REPORT

GEOLOGIC HAZARDS EVALUATION

LOT 44 BIG SKY ESTATES NO. 1

4075 BLUEBELL DRIVE

LIBERTY, WEBER COUNTY, UTAH

Prepared for

Carson Young
Solitude Builders
PO Box 529
Eden, Utah 84310

June 4, 2016

Prepared by

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

Voice: 801.359.7222
Fax: 801.990.4601
Web: www.westerngeologic-com

WESTERN GEOLOGIC, LLC
2150 SOUTH 1300 EAST, SUITE 500
SALT LAKE CITY, UT 84106 USA

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

June 4, 2016

Carson Young
Solitude Builders
PO Box 529
Eden, Utah 84310

SUBJECT: Geologic Hazards Evaluation
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

Dear Mr. Young:

This report presents results of an engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for Lot 44 in the Big Sky Estates No. 1 Subdivision at 4075 Bluebell Drive in Liberty, Weber County, Utah (Figure 1 – Project Location). The site is at the margin of northwestern Ogden Valley at the eastern base of the Wasatch Range in the SW1/4 Section 33, Township 7 North, Range 1 East (Salt Lake Base Line and Meridian; Figure 1). Elevation of the site ranges from about 5,545 feet to 5,610 feet above sea level. It is our understanding that the current intended site use is for development of one residential home in the central part of the site.

PURPOSE AND SCOPE

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

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

- A site reconnaissance conducted by an experienced certified engineering geologist to assess the site setting and look for adverse geologic conditions;
- Excavation and logging of three test pits on April 29, 2016 to evaluate subsurface conditions at the property;

- Review of readily-available geologic maps, reports, and air photos; and
- Evaluation of available data and preparation of this report, which presents the results of our study.

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

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows the site is at the western margin of Ogden Valley between Pole Canyon and Coal Hollow Creeks, and is on southeast- to east-facing slopes slightly below a hilltop overlooking Ogden Valley to the east and Nordic Valley to the west and northwest (Figure 1). Pole Canyon Creek flows to the north about 1,950 feet west of the property, and Coal Canyon Creek flows to the northeast about 650 feet to the southeast. Nordic Valley Ski Area is about one mile to the northwest. No active drainages are shown crossing the site on Figure 1. However, one small drainage that may be seasonally active reportedly flows to the east across the property into Coal Canyon from slightly below the cul-de-sac bordering the site on the west (AGEC, 2014). No springs or seeps were observed at the site or are shown in the site area on Figure 1.

The site is the western margin of Ogden Valley about 1.1 miles northwest of the north arm of Pineview Reservoir. The valley bottom to the east is dominated by unconsolidated lacustrine and alluvial basin-fill deposits, whereas slopes in the site area are mainly in weathered Tertiary-age tuffaceous bedrock and landslide colluvium from a complex series of overlapping failures since Late Pleistocene time. The Utah Division of Water Rights Well Driller Database shows one water well about 2,000 feet southwest of the property that has a reported depth to static groundwater of 50 feet, but no site-specific groundwater information was available and no groundwater was encountered in the boring conducted by GSH at the property to its explored depth of 46.5 feet. Given all the above, we anticipate the depth to the shallow aquifer at the Project is somewhere between 50 and 100 feet. However, groundwater depths at the site likely vary seasonally from snowmelt runoff and annually from climatic fluctuations. Such variations would be typical for an alpine environment. Perched conditions above less-permeable, clay-rich bedrock layers may also be present in the subsurface that could cause locally shallower groundwater levels.

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

GEOLOGY

Surficial Geology

The site is located on the northwestern margin of Ogden Valley, a sediment-filled intermontane valley within the Wasatch Range, a major north-south trending mountain range marking the eastern boundary of the Basin and Range physiographic province (Stokes; 1977, 1986). Surficial geology of the site is shown on unpublished, 1:24,000-scale, Utah Geological Survey (UGS) mapping from 2014 (Figure 2). The 2014 mapping is part of an ongoing surficial geologic mapping project for Ogden Valley that will be, in part, incorporated into an optimized update of Coogan and King (2001). The unpublished mapping was provided for this report since it represents the most-recent geologic information available for the area, although it will be replaced by the official optimized map.

Figure 2 shows the site in bedrock of the Norwood Formation, with possible landslide and slump deposits near the southeast site corner (units Tn and Qmc?, Figure 2). Descriptions of geologic units within 0.5 miles of the site from the adjoining Snow Basin Quadrangle (King and others, 2008) are as follows:

***Qaf* – Alluvial-fan deposits, undivided (Holocene and Pleistocene)**. *Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Mapped where fan age uncertain or for composite fans where portions of fans with different ages cannot be shown separately at map scale.*

***Qaf1, Qafy* – Younger alluvial-fan deposits (Holocene and uppermost Pleistocene) -** *Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 40 feet (12 m) thick. Near late Pleistocene Lake Bonneville, deposits with suffixes 1 and y are younger than Lake Bonneville (mostly Holocene), are active, and impinge on present-day drainages like the Weber River and Cottonwood Creek; Qafy fans may be partly older than Qaf1 fans, and may be as old as uppermost Pleistocene Provo shoreline.*

***Qmdf* – Debris- and mud-flow deposits (Holocene and uppermost Pleistocene)**. *Poorly sorted, clay- to boulder-sized material, typically with distinct natural lateral levees, channels, and lack of vegetation; older deposits can be vegetated; 0 to 40 feet (0-12 m) thick.*

Qms, Qms1, Qmsy, Qmso – Landslide and slump deposits (Holocene and Pleistocene). *Poorly sorted clay- to boulder-sized material; locally includes flow deposits; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in deposits; Qms may be in contact with Qms when two different slide/slumps abut; locally, unit involved in slide/slump is shown in parentheses where a nearly intact block is visible; Qms and Qmso queried (?) where bedrock block may be in place; thickness highly variable, boreholes in Rogers (1986) show thicknesses of about 20 to 30 feet (6-9 m) on small slides/flows. Qms without suffix is mapped where age uncertain (though likely Holocene and/or upper Pleistocene), where portions of slide/slump complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides/slumps of different ages are not distinct. Estimated time of emplacement indicated by relative age number and letter suffixes with: 1 - likely emplaced in the last 80 to 150 years, mostly historical; y - post- Lake Bonneville in age and mostly pre-historic; and o – likely emplaced before Lake Bonneville transgression. Suffixes y (as well as 1) and o indicate probable Holocene and Pleistocene ages, respectively. Qmso typically mapped where rumpled morphology typical of mass movements has been diminished and/or younger surficial deposits cover or cut Qmso. These older deposits are as unstable as other landslides and slumps, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.*

Qmc – Landslide and slump, and colluvial deposits, undivided (Holocene and Pleistocene). *Mapped where landslides and slumps are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of slides and slumps, and colluvial deposits is not possible at map scale; locally includes talus and debris flows; typically mapped where landslides and slumps are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides and slumps has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 0 to 40 feet (0-12 m) thick. These deposits are as unstable as other landslides and slumps units (Qms).*

Qac – Alluvium and colluvium (Holocene and Pleistocene). *Includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits; 0 to 20 feet (0-6 m) thick.*

Qls – Lake Bonneville sand (upper Pleistocene). *Mostly sand with some silt and gravel deposited nearshore in Morgan Valley; typically less than 20 feet (6 m) thick, but thicker in "bench" east of Cottonwood Creek in southeast corner of Snow Basin quadrangle.*

Qafp, Qafb, Qafo – Older alluvial-fan deposits (upper and middle(?) Pleistocene). *Incised fans of mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Fans labeled Qafp and Qafb are graded to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively. Near Lake Bonneville, unit Qafo is older than (above and* *typically incised/eroded at) the Bonneville shoreline; upstream unit Qafo is topographically higher than fans graded to the Bonneville shoreline (Qafb). Elsewhere relative-age letters only apply to local drainages. Like Qa and Qat suffixes, ages are partly based on heights above present drainages (table 1), in this case heights at drainage-eroded edge of fan, with Qafp about 35 to 45 feet (10 to 12 m) above, Qafb 50 to 75 feet (15-23 m) above, and Qafo about 70 to 110 feet (20-35 m) above present drainages. Dates presented in Sullivan and Nelson (1992) imply Qafo to southeast in Morgan quadrangle considerably predates Lake Bonneville and is middle Pleistocene in age (300-600 ka). This means these older fans could be related to Pokes Point lake cycle (at about 200 ka, after McCoy, 1987) (Kansan continental glaciation?, 300-400 ka) and/or pre Pokes Point (Nebraskan continental glaciation?, >500 ka); however, the Bonneville shoreline is obscure on this fan.*

