan Christenson, PE (Gardner Engineering), Proponent Engineering Consultant.
Eric Housholder, (Wolf Creek Bridges Holding Co.) Proponent Project Manager

Because potential geological hazards identified during the development review appear to impact the proposed Project improvements, and because little is known as to the real potential and severity of the recently identified potential geological hazards, Weber County Staff has determined that appropriate studies be conducted, as stipulated by the requirements of the Weber County Hillside Development Review Procedures and Standards, including Chapter 38, Natural Hazards Overlay District, of the Weber County Zoning Ordinance.

Although site layout and design for the Project is not finalized at this time, the Project proponents have asked GSH to conduct these desk top studies for the preliminary engineering geology mapping and evaluation for the Project site. The purposes of this preliminary engineering geology mapping and evaluation are to provide the Project proponents with an understanding as to the potential and severity of the geological hazards identified on the site, and to develop a workable Geologic Hazards Work Plan to suffice the Chapter 38, Natural Hazards Overlay District requirements.

1.1 Scope of Work

To carry out preliminary engineering geology mapping and evaluation (desk top studies), GSH has performed the following scope of work:

1. ***Literature Review:*** *A preliminary study and review of published and unpublished geologic and geotechnical information pertinent to the site (both regional and site specific);*
2. ***Technical Analysis****: A review and interpretation of available stereoscopic and oblique aerial photographs, DEMs, LiDAR and GIS studies;*
3. ***Geologic Mapping:*** *Preparation of site specific geologic mapping, including, but not necessarily limited to, identification and characterization of the potential geological hazards present on the site, and site GIS database;*
4. ***Work Plan:*** *Development of a Geologic Hazards Work Plan in concurrence with Weber County staff and County Geological and Geotechnical Engineering consultants;*
5. ***Summary Report:*** *A summary preliminary report to document our preliminary findings and support work plan development final report documentation.*

2. Site Engineering Geology Analysis

2.1 Literature Review

As part of these preliminary studies existing previous reports and geological literature sources were reviewed. Specific to the site and immediate surrounding area, geotechnical reporting and mapping by our staff GSH Geotechnical Inc. (2016), and an untitled and undated Site Concept Plan provided by Lewis Homes were reviewed. The 2016 geotechnical study was performed to evaluate the Project site conditions and soils relevant to site development engineering, earthwork, and foundation requirements. As part of the 2016 study 33 test pits were excavated and sampled. Geologic mapping and studies pertaining the Project and Ogden Valley area in general, included USGS geological mapping by Sorensen and Crittenden (1979), UGS geological and groundwater reporting by Avery (1994), and in-progress UGS mapping by King and McDonald (2014).

2.2 GIS Data Integration and Analysis

Our GIS data integration 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 and McDonald (2014); 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 of the site, 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; the GRASS® (Geographic Resources Analysis Support System, 2013) r.slope and r.shaded.relief modules.

The following GIS layers have been developed or processed for this analysis:

1. Engineering Geology; vector file developed and modified from geological mapping of King and McDonald, 2014, and reviewed from aerial imagery.
2. Cienega Areas; vector file of groundwater effluent zones identified from referenced aerial imagery.
3. Contour Elevations (2 foot); vector file of elevation contours processed from 2006 2.0 meter LiDAR data.
4. Shaded Relief; raster file of surface relief shading processed from 2006 2.0 meter LiDAR data.
5. Slope Gradient; raster file of surface slope gradients processed from 2006 2.0 meter LiDAR data.
6. Geological/Natural Hazards; vector file of data integrated from the above listed layers and reference data classified according the following areal categories;
    a. shallow-seasonal groundwater,
    b. alluvial fan-debris flow hazards,
    c. landslide-mass movement hazards,
    d. alluvial fan-debris flow hazards/landslide-mass movement hazards (combined area),
    e. slope stability hazards,
    f. flood hazards, and
    g. steep slopes.

3. SITE CONDITIONS

The site conditions and site engineering geology were interpreted through an integrated compilation of data including a review of literature and mapping from previous studies conducted in the area (Sorensen and Crittenden, 1979; Currey and Oviatt, 1985; Bryant, 1988; Coogan and King, 2001; and King and McDonald, 2014), photogeologic analyses of 2014 and 2012 imagery shown on Figure 2, and historical stereoscopic imagery flown in 1946. GIS analyses of elevation and geoprocessed DEM terrain data as discussed in the previous section and shown on Figure 5. Seismic hazards information was developed from United States Geologic Survey (USGS) databases (Peterson, et al., 2008).

3.1 Surface

A surface reconnaissance of the Project area was conducted on March 16 and 17 of this year, limited subsurface observations were made during the reconnaissance however the results and analysis of the subsurface observations are not yet available at the time of this reporting.