***Tn – Norwood Formation (lower Oligocene and upper Eocene)** - Typically light-gray to light brown, altered tuff (claystone), tuffaceous siltstone, sandstone, and conglomerate; locally colored light shades of red and green; variable calcareous cement and zeolitization, that is less common to south of Snow Basin quadrangle; zeolite marker beds mapped as an aid to recognizing geologic structure; locally includes landslides and slumps that are too small to show at map scale.*

Upper Norwood Formation, as exposed on east margin of Snow Basin quadrangle and to east in Durst Mountain quadrangle, contains interbedded claystone (tuffaceous beds), fine- to coarse-grained sandstone, gray granule to small pebble conglomerate, with chert and carbonate clasts, as well as conglomerate interbeds with quartzite pebble clasts like those in unit Tcg; interbedded with more extensive quartzite-clast conglomerate, some mapped as Tcg, to east in Durst Mountain quadrangle (see Coogan and King, 2006); north of Wasatch Formation (Tw) knob on Snow Basin-Durst Mountain quadrangle boundary, the Norwood contains intermittent quartzite gravel (quartzite-richest exposures mapped as Tcg?); also, gravel-rich beds containing mostly chert and carbonate clasts are common north of the knob, and with quartzite-bearing beds, are involved in multiple landslides that obscure bedding and structure; these variations and disruptions make it difficult to map a consistent Tcg-Tn contact (see also unit Tcg description above and in Coogan and King, 2006); based on outcrop pattern, dip, and topography, Norwood is at least 7000 feet (2135 m) thick in Snow Basin quadrangle; it thins to the south, so is about 5000 feet (1525 m) thick north of Morgan, and only about 1500 feet (460 m) thick east of East Canyon Creek in the type area in Porterville quadrangle (Eardley, 1944) (not 2500+ feet [800+ m] inferred by Bryant and others, 1989, p. K6).

Zeolite beds mapped in the Norwood indicate a generally east-dipping homocline with minor faulting. A broad, north-south-oriented, doubly plunging syncline is superimposed on the homocline but the east limb of the syncline and companion anticline are obscured by landslide complexes. The common fold limb may dip steeply to the west. Also the zeolite beds become obscure to the east, due to the increased abundance of clastic sediment, making the zeolite beds thinner and less pure, and therefore less distinct. Norwood generally considered younger than the Fowkes Formation, but not well dated due to alteration. Corrected Norwood K-Ar ages are

38.4 Ma (sanidine) from Norwood type area (Evernden and others, 1964) and 39.3 Ma (biotite) from farther south in East Canyon (Mann, 1974), while Fowkes $^{40}Ar/^{39}Ar$ ages are 40.41 Ma and 38.78 Ma on biotite and hornblende, respectively, from Utah to east near Wyoming (Coogan and King, unpublished). To north in southern Cache Valley, basal part of unit similar to Fowkes and Norwood ("resting" on Wasatch and less than 600 feet [180 m] or about 1200 feet [260 m] thick) dated at 44.2 + 1.7 Ma and 48.6 + 1.3 Ma K-Ar on hornblende and biotite, respectively (Smith, 1997; King and Solomon, 2008); though the biotite date is suspect, its age is similar to older dates on the Fowkes Formation in Wyoming, which are: 47.94 + 0.17 Ma ($^{40}Ar/^{39}Ar$, sanidine) at the northeast end of the Crawford Mountains (Smith and others, 2008, p. 67), south of the Fowkes type area (see Oriel and Tracey, 1970); 49.1 Ma (biotite; recalculated; dated in 1977, but decay constant not reported, so may not need to be recalculated), reported as 47.9 + 1.9 Ma by Nelson (1979) and likely from near the base of the Fowkes near Evanston, Wyoming (Nelson, 1973); and 48.9 Ma K-Ar (hornblende; recalculated) from the Fowkes type area near Leefe, Wyoming (47.7 + 1.5 Ma, Oriel and Tracey, 1970). The Norwood is different in the southern Peterson and Morgan quadrangles, near the type area (see Eardley, 1944), where it contains extensive unaltered tuff (hence the name Norwood Tuff), has cut-and-fill structures (fluvial), and includes volcanic-clast conglomerate; in the Morgan quadrangle, it also contains local limestone and silica-cemented rocks. Unit referred to here as Norwood Formation, rather than Norwood Tuff, because the type area includes only part of the formation (see thickness in following paragraph), the Norwood contains many lithologies, and this emphasizes that it is not tuffaceous away from the type area.

Citations in the above unit descriptions are provided in King and others (2008).

Figure 2 shows several strike and dip measurements in Norwood Formation in the site area. Those shown in black where measured by the UGS, whereas those in purple are from U.S. Geological Survey (USGS) data (Jon King, verbal communication, February 29, 2016). The nearest measurement is about 700 feet northwest of the property and shows a strike/dip of N46°W 40° NE. Several additional measurements are to the east and southeast that show generally northwest-trending strikes and dips generally between about 27 to 46 degrees to the northeast. Norwood Formation bedrock in the area has average dips of about 30 to 45 degrees, although this unit has local depositional variations that may produce lower and higher dips within a relatively short distance (Jon King, verbal communication, February 29, 2016).

Seismotectonic Setting

The property is located at the western margin of Ogden Valley, a roughly 40-square mile back valley described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys of the northern Wasatch Range are in a transition zone between the Basin and Range and Middle Rocky Mountains provinces (Stokes, 1977, 1986). The Basin and Range is characterized by a series of generally north-trending elongate mountain ranges, separated by predominately alluvial and lacustrine sediment-filled valleys and typically bounded on one or both sides by major normal faults (Stewart, 1978). The boundary between the Basin and Range and Middle

Rocky Mountains provinces is the prominent, west-facing escarpment along the Wasatch fault zone at the base of the Wasatch Range. Late Cenozoic normal faulting, a characteristic of the Basin and Range, began between about 17 and 10 million years ago in the Nevada (Stewart, 1980) and Utah (Anderson, 1989) portions of the province. The faulting is a result of a roughly east-west directed, regional extensional stress regime that has continued to the present (Zoback and Zoback, 1989; Zoback, 1989). The back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the east and west sides of the valley. The Ogden Valley southwestern margin fault and North Fork fault (Black and others, 2003) are shown on Figure 2 trending northwestward about 900 feet to the southwest and 3,750 feet to the northeast, respectively. The most recent movement on these faults is pre-Holocene (Sullivan and others, 1986). The faults are concealed where mantled by Late Pleistocene and Holocene surficial deposits (Figure 2, dashed and dotted bold lines). Norwood Formation mapped in the site area (Figure 2, unit Tn) likely represents an in-place faulted block preserved between the faults (Jon King, verbal communication, February 29, 2016).

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

Lake Bonneville History

Lakes occupied nearly 100 basins in the western United States during late-Quaternary time, the largest of which was Lake Bonneville in northwestern Utah. The Bonneville basin consists of several topographically closed basins created by regional extension in the Basin and Range (Gwynn, 1980; Miller, 1990), and has been an area of internal drainage for much of the past 15 million years. Lake Bonneville consisted of numerous topographically closed basins, including the Salt Lake and Cache Valleys (Oviatt and others, 1992). Portions of Ogden Valley were inundated by Lake Bonneville at its highstand. Sediments from Lake Bonneville are not mapped at the site, but are shown at lower elevations to the east and northeast on Figure 2.

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

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

SITE CHARACTERIZATION

Empirical Observations

On April 29, 2016, Mr. Bill D. Black of Western GeoLogic conducted a reconnaissance of the property. Weather at the time of the site reconnaissance was partly cloudy with temperatures in the 50's (°F). The site is at the western margin of Ogden Valley on heavily vegetated east- to southeast-facing slopes slightly overlooking Ogden Valley to the east. Coal Canyon Creek is to the southeast of the site. Native vegetation appeared to consist of oak brush and mature trees. No active streams are mapped crossing the site or were observed, and no bedrock outcrops were evident at the site or in adjacent slopes. However, a small seasonal drainage reportedly once flowed to the east in a drainage easement crossing the lot from slightly below Bluebell Drive. The drainage channel was reportedly about 1.5 feet deep and 6 feet wide below the cul-de-sac in 2014 (AGEC, 2014).

Air Photo Observations

High-resolution orthophotography from 2012 and 1-meter bare earth DEM LIDAR from 2011 available from the Utah AGRC (Figures 3A and 3B) were reviewed to obtain information about the geomorphology of the site area. Only the westernmost (upper) part of the small seasonal drainage reported by AGEC (2014) is evident on the 2012 photo (Figure 3A). Figures 3A and 3B also show the southeast part of the site straddles a landslide that appears to have originated to the southwest. Morphology of the landslide appears subdued or obscured, suggesting it may be an older feature (possibly latest Pleistocene to early Holocene in age). The landslide trends northeastward across the southeast corner of the lot and then turns downslope toward the east (Figures 3A and 3B).

Figure 3B shows a lineament that begins near the head of the landslide and trends into the property. We infer this lineament is a tension crack from a younger failure that is occurring on the margin of the older landslide (Figure 3B, Tension Crack). Below Bluebell Drive, the LIDAR imagery suggest that the crack may be widening as the younger landslide creeps downslope (Figure 3B, Pull-Apart Zone). The tension crack then makes an abrupt 90-degree turn to the southeast slightly southwest of the small seasonal drainage, travels downslope for a short distance, and then dies out. We infer this latter feature is a lateral shear on the northeastern margin of the younger failure (Figure 3B, Lateral Shear). The boring conducted by GSH at the site is about 24 feet to the southeast and topographically below the tension crack (Figure 3B), and reportedly encountered a disturbed/weak zone containing roots between 25 and 40 feet in depth. This confirms that the tension crack is not just a surficial feature and continues at depth. The roots are likely from large trees that have preferentially followed the tension crack because it is a zone of weakness and groundwater percolation. No evidence of other geologic hazards were observed on the air photos in the site area.

Subsurface Investigation

Three test pits were excavated at the property in April 2016 to evaluate subsurface conditions. Test pit locations are shown on Figures 3A-3C, and were measured using a hand-held GPS unit and trend and distance methods from known points. The test pits were logged at a scale of 1 inch equals 5 feet (1:60). No complications were encountered that substantially impacted the subsurface investigation. The test pit exposures were digitally photographed at five-foot intervals to document subsurface conditions. The photos are not provided herein, but are available on request.

Test pits 1 and 2 (Figures 4A and 4B) both exposed a similar sequence of weathered Norwood Formation consisting of an upper clay-rich conglomerate overlying interbedded claystone and siltstone. Bedding in test pit 1 showed a strike/dip of N30°W 22° NE, whereas test pit 2 bedding showed a strike/dip of N36°W 20°NE. Both of these bedding strikes and dips appear similar to reported regional measurements, suggesting the sequence is intact bedrock. However, test pit 3 (Figure 4C) exposed a backtilted sequence of Norwood Formation that we infer is a rafted landslide block. Bedding in this test pit showed a strike/dip of N85°E 35°NW. East-west strikes are typical for deformed landslide blocks in the area on Figure 2. No other evidence of geologic hazards was exposed in the test pits, except for water seepage along the contact between the conglomerate and underlying claystone (units 1 and 2, Figure 4A) in test pit 1 that appeared to be from recent rainfall. This suggests that surface water percolating through the subsurface is perching on the less-permeable clay layers.

Cross Section

Figure 5 shows a cross section across the slope south of the proposed home location at a scale of 1 inch equals 25 feet with no vertical exaggeration. The profile location is shown on Figure 3C (A-A’, in blue). Units and contacts are inferred based on the subsurface data discussed above and our review of the log for the GSH boring in the western part of the site (which is not reproduced herein). We use an overall dip of 15 degrees for contacts within the Norwood Formation, which is corrected from an average of 21 degrees to account for the difference between the profile trend and dip direction. As discussed above, the boring conducted by GSH at the site exposed a deformed zone containing roots at a depth of 25 to 40 feet below the ground surface that likely corresponds to the tension crack and pull-apart zone upslope from the boring. Given the above depths and distance between the boring and tension crack (24 feet), dip of the shear would be about 45 to 60 degrees. The area between the tension crack and existing landslide on the cross section appears to represent a smaller failure working its way downslope. The lateral shear along the margin of this failure (Figures 3B and 3C) is not displayed on the cross section because of difficulty representing it in two dimensions, although it would likely be subvertical and near where the pull-apart zone coalesces (85-90 feet on Figure 5).

GEOLOGIC HAZARDS

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

Table 1. *Geologic hazards summary for Lot 44 Big Sky Estates No. 1.*

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

Earthquake Ground Shaking

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

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

Table 2. *Seismic hazards summary for Lot 44 Big Sky Estates No. 1. (Site Location: 41.298053º N, -111.849567º W)*

S_S	*0.978 g*
S_1	*0.336 g*
S_{MS} (F_a x S_S)	*1.084 g*
S_{M1} (F_v x S_1)	*0.581 g*
S_{DS} (2/3 x S_{MS})	*0.723 g*
S_{D1} (2/3 x S_{M1})	*0.387 g*
Site Coefficient, F_a	*= 1.109*
Site Coefficient, F_v	*= 1.727*

Given the above information, earthquake ground shaking poses a high risk to the site. The hazard from earthquake ground shaking can be adequately mitigated by design and construction of homes in accordance with appropriate building codes. The Project structural and/or geotechnical engineer, in conjunction with the developer, should confirm and evaluate the seismic ground-shaking hazard and provide appropriate seismic design parameters as needed.

Surface Fault Rupture

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

The nearest active fault to the site is the Weber segment of the WFZ about 4.2 miles to the west, and no evidence of active surface faulting is mapped or was evident at the site. Based on this, the hazard from surface faulting is rated as low.

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

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

Tectonic Deformation
Tectonic deformation refers to subsidence from warping, lowering, and tilting of a valley floor that accompanies surface-faulting earthquakes on normal faults. Large-scale tectonic subsidence may accompany earthquakes along large normal faults (Lund, 1990). Tectonic subsidence is believed to mainly impact those areas immediately adjacent to the downthrown side of a normal fault. No active faults are mapped in the site area. Based on this, the risk from tectonic subsidence is rated as low.

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

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

No active drainages cross the site or were evident, and based on this the hazard from stream flooding should be low. However, there was a small seasonal drainage that reportedly had an easement crossing the site (AGEC, 2014). Site hydrology and runoff should therefore be addressed in the civil engineering design and grading plan for the Project.

Shallow Groundwater
No springs or seeps are shown on the topographic map for the site or were reported or observed, and no groundwater was encountered in the boring conducted by GSH. Given this, the depth to static groundwater is at least more than 46.5 feet. Based on the above, we rate the risk from shallow groundwater as low. However, proper site drainage should maintained so that groundwater does not pose a future risk of slope instability. It is also possible that groundwater levels may fluctuate seasonally and following snowmelt or rainstorms, and may be perched locally over less permeable bedrock layers.

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

The southeast part of the site is on what appears to be an older (latest Pleistocene to early Holocene) landslide that originated to the southwest of the property. A rafted block in this landslide was observed in test pit 3, but test pits 1 and 2 both exposed undeformed bedrock layers. A younger failure marked by a tension crack, pull-apart zone, and lateral shear appears to be forming on the north margin of the old landslide in the western part of the property (Figures 3B and 3C). The boring conducted by GSH downslope of the tension crack exposed a disturbed/weak zone between 25 and 40 feet in depth that likely corresponds to the basal shear of this younger landslide in the subsurface. The lateral shear for this failure appears to trend to near the southwest corner of the proposed home (Figure 3C).

Given all the above, we rate the hazard from landsliding as high. We recommend stability of the slopes be evaluated in a geotechnical engineering evaluation prior to building based on site specific data and subsurface information included in this report. Recommendations for reducing the risk from landsliding should be provided if factors of safety are determined to be unsuitable. The stability evaluation should take into account possible perched groundwater and fluctuating seasonal levels.

Additional exploration to determine if shearing may be present beneath the home footprint was considered outside the scope of our evaluation. Reducing risk to the structure and occupants is a significant concern given the site conditions described above. We therefore recommend that the proposed home location be moved at least 30 feet away from the presumed lateral shear location and that the excavation for the home be inspected by a licensed engineering geologist to confirm that no deformation is present. Relocating the home northward, as indicated on Figure 3C (and recommended above), would reduce the risk from landsliding and does not appear to pose a significant development constraint, although the proposed location for the septic system may also need to be moved to the northeast. Care should also be taken that site grading does not destabilize slopes in this area without prior geotechnical analysis and grading plans, and that proper drainage is maintained.

Debris Flows

Debris flow hazards are typically associated with unconsolidated alluvial fan deposits at the mouths of large range-front drainages, such as those along the Wasatch Front. Debris flows have historically significant damage in the Wasatch Front area. The site is not in any mapped alluvial-fan deposits, and no evidence of debris-flow channels, levees, or other debris-flow features was observed. Based on the above, we rate the hazard from debris flows at the site as low.

Rock Fall

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

Swelling and Collapsible Soils

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

CONCLUSIONS AND RECOMMENDATIONS

Geologic hazards posing a high relative risk to the site are earthquake ground shaking and landslides. Problem soils also pose a moderate-risk hazard. The following recommendations are provided with regard to the geologic characterizations in this report:

- ***Home Location and Excavation Inspection*** – To reduce the risk from landsliding, we recommend that the proposed home location be moved at least 30 feet away from the presumed lateral shear location as shown on Figure 3C, and that the excavation for the home be inspected by a licensed engineering geologist to confirm that no deformation is present, as well as to recognize any differing conditions that could affect the performance of the planned structure. The proposed location for the septic system may also need to be moved slightly to the northeast to accommodate this new location. If the home footing is located over the excavation for test pit 1, or any prior percolation test pits, care should also be taken that the backfilled material is removed and/or replaced by structural fill, as noted below.