As shown on Figure 1 and Figure 2, the Project site consists of an area of 195 acres that is currently vacant and undeveloped. Surface vegetation consists of open areas of grasses, weeds and sage brush, with wooded cover of scrub oak, alder and maple trees occupying slopes on the south side of the Project, and cottonwood and willows occupying the riparian zones of the site. The topography of the site consists of a "piedmont" slope, which is an intermediate slope surface between the mountains and the valley bottom. The elevation of the Project is between 5,160 feet on the very southwest of the property and 5,700 feet on the northeast of the property. This piedmont slope is located at the base of 7,000 foot high ridgelines that buttress James Peak which rises to 9,424 feet, approximately 4 miles northeast of the Project. The floodplain of the North Fork of the Ogden River forms the lowest elevations in the site vicinity with elevations on the order of 5,060 feet to 5,100 feet along the grade of the river approximately 1/3-mile west of the site. Wolf Creek is a through-flowing perennial stream that drains from the James Peak area on the north, and passes the site near the eastern boundary. Two unnamed, apparently ephemeral, drainages cross the site from northeast to southwest. An array of cienegas occurs along the piedmont slope surface where emergent groundwater apparently intercepts the ground surface along the mountain front. A sewer line for the service of Powder Mountain Resort, located approximately 3.5 miles northeast of the site, crosses the northeast corner of the Project and terminates at a lagoon system approximately 2000 feet northwest of the site. The site, as shown on Figure 2, is bordered on the south and west by vacant property and residential land uses, and on the north and east by steeply sloped unimproved ground. State Road SR-158, locally known as Powder Mountain Road, passes the Project site on the east along Wolf Creek.

3.2 Geologic Setting

The site is located in Ogden Valley on the southwestern flank of James Peak. 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 western boundary of the Wasatch Range (Wasatch Front) is marked by the Wasatch fault, approximately 5.5 miles west of the site, and provides the basis of division between the Middle Rocky Mountain Physiographic Province 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 crests of Lewis Peak (8,031 feet) west of the valley and James Peak on the east. 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, 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, including the past one million years, permanent ice and glaciers have periodically occupied the higher elevation summits surrounding the site, and waters of Lake Bonneville have transgressed within a few feet of the Project boundary approximately 15,000 years ago (Currey and Oviatt, 1985).

The Project site location occupies a piedmont surface that is believed to be largely underlain by eroded Precambrian rocks (Sorensen and Crittenden,1979), 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).

3.5 Site Engineering Geology

The previous existing 1:24,000 scale mapping of the site was prepared by US Geological Survey geologist in 1979 (Sorensen and Crittenden,1979), wherein the 1979 mapping focused on the distribution of bedrock formation contacts and structure of the area. More recent mapping efforts by Utah Geological Survey (UGS) geologist, Coogan and King, (2001), and King and McDonald (2014) has included mapping that is more inclusive of the surficial Quaternary soils that are more indicative of engineering geology conditions and hazard processes. The King and McDonald (2014) mapping is a 1:24,000 scale U.S. Geological Survey quadrangle based effort that is currently distributed as an "In-Progress Document" subject to review and revision.

Our interpretation of the site engineering geology is presented on Figure 4 Site Engineering Geology. The engineering geologic mapping shown on Figure 4 is largely based on previous mapping prepared by King and McDonald (2014), with amendments to the mapping drawn herein on the basis of the findings of this study. A summary of the mapping units identified on/or in the vicinity of the Project are listed below in relative or inferred age sequence (youngest-top to oldest bottom):

Qal - Stream alluvium and flood-plain deposits (Holocene)
Af1 - Alluvial-fan deposits, younger-active (Holocene)
Qaf? - Alluvial-fan deposits, undivided (Holocene and Pleistocene)
Qafy - Younger alluvial-fan deposits (Holocene and uppermost Pleistocene)
Qaf2, Qafp?, Qafb?, Qafo? - Older alluvial-fan deposits (upper and middle (?) Pleistocene)
Qafou?, Qafoe? - Eroded old alluvial-fan deposits (middle and lower Pleistocene)
Qac, Qac? - Alluvium and colluvium (Holocene and Pleistocene)
Qacg, Qacg? - Gravelly alluvium and colluvium deposits (Holocene and Pleistocene)
Qac/Qafo? - Alluvium and colluvium (Holocene and Pleistocene), over older alluvial-fan deposits (upper and middle(?) Pleistocene)
Qc - Colluvium (Holocene and Pleistocene)
Qcg - Gravelly colluvial deposits (Holocene and Pleistocene)
Qms, Qmsh, Qmsy, Qmso(?) - Landslide and slump deposits (Holocene and Pleistocene)
Qmc - Landslide and slump, and colluvial deposits, undivided (Holocene and Pleistocene)
Qmdfp? - Debris- and mud-flow deposits (Holocene and Pleistocene)
Qdlb?, Qdlbs/Zarx - Lake Bonneville delta and lacustrine deposits, undivided (upper Pleistocene)
Zkc - Kelly Canyon Formation, Siltstone-quartzite
Zmcc - Maple Canyon Formation, conglomerate member
Zmcc1 - Maple Canyon Formation, lower conglomerate member
Zmcc2, Zmcc2? - Maple Canyon Formation, argillite
Zmcg, Zpg - Maple Canton Formation, green arkose member

The engineering geology mapping included the delineation of **Cienega Areas** on the Project site. The significance of the cienega areas is that these are areas of groundwater emergence, with affect of shallow groundwater limiting site development, and the affect of groundwater reducing soil strength of the site slopes.