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

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

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

LIMITATIONS

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

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

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

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

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

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

Sincerely,
Western GeoLogic, LLC

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

Reviewed by:

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

ATTACHMENTS

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

G:\Western GeoLogic\PROJECTS\Solitude Builders\Liberty, UT - Geologic Hazards Eval - 4075 Bluebell Drive #4050\Geologic Hazards Evaluation - 4075 Bluebell Drive.docx

REFERENCES

Anderson, R.E., 1989, Tectonic evolution of the intermontane system--Basin and Range, Colorado Plateau, and High Lava Plains, *in* Pakiser, L.C., and Mooney, W.D., editors, Geophysical framework of the continental United States: Geological Society of America Memoir 172, p. 163-176.

Applied Geotechnical Engineering Consultants, 2014, Additional percolation testing results—Lot 44, Big Sky Estates, 4075 Bluebell Drive, Liberty, Utah: unpublished consultant's report dated December 12, 2014 prepared for Watts Enterprises, AGEC Project No. 1140736, 4 p. with various attachments.

Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and evaluation of earthquake hazards and risk in the Wasatch Front area, Utah, *in* Gori, P.L. and Hays, W.W., editors, Assessment of Regional Earthquake Hazards and Risk along the Wasatch Front, Utah: Washington, D.C, U.S. Geological Survey Professional Paper 1500-D, Government Printing Office, p. D1-D36.

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

Black, B.D., Hecker, Suzanne, Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003, Quaternary fault and fold database and map of Utah: Utah Geological Survey Map 193DM, CD-ROM.

Coogan, J.C., and King, J.K., 2001, Progress Report--Geologic Map of the Ogden 30' X 60' Quadrangle, Utah and Wyoming, year 3 of 3: Utah Geological Survey Open-File Report 380, scale 1:100,000, 31 p. pamphlet.

Gilbert, G.K., 1928, Studies of Basin and Range Structure: U.S. Geological Survey Professional Paper 153, 89 p.

Gwynn, J.W. (Editor), 1980, Great Salt Lake--A scientific, historical, and economic overview: Utah Geological Survey Bulletin 166, 400 p.

Jarrett, R.D., and Malde, H.E., 1987, Paleodischarge of the late Pleistocene Bonneville flood, Snake River, Idaho, computed from new evidence: Geological Society of America Bulletin, v. 99, p. 127-134.

King, J.K., Yonkee, Adolph, and Coogan, J.C., 2008, Interim geologic map of the Snow Basin Quadrangle and part of the Huntsville Quadrangle, Davis, Morgan, And Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000, 23 p. pamphlet.

Lund, W.R. (Editor), 1990. Engineering geology of the Salt Lake City metropolitan area, Utah: Utah Geological and Mineral Survey Bulletin 126, 66 p.

Miller, D.M., 1990, Mesozoic and Cenozoic tectonic evolution of the northeastern Great Basin, *in* Shaddrick, D.R., Kizis, J.R., and Hunsaker, E.L. III, editors, Geology and Ore Deposits of the Northeastern Great Basin: Geological Society of Nevada Field Trip No. 5, p. 43-73.

O'Connor, J.E., 1993, Hydrology, hydraulics, and geomorphology of the Bonneville flood: Geological Society of America Special Paper 274, 83 p.

Oviatt, C.G., 2015, Chronology of Lake Bonneville, 30,000 to 10,000 yr B.P.: Quaternary Science Reviews, v. 110 (2015), p. 166-171.

Oviatt, C.G., Currey, D.R., and Sack, Dorothy, 1992, Radiocarbon chronology of Lake Bonneville, Eastern Great Basin, USA: Paleogeography, Paleoclimatology, Paleoecology, v. 99, p. 225-241.

Sbar, M.L., Barazangi, M., Dorman, J., Scholz, C.H., and Smith, R.B., 1972, Tectonics of the Intermountain Seismic Belt, western United States--Microearthquake seismicity and composite fault plane solutions: Geological Society of America Bulletin, v. 83, p. 13-28.

Smith, R.B., and Arabasz, W.J., 1991, Seismicity of the Intermountain Seismic Belt, *in* Slemmons, D.B., Engdahl, E.R., Zoback, M.D., and Blackwell, D.D., editors, Neotectonics of North America: Geological Society of America, Decade of North American Geology Map v. 1, p. 185-228.

Smith, R.B. and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain Seismic Belt: Geological Society of America Bulletin, v. 85, p. 1205-1218.

Stewart, J.H., 1978, Basin-range structure in western North America, a review, *in* Smith, R.B., and Eaton, G.P., editors, Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 341-367.

____, 1980, Geology of Nevada: Nevada Bureau of Mines and Geology Special Publication 4.

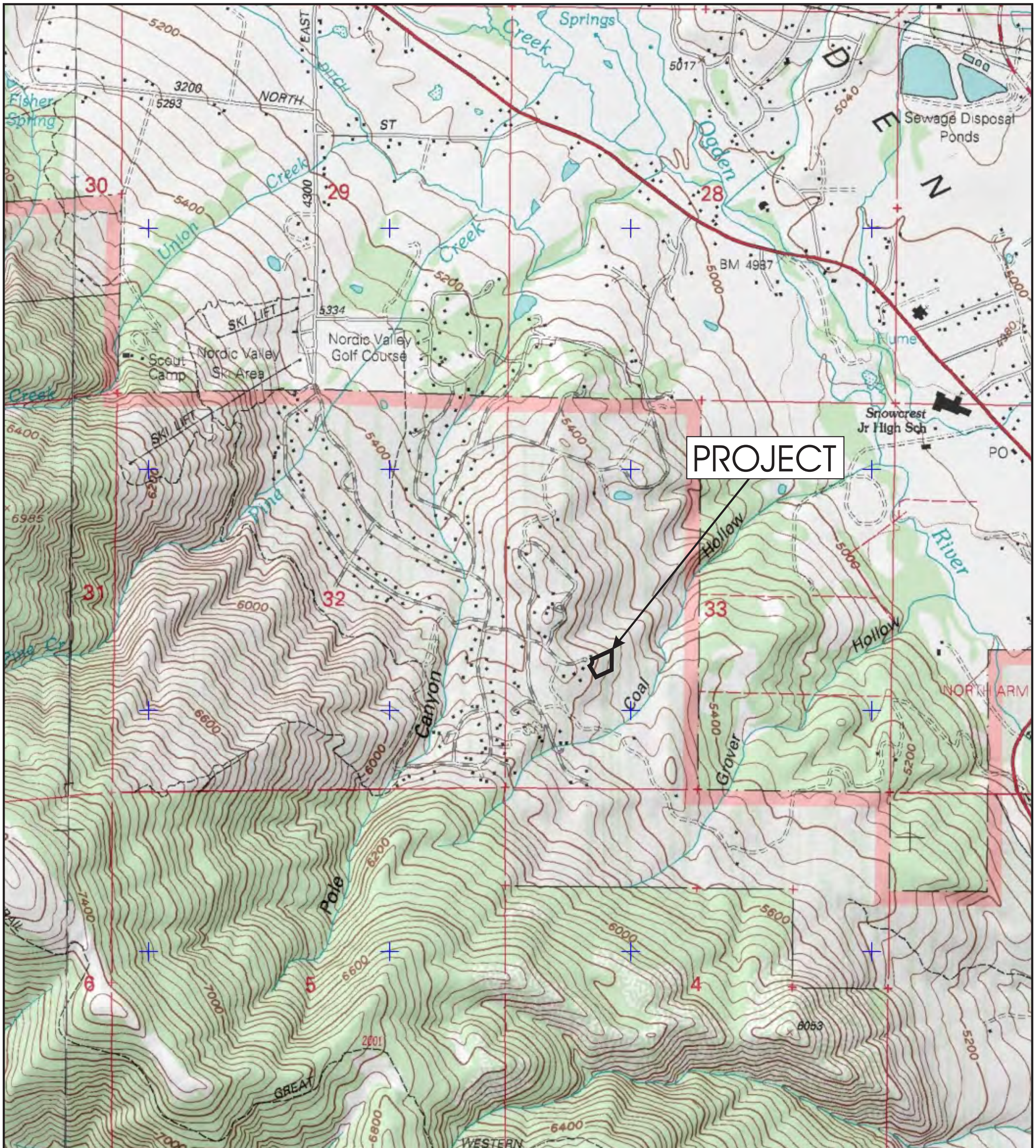
Stokes, W.L., 1977, Physiographic subdivisions of Utah: Utah Geological and Mineral Survey Map 43, scale 1:2,400,000.