Site slopes and terrain conditions are presented on Figure 5, Site Slope and Terrain. The elevation contours and site slope gradients on Figure 5 were developed from our LiDAR analysis. Surface gradients were found to range from near level to over 65-percent as shown on Figure 5. For the Project area, the slope gradient averaged 13.6-percent, with areas both above and below the average as shown on Figure 5. The critical slope gradient for site development considerations according to the Weber County Code is 25-percent or greater. The terrain features illustrated by the relief shading on Figure 5, assisted in the interpretation and/or confirmation of the engineering geology units presented in Figure 4.

4. DISCUSSIONS AND RECOMMENDATIONS

4.1. Site Specific Geologic/Natural Hazards

On the basis of our literature reviews, site engineering geology mapping, and slope and terrain mapping we have prepared a Geologic/Natural Hazards Exposure map for the Project site, as shown on Figure 6. This map has been classified for the delineation of potential geologic or natural hazards, including; a) shallow-seasonal groundwater, b) alluvial fan-debris flow hazards, c) landslide-mass movement hazards, d) alluvial fan-debris flow hazards/landslide-mass movement hazards (combined area), e) slope stability hazards, f) flood hazards, and g) steep slopes.

4.1.1 Shallow-Seasonal Groundwater Hazard**s** or conditions include the mapped cienega areas as shown on Figure 4, where groundwater emerges to the surface. These areas were identified through the aerial photography analysis and site reconnaissance. The affect of shallow groundwater presents limitations for site development, and will also affect the soil strength and mass of site slopes, which can negatively affect slope stability.

4.1.2 Alluvial Fan-Debris Flow Hazards Hazards or condtions include debris flows and clear-water flooding that are systemic processes that occur on active alluvial fan surfaces. Debris-flow hazards involve the rapid downslope movement of hyper-concentrated sediments in response to intense rainfall and/or snowmelt events. The debris-flow sediments typically originate in steep drainage basins, and move downslope as a concentrated and confined flow. After the flow passes through the originating canyon mouth, beyond the steep and confining limits of the drainage basin onto an open valley floor, the flow will slow and come to a rest, forming an alluvial fan deposit (Giraud, 2005). Over time successive debris-flow-alluvial fan events will construct significantly large alluvial fan systems at the mouths of the contributing canyons or drainage basins.

Clear-water flood, without debris, can also occur on alluvial fan surfaces in response to meteorological/snowmelt events.

Alluvial Fan-Debris Flow Hazard areas shown on Figure 6 include engineering geology units mapped as **Af1, Qaf?** and **Qafy** on Figure 4,.

4.1.3 Landslide-Mass Movement Hazards, Landslide-mass movement processes are the downslope movement of a mass of soil, surficial deposits or bedrock, that includes a continuum of processes between landslides, earth-flows, debris flows and debris avalanches, and rock falls. Landslide hazards are identified where terrain features such as head scarps (main scarps), minor scarps, transverse cracks and ridges, hummocky surfaces, and toe development are observed (Varnes, 1978).

The Landslide-Mass Movement Hazard areas shown on Figure 6 include engineering geology units mapped as **Qms** on Figure 4. The locations of the landslide deposits on the Project area appear to correlate to areas downslope of Maple Canyon Formation argillite beds mapped as **Zmcc2** on Figure 4.

4.1.4 Alluvial Fan-Debris Flow Hazards/Landslide-Mass Movement Hazards (Combined Area) These hazard areas as shown on Figure 6, include areas on Figure 4 where both these hazard conditions are present.

4.1.5 Slope Stability Hazards Although evidence of active landslide movement is not apparent, areas on the Project covered with soils that are inherently weak and/or expansive, or consisting of older landslide deposits, which may become unstable upon implementation of site grading improvements or structural loading. These areas are classified on Figure 6 as Slope Stability Hazards, and include areas mapped on Figure 4 as **Qmc** and **Qmso**.

4.1.6 Flood Hazards Flood hazard areas shown on Figure 6 include areas on the project that where alluvial stream deposition has occurred in response to overbank stream flows. These include areas mapped as **Qac** on Figure 4.

4.1.7 Steep Slopes Steep slope conditions present difficulty in maintaining and controlling slope stability and runoff when improvements such as grading are made in these areas. By rule Weber County limits site development improvements on slopes 25-percent grade or steeper. The areas shown on Figure 6 as Steep Slopes include slopes identified through our LiDAR analysis as shown on Figure 5.

4.1.8 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 0.17*g*, and for a two-percent probability of exceedance in 50 years is as high as 0.37*g* for the site. Ground accelerations greater than these are possible but will have a lower probability of occurrence.

4.1.9 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 5.5 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). An older Quaternary aged fault, the Ogden Valley northeastern margin fault ends approximately 0.7 miles east of the site (Black et al., 2004). This older fault is not expected to move during the design life of the Project.

4.1.10 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.