____, 1986, Geology of Utah: Salt Lake City, University of Utah Museum of Natural History and Utah Geological and Mineral Survey, 280 p.

Sullivan, J.T., Nelson, A.R., LaForge, R.C., Wood, C.K., and Hansen, R.A., 1986, Regional seismotectonic study for the back valleys of the Wasatch Mountains in northeastern Utah: Denver, Colorado, U.S. Bureau of Reclamation, Seismotectonic Section, Division of Geology, Engineering and Research Center, unpublished report, 317 p.

Zoback, M.L., 1989. State of stress and modern deformation of the northern Basin and Range province: Journal of Geophysical Research, v. 94, p. 7105-7128.

Zoback, M.L. and Zoback, M.D., 1989. Tectonic stress field of the conterminous United States: Boulder, Colorado, Geological Society of America Memoir, v. 172, p. 523-539.



Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville, 1998;
Project location SW1/4, Section 33, T7N, R1E (SLBM); about 5,525 to 5,615 feet elevation (ASL).

WESTERN GEOLOGIC

0 1000 2000 feet

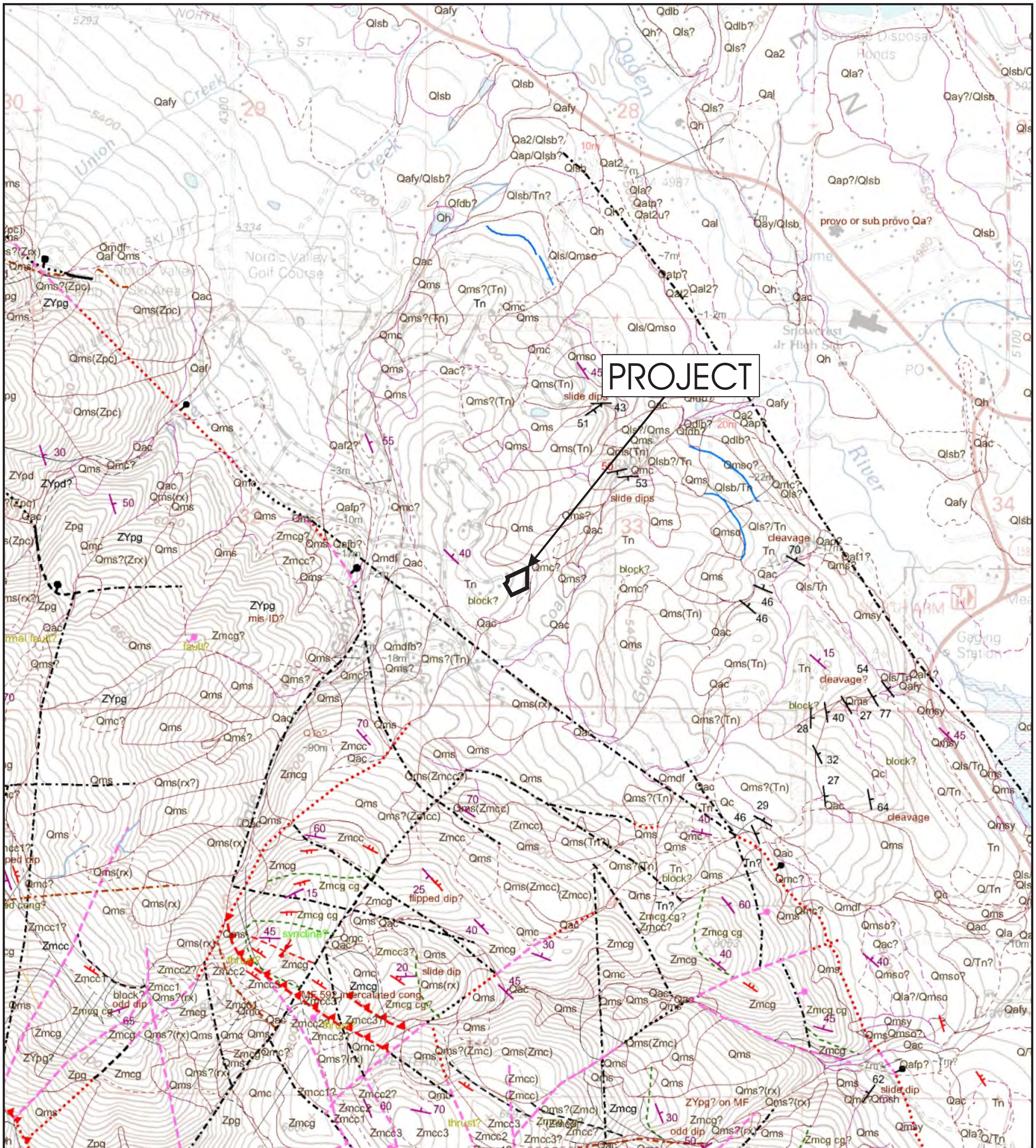
Scale 1:24,000
(1 inch = 2000 feet)

LOCATION MAP

GEOLOGIC HAZARDS EVALUATION

Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 1



Source: 2014 unpublished Utah Geological Survey mapping; see text for description of nearby surficial geologic units.

WESTERN GEOLOGIC

N W E S

0 1000 2000 feet

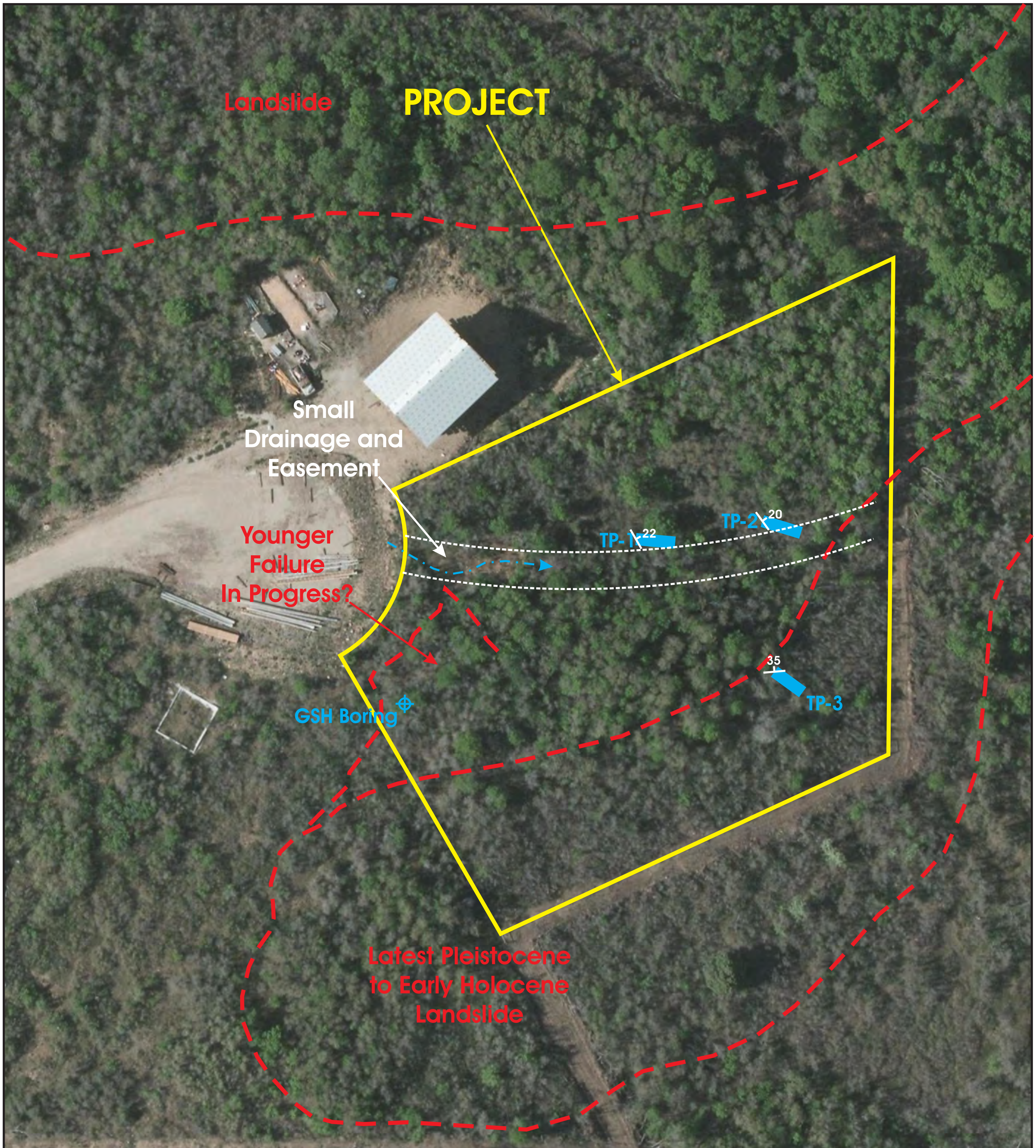
Scale 1:24,000
(1 inch = 2000 feet)