No area-wide liquefaction potential studies have been conducted for the Ogden Valley area, thus this potential hazard has not been mapped in the Project vicinity. Because liquefaction commonly occurs in saturated non-cohesive soils such as alluvium, areas of the Project vicinity mapped as **Qac** should be considered susceptible to liquefaction processes.

4.1.11 Rockfall and Avalanche Hazards: Rockfall and avalanche hazards were not identified on the Project during this desk top study. The Project boundary appears to be located an adequate distance from the steep slope areas northeast of the site where such hazards may originate, however a future on-site reconnaissance should be conducted to evaluate the presence or absence of this hazard on the site.

4.1.12 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 is mapped as "Moderate" for parts of the Project area included in studies by the UGS (Solomon, 1996).

6. CONCLUSIONS

The Project site is located on a piedmont surface that is essentially the transition zone between the mountains and the valley bottom, where exposure to potential geologic and natural hazards may exist. Based upon our reconnaissance level geological studies herein, we believe that the proposed Bridges at Wolf Creek Master Plan Project site is suitable for development. This conclusion assumes that remedial measures will made for improvements that may be exposed to the hazard areas identified on Figure 6.

Remedial hazard risk reduction measures will need to be implemented where improvements will be exposed or potentially exposed to the hazard processes. These areas are shown on Figure 6, however more detailed and specific studies may find conditions different than those presented on Figure 6. Risk reduction measures may include site engineering measures to contain, deflect, drain or stabilize these processes, and/or include site development planning to avoid exposure to the hazards. Further study of the site and geologic conditions will be required to evaluate potential geologic hazards shown on Figure 6.

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, Site Vicinity Map
Figure 2, Site Plan Aerial Imagery
Figure 3, Proposed Layout and Aerial Imagery
Figure 4, Site Engineering Geology
Figure 5 Site Slope and Terrain
Figure 6 Geologic/Natural Hazard Exposure

REFERENCES

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-weter hydrology of Ogden Valley and sudrrounding area , eastern Weber County, Utah, and simulation of ground-water flor 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 04/21/2016 12:22 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, accessed 04/21/2016 12:21 PM.

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., 2001, Geologic map of the Ogden 30’ x 60’ quadrangle: Utah Geological Survey Open-File Report 380, scale 1:100,000.

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

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

Giraud, R.E., 2005, Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah: Utah Geological Survey Miscellaneous Publication 05-6, 16 p.

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

GSH Geothchnical Inc., 2016, Report Geotechnical Study, The Bridges at Wolf Creek, Northwest of Fairway Drive, near Eden, Weber County, Utah: Unpublished consultants report, 17p.

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

Petersen, M.D., Frankel, A.D., Harmsen, S.C., Mueller, S.C., Haller, K.M., Wheeler, R.L., Wesson, R.L., Zeng, Y., Boyd, O.S., Perkins, D.M., Luco, N., Field, E.H., Wills, C.J., and Rukstales, K.S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: USGS Open-File Report 2008-1128, 128p.

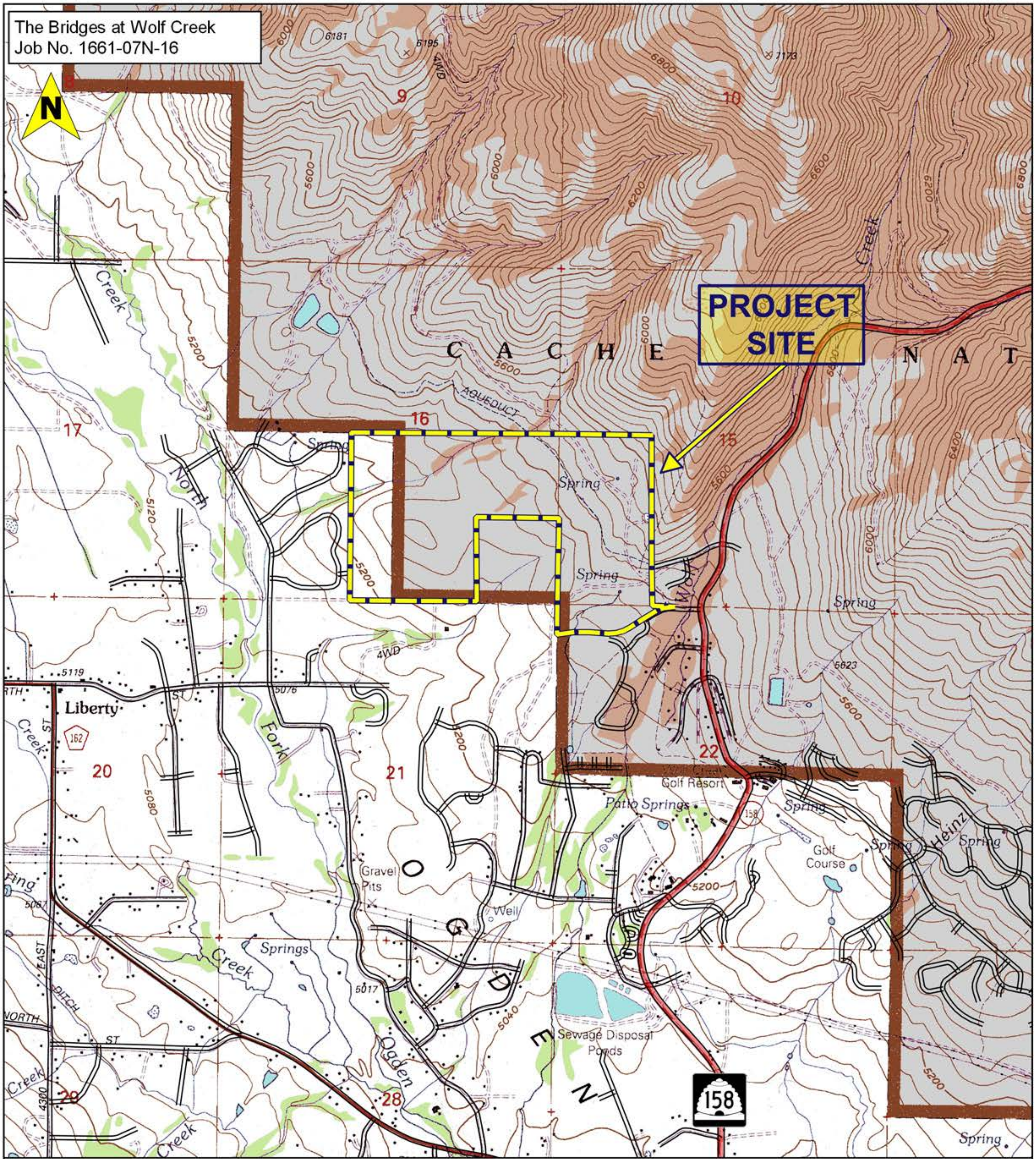
Solomon, B.J., 1996, Radon-Hazard potential in Ogden Valley, Utah, Utah Geological Survey, Public Information Series 36, 2p., scale 1:100,000.