GEOLOGIC MAP

GEOLOGIC HAZARDS EVALUATION

Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 2



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

WESTERN GEOLOGIC

N W E S

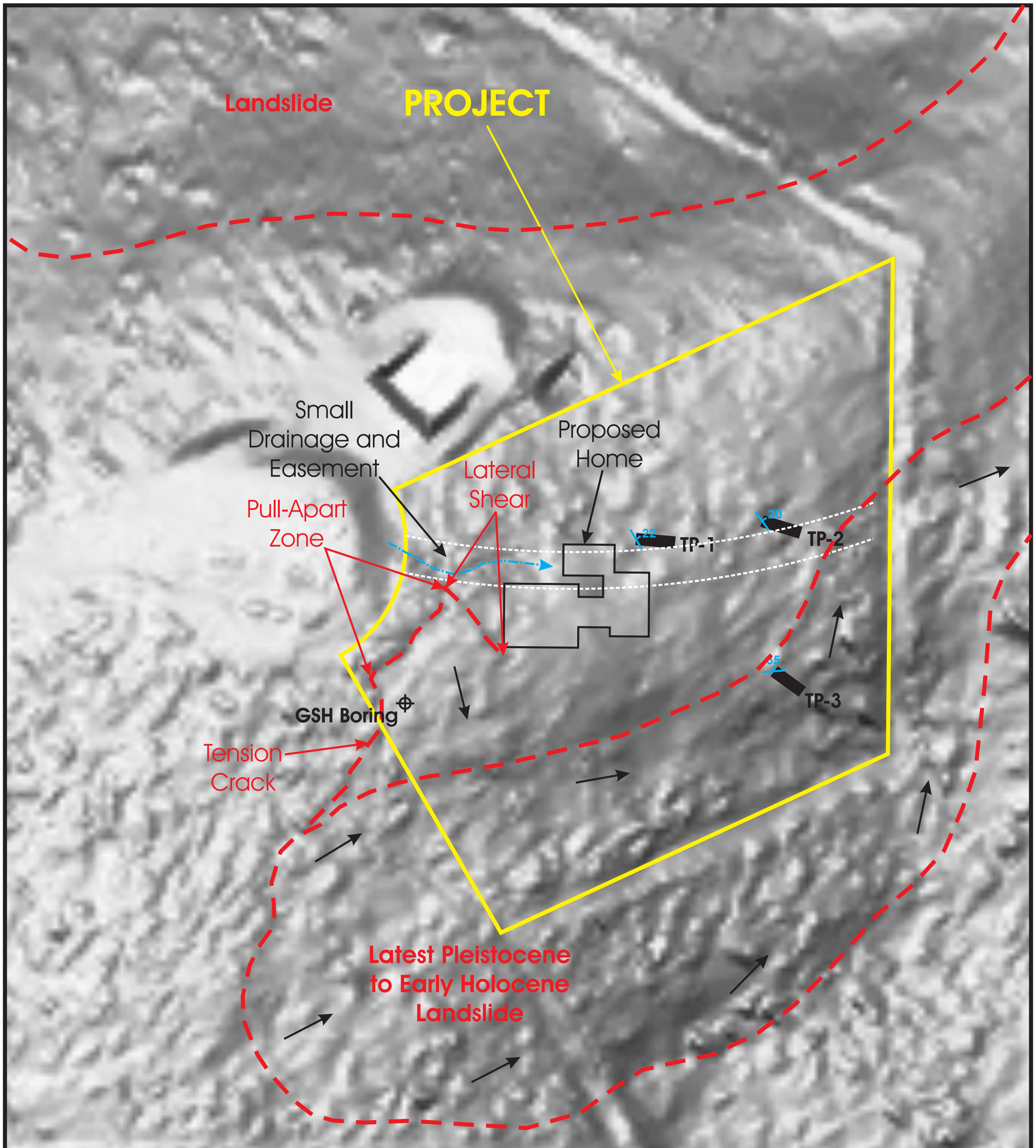
0 40 80 feet

Scale 1:960
(1 inch = 80 feet)

2012 AERIAL PHOTO

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 3A



Source: Utah AGRC, 2011 LIDAR Bare Earth DEM.

WESTERN GEOLOGIC

N W E S

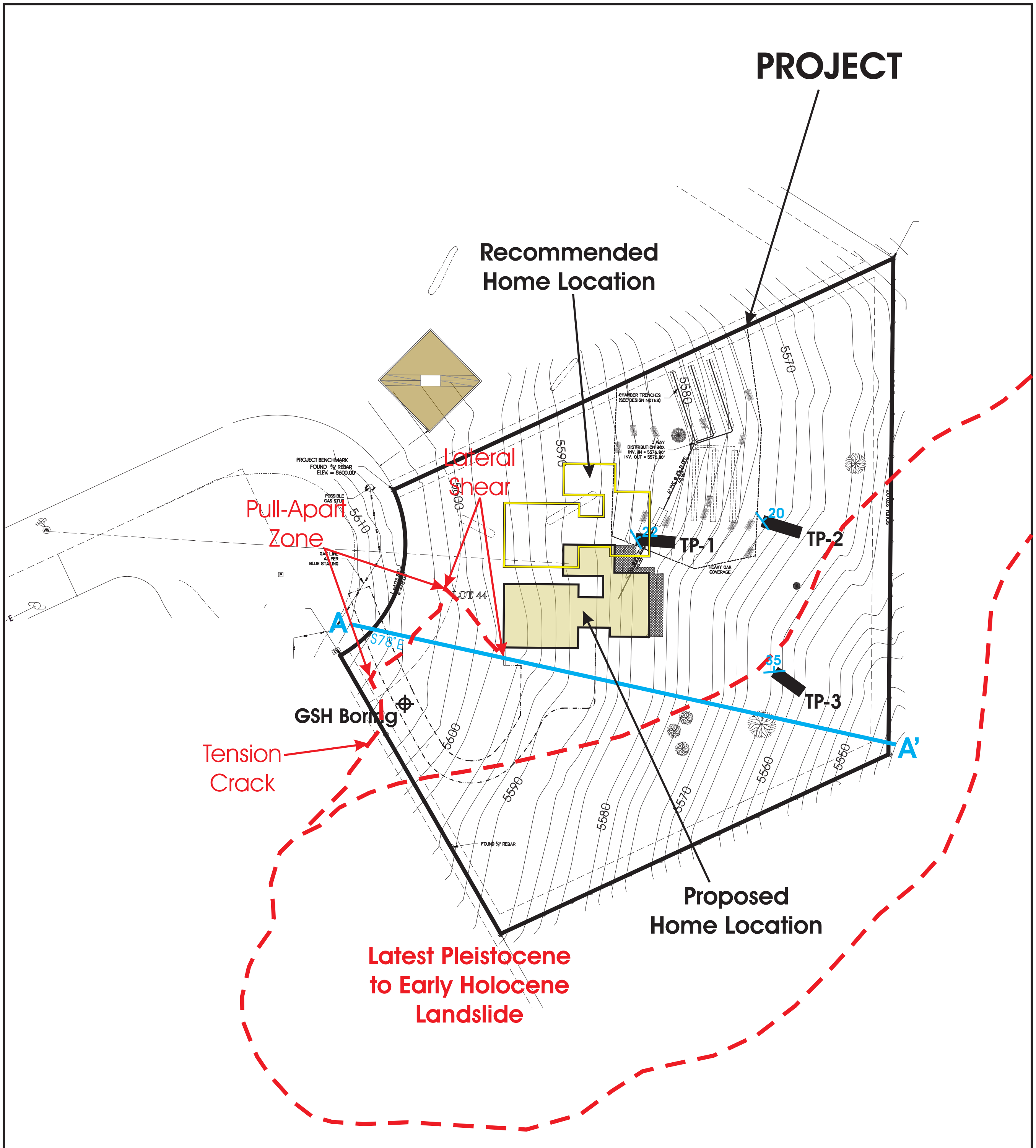
0 40 80 feet

Scale 1:960
(1 inch = 80 feet)