Sorensen, M.L., and Crittenden, M.D., Jr., 1979, Geologic map of the Huntsville quadrangle, Weber and Cache Counties, Utah: U.S. Geological Survey Geologic Quadrangle Series
Map GQ-1503, scale 1:24,000.

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

Weber County Code (2015), retrieved from:
http://www.co.weber.ut.us/mediawiki/index.php/Natural_Hazards_Overlay_Districts

The Bridges at Wolf Creek
Job No. 1661-07N-16



Base: 1998 7.5 Minute USGS Topographic Map
Titled Huntsville, Utah.

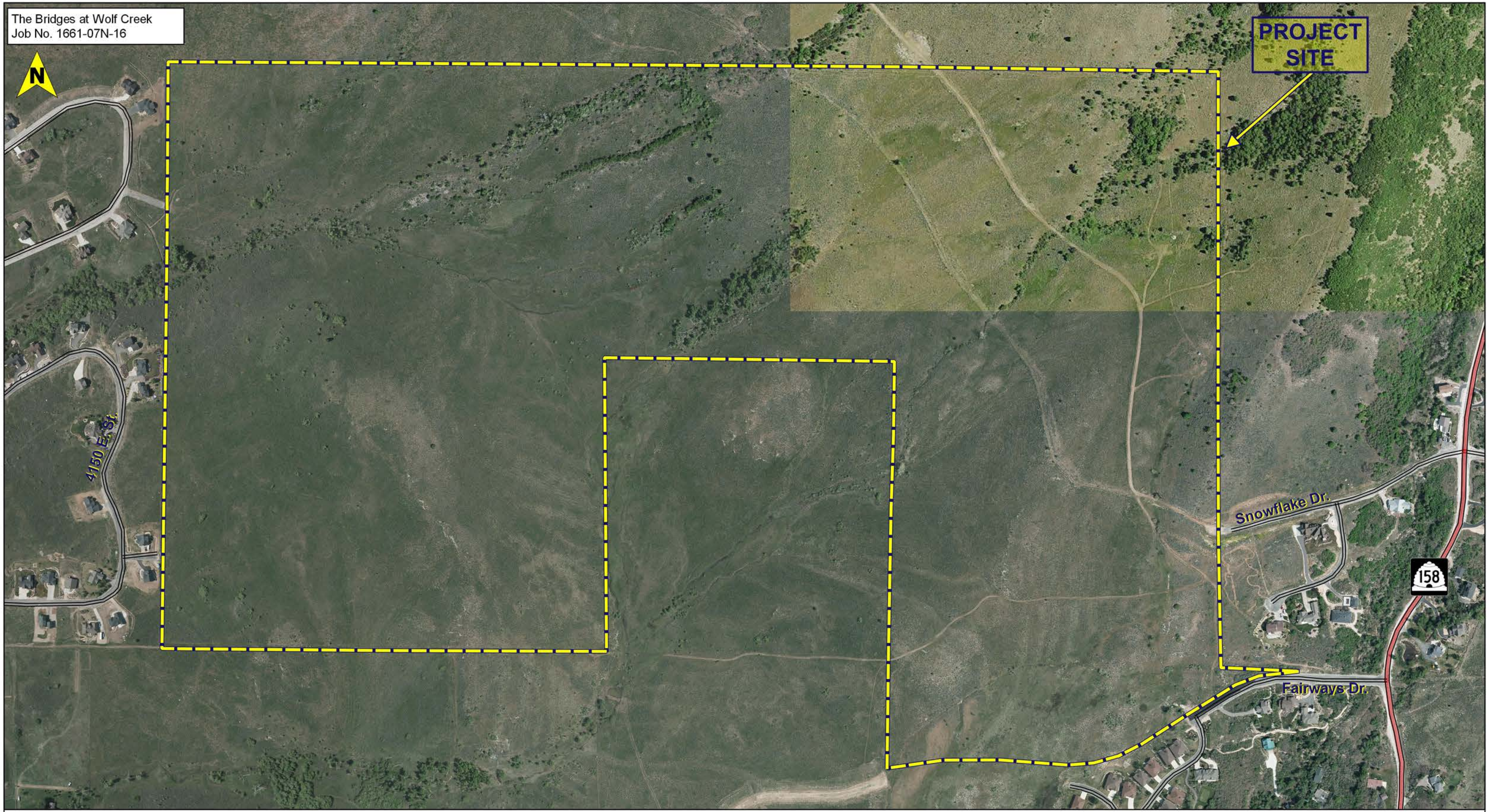
0 2000 4000 ft

1:24,000

FIGURE 1
SITE
VICINITY MAP

GSH

The Bridges at Wolf Creek
Job No. 1661-07N-16



Base: 2012 5.0 inch Color HRO Orthoimagery, and 2014 1.0m
NAIP Orthimagery (NE) from Utah AGRC; http://gis.utah.gov/

0 400 800 1200 ft

1:4,800

FIGURE 2
SITE PLAN AND AERIAL IMAGERY

GSH

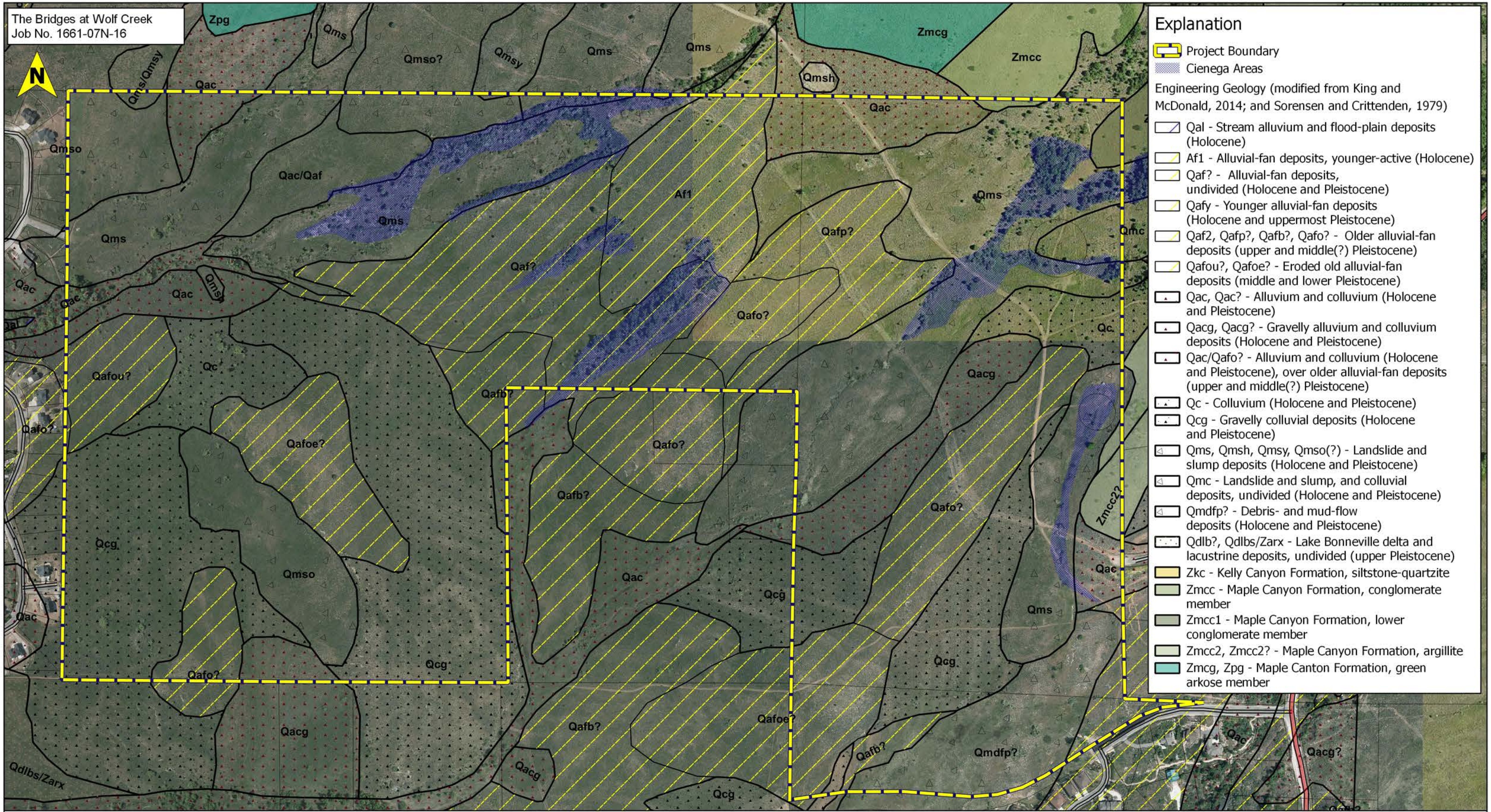
The Bridges at Wolf Creek
Job No. 1661-07N-16