2011 LIDAR IMAGE

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 3B



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

WESTERN GEOLOGIC

N W E S

0 40 80 feet

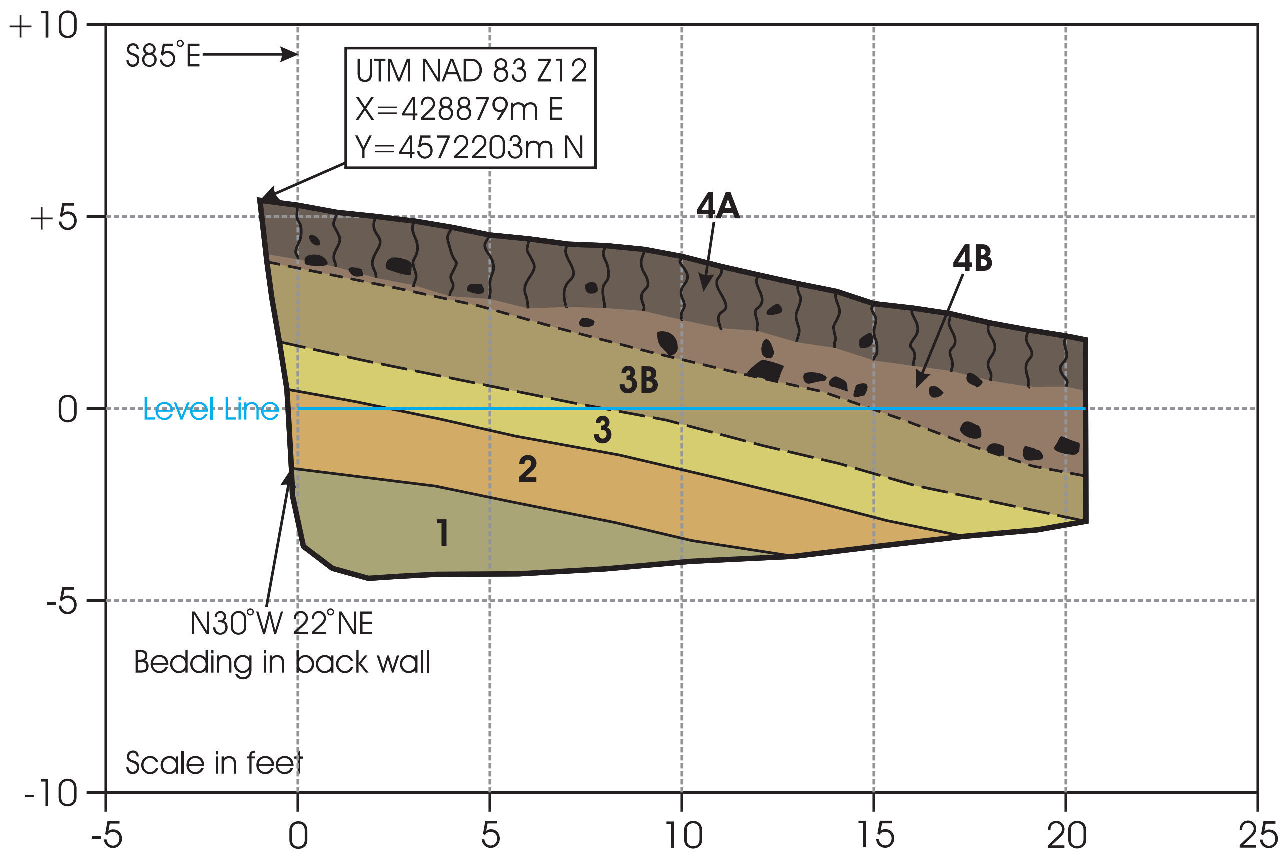
Scale 1:960
(1 inch = 80 feet)

SITE PLAN

GEOLOGIC HAZARDS EVALUATION

Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 3C



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - Weathered tuffaceous claystone comprised of olive- to reddish-brown, moderate to high density, poorly bedded, lean to fat clay (CL/CH).

Unit 2. *Tertiary Norwood Formation* - Weathered tuffaceous siltstone comprised of pale-brown to pink, moderate density, poorly bedded, carbonate-enriched, silt (ML).

Unit 3. *Tertiary Norwood Formation* - Weathered tuffaceous claystone comprised of olive- to reddish-brown, moderate density, poorly bedded, sandy lean to fat clay (CL/CH).

3B. Bt soil horizon formed in unit 3.

Unit 4. *Tertiary Norwood Formation* - Weathered tuffaceous conglomerate comprised of brown to dark brown, moderate density, poorly bedded to massive, root-penetrated, lean clay (CL) grading upward to clayey sand with cobbles (SC); clasts subangular to subround with stage II carbonate.

4B. Bt soil horizon formed in unit 4.

4A. Modern A-horizon soil formed in unit 4.

WESTERN GEOLOGIC

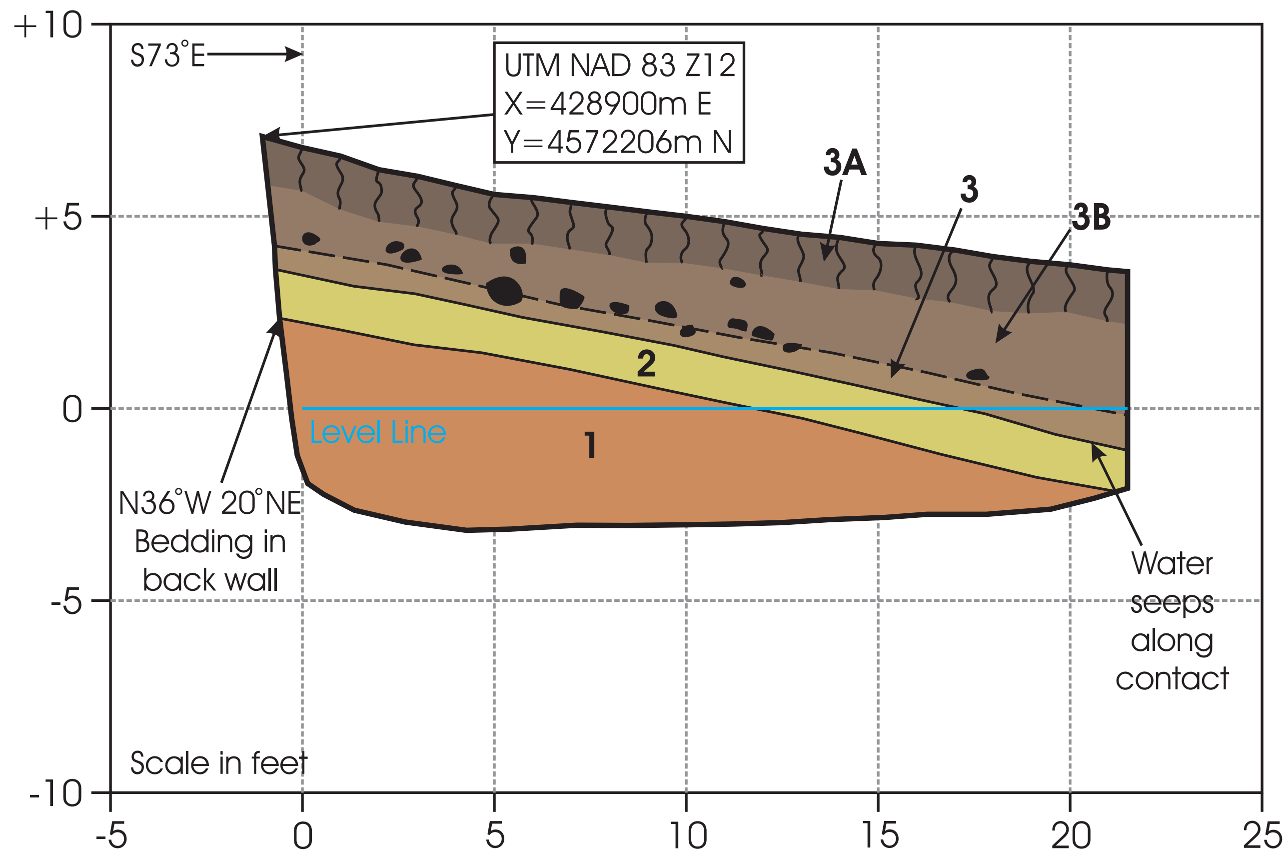
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on April 29, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 1 LOG

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 4A



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - Weathered tuffaceous siltstone to claystone comprised of reddish-brown, moderate to high density, poorly bedded, carbonate-enriched silt to lean clay (ML/CL).

Unit 2. *Tertiary Norwood Formation* - Weathered tuffaceous claystone comprised of olive- to brownish-olive, moderate to high density, poorly bedded, lean to fat clay (CL/CH).

Unit 3. *Tertiary Norwood Formation* - Weathered tuffaceous conglomerate comprised of brown to dark brown, moderate density, poorly bedded to massive, root-penetrated, sandy clay (CL) with cobbles and trace gravel; clasts subangular to subround with stage II carbonate.

3B. Bt soil horizon formed in unit 3.

3A. Modern A-horizon soil formed in unit 3.

WESTERN GEOLOGIC

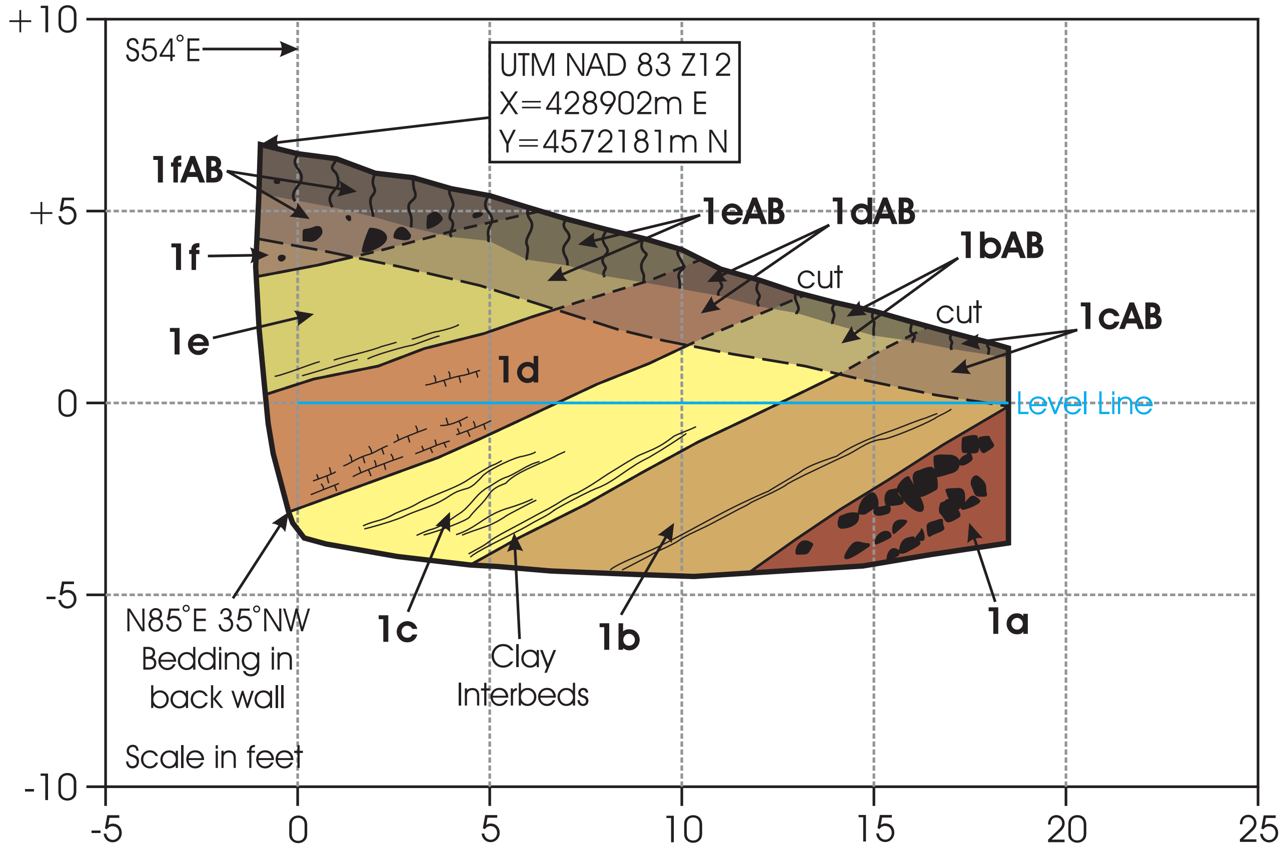
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on April 29, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 2 LOG

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 4B



UNIT DESCRIPTIONS

Unit 1. *Late Pleistocene to Holocene Landslide Colluvium* - Rafted and backtilted block of Tertiary Norwood Formation.

1a. Moderate density, massive to poorly bedded, fractured claystone comprised of pale-gray clasts in a matrix of dark-reddish-brown lean to fat clay (CL/CH).

1b. Orange-olive, moderate density, poorly bedded, tuffaceous sandstone (SC).

1bAB. Bt and modern A-horizon soils formed in unit 1b.

1c. Pale-olive-brown, moderate density, poorly bedded, interbedded tuffaceous sandstone and claystone (SC/CH).

1cAB. Bt and modern A-horizon soils formed in unit 1c.

1d. Orange- to dark-reddish-brown, moderate to high density, well to poorly bedded, claystone (CL/CH).

1dAB. Bt and modern A-horizon soils formed in unit 1d.

1e. Orange to olive, moderate to high density, well bedded, claystone (CL/CH).

1eAB. Bt and modern A-horizon soils formed in unit 1e.

1f. Reddish-brown, massive to poorly bedded, tuffaceous conglomerate comprised of sandy lean to fat clay (CL/CH) with cobbles and gravel.

1fAB. Bt and modern A-horizon soils formed in unit 1f.

WESTERN GEOLOGIC

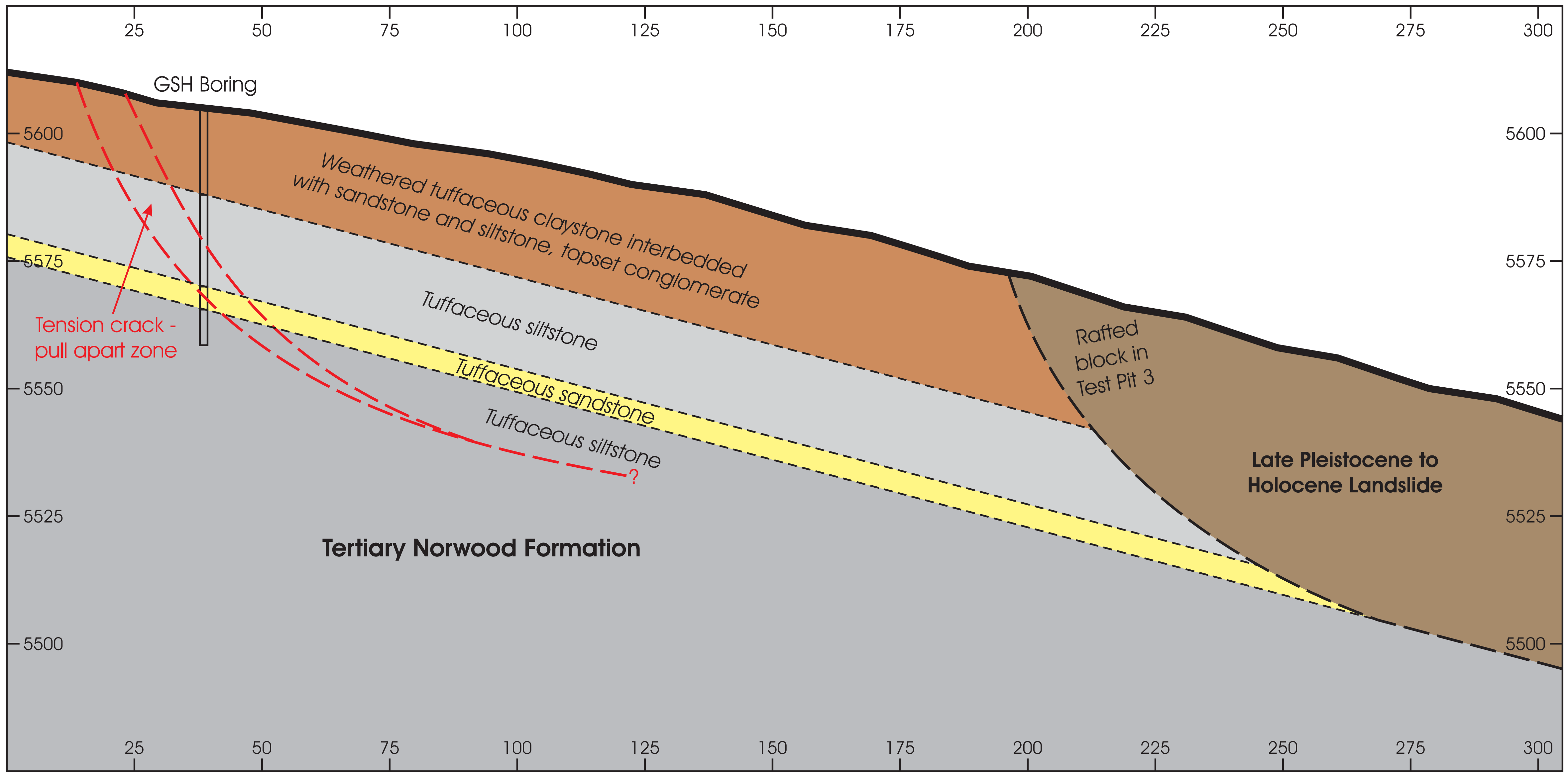
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Logged by Bill D. Black, P.G.
on April 29, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 3 LOG

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 4C



SCALE: 1 inch = 25 feet
No vertical exaggeration
Contacts based on subsurface data and are inferred in unexplored areas and at depth

WESTERN GEOLOGIC

CROSS SECTION

GEOLOGIC HAZARDS EVALUATION
Lot 44 Big Sky Estates No. 1
4075 Bluebell Drive
Liberty, Weber County, Utah

FIGURE 5