Base: 2012 5.0 inch Color HRO Orthoimagery, and 2014 1.0m NAIP Orthimagery (NE) from Utah AGRC; http://gis.utah.gov/
Layout: From .pdf drawing tited "Overall Plan - new neighborhood 041816.pdf"

0 400 800 1200 ft
1:4,800

FIGURE 3
PROPOSED LAYOUT AND AERIAL IMAGERY

GSH



Base: 2012 5.0 inch Color HRO Orthoimagery, and 2014 1.0m NAIP Orthimagery (NE) from Utah AGRC; http://gis.utah.gov/
Geology: King, J.K., and McDonald, G.N., 2014, Progress report geologic map of the Huntsville quadrangle, Weber and Cache Counties, Utah: Utah Geological Survey files, scale 1:24,000.
Sorensen, M.L., and Crittenden, M.D., Jr., 1979, Geologic map of the Huntsville quadrangle, Weber and Cache Counties, Utah: U.S. Geological Survey Geologic Quadrangle Series Map GQ-1503, scale 1:24,000.

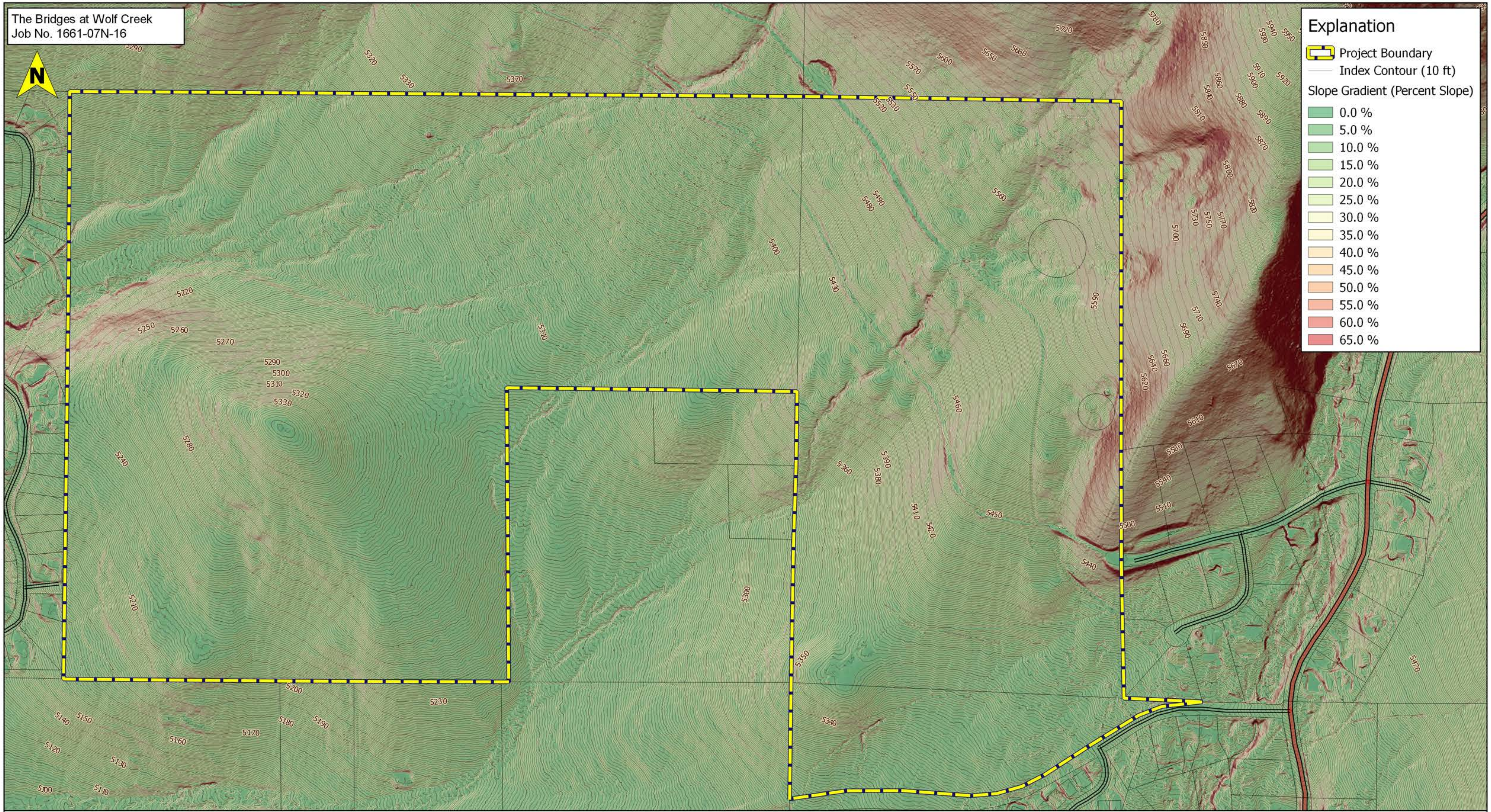
0 400 800 1200 ft

1:4,800

FIGURE 4
SITE ENGINEERING GEOLOGY

GSH

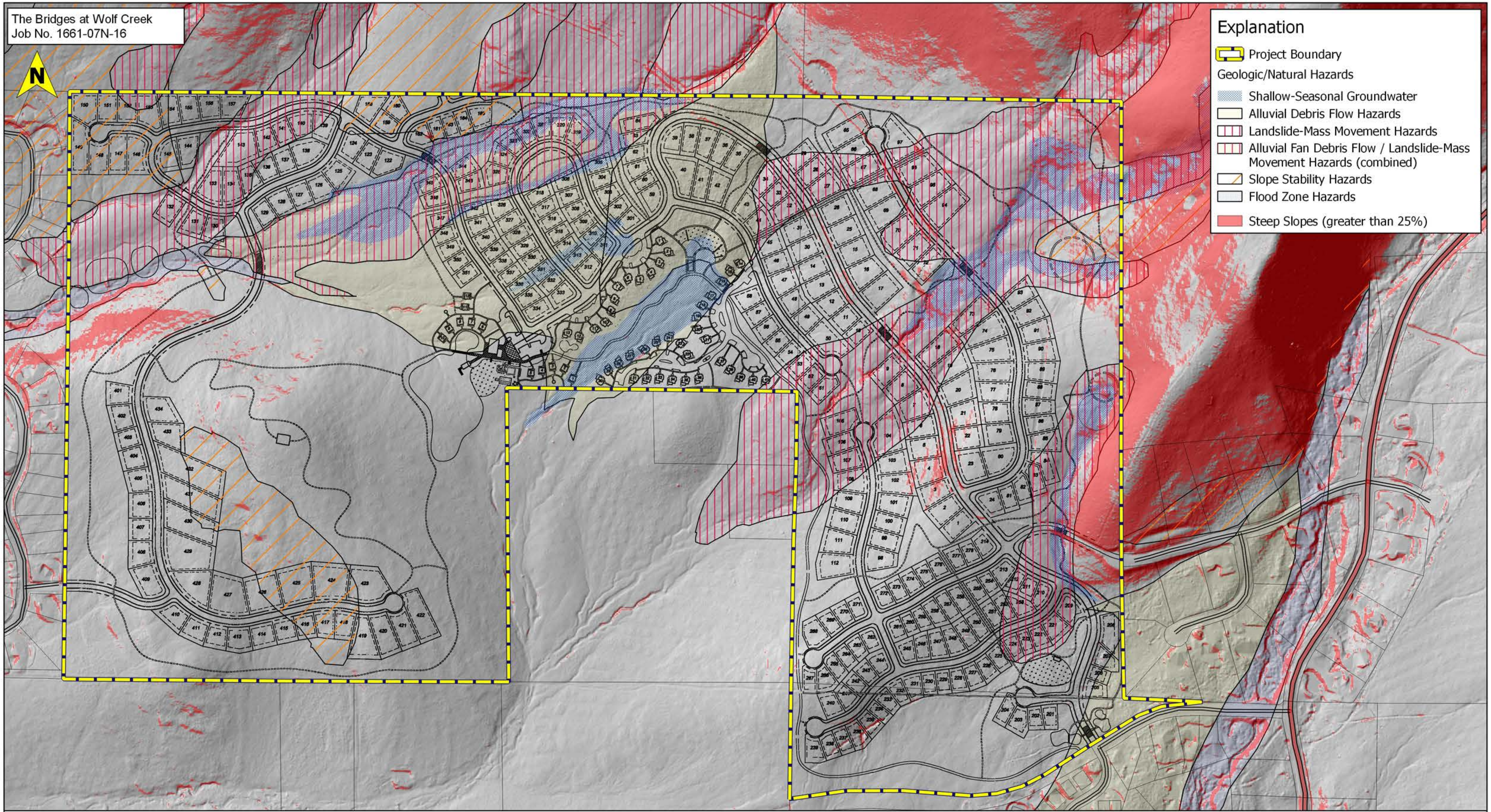
The Bridges at Wolf Creek
Job No. 1661-07N-16



Base: 2011 1.0m Geoprocessed LiDAR from Utah AGRC;
http://gis.utah.gov/

FIGURE 5
SITE SLOPE
AND TERRAIN

GSH



Base: 2011 1.0m Geoprocessed LiDAR from Utah AGRC;
http://gis.utah.gov/
Layout: From .pdf drawing tited "Overall Plan - new neighborhood

0 400 800 1200 ft

1:4,800

FIGURE 6
GEOLOGIC/NATURAL HAZARD EXPOSURE

GSH