REPORT

GEOLOGIC HAZARDS EVALUATION

LOT 23 BIG SKY ESTATES NO. 1

2292 NORTH PANORAMA CIRCLE

LIBERTY, WEBER COUNTY, UTAH

Prepared for

GSH Geotechnical
1596 West 2650 South, Suite 107
Ogden, Utah 84401

March 1, 2016

Prepared by

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March 1, 2016

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SUBJECT: Geologic Hazards Evaluation
Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

Dear Mr. Harris:

This report presents results of an engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for Lot 23 in the Big Sky Estates No. 1 Subdivision at 2292 North Panorama Circle, 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 5,530 feet to 5,640 feet above sea level. It is our understanding that the current intended site use is for development of one residential home in the northwestern 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 four trenches and two test pits between January 13 and February 5, 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. The original Project scope was approved in a work plan dated December 9, 2015. Trench 1 and test pits TP-1 and 2 were reviewed by Elliott Lipps, Weber County Contract Geologic Reviewer, on January 18, 2016. However, we note that field conditions were not optimal at this time due to snowfall. Based on suggestions provided during this field review, a supplemental work plan was prepared dated February 1, 2016. Trenches 2 through 4 were visually observed by Dana Shuler, Weber County Engineer, on February 8, 2016, but no geologic field review was conducted.

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 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 1,400 feet west of the property, and Coal Canyon Creek flows to the northeast about 1,000 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, several small drainages that may be seasonally active cross the property and flow downslope to the east. No springs or seeps were observed at the site or are shown in the site area on Figure 1, although slopes at the Project were heavily snow covered at the time of our reconnaissance.

The site is the western margin of Ogden Valley about 1.2 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 50.5 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.

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 reportedly part of an ongoing surficial geologic mapping project for Ogden Valley, although there currently are no plans for its publication (Jon King, verbal communication, March 1, 2016). However, this mapping was provided for this report since it represents the most-recent geologic information available for the area. We caution that the unpublished mapping is subject to revision and further includes a disclaimer that it should not be quoted or distributed.

Unpublished UGS mapping shows the site straddles the contact between bedrock of the Norwood Formation on the west and Pleistocene- to Holocene-age landslide deposits on the east (units Tn and Qms, 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 650 feet southwest of the property and shows a strike/dip of N46°W 40° NE. Three additional measurements are from 3,300 to 5,200 feet to the southeast and show strikes and dips of N50°W 46° NE, N49°W 15° NE, and N28°W 32° NE. 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 1,450 feet to the southwest and 3,500 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 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 (Donald Currey, University of Utah; written communication to the Utah Geological Survey, 1996; and verbal communication to the Utah Quaternary Fault Parameters Working Group, 2004). Approximately 32,500 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, after about 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. The lake remained at its highest level until 16,500 years ago, when headward erosion of the Snake River-Bonneville basin drainage divide 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).

Following the Bonneville flood, the lake stabilized and formed a lower shoreline referred to as the Provo shoreline. 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 experienced a brief transgression between 12,800 and 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 from the Provo shoreline.

SITE CHARACTERIZATION

Empirical Observations

Between January 13 and February 5, 2016, Mr. Bill D. Black of Western GeoLogic conducted a reconnaissance of the property. Weather at the time of the initial site reconnaissance was clear with temperatures in the 30's (°F), although conditions varied. Site observations were restricted by heavy snow cover. The site is at the western margin of Ogden Valley on east-facing slopes slightly below a hilltop overlooking Ogden Valley to the east and Nordic Valley to the west and northwest. Pole and Coal Canyon Creeks are to the northwest and southeast of the site. Native vegetation appeared to consist of heavy oak brush and tree cover. No active streams cross the site or were observed, and no bedrock outcrops were evident at the site or in adjacent slopes.

Air Photo Observations

High-resolution orthophotography from 2012 and 1-meter bare earth DEM LIDAR from 2011 available from the Utah AGRC (Figure 3) were reviewed to obtain information about the geomorphology of the site area. Figure 3 shows the site straddles a slump that appears to have originated in a small hollow south of the southwest property corner. The slump appears to trend northeastward and then turn downslope toward the east, where it coalesces with a larger failure (Figure 3). Several small seasonal drainages also appear to cross the property, downcut through the failure, and then flow downslope to the east-southeast (Figure 3). The central drainage appears to head in the hollow where the slump originated and may be from a seep (Figure 3). The southern drainage south of the property is short and may also be from a seep or spring. No evidence of other geologic hazards were observed on the air photos in the site area.

Subsurface Investigation

Four trenches and two test pits were excavated at the property between January 13 and February 5, 2016 to evaluate subsurface conditions. Trench and test pit locations are shown on Figure 4, and were measured using a hand-held GPS unit and trend and distance methods from known points. The trench and test pit locations are considered accurate to within one foot. The trenches and test pits were logged at a scale of 1 inch equals 5 feet (1:60). The original trench and test pit logs are provided on Figures 5 through 9, but were externally cropped for this report to facilitate consistent unit labeling and descriptions and to remove areas of field damage. Given the logging scale and trench lengths, trenches 1 and 2 required multiple 11" x 17" sheets (Figures 5A-C and 6A-B). Overviews of these trenches are therefore provided at a smaller scale on Figures 5E and 6C. Unit descriptions for trench 1 are provided on Figure 5D. Except for occasional poor weather conditions, no other complications were encountered that substantially impacted the subsurface investigation. The trench and test pit exposures were digitally photographed at 5-foot intervals to document subsurface conditions. The photos are not provided herein, but are available on request. However, no photos of trench 3 are available due to overexposure from camera damage, which was not noticed at the time the photos were taken.

Trench 1 exposed a coarsening-upward sequence of what we infer is in-place tuffaceous conglomerate of the Tertiary Norwood Formation (units 1a-1j, Figures 5A-E). One strike/dip measurement was obtained from the base of unit 1b (Figure 5A), which showed a strike and dip of N40°W 10-12° NE. Although this measurement shows a dip lower than the believed average for the Norwood Tuff, it is near the range of nearby measurements discussed in the Surficial Geology Section above. We believe the low dip reflects a local depositional variation. We also note that unit contacts appear to have low overall dips on Figures 5A-C, which is due to apparent dips caused by a difference of 50 to 65 degrees between the trench trend and measured dip direction. At roughly station 1+06 feet, trench 1 exposed a shear representing the left-lateral margin of the slope failure originating from the southwest. Unit 2 is colluvium from the landslide, and consists of a coarse, basal, wedge-shaped deposit (unit 2b) overlain by sandy clay to clayey sand (unit 2a) in which the modern A-horizon is forming (unit 2aA). At stations 1+35 feet,1+60 feet, and 1+75 feet (Figure 5C), the shear steps across and down through

fine-grained clay layers in unit 1j, which we believe reflects oblique deformation at the slide margin. Unit 2 shows a maximum thickness in trench 1 of 7.5 feet at station 1+75 feet (Figure 5C). No other evidence of deformation was exposed in the trench.

Trench 2 was excavated to confirm subsurface information provided by trench 1 in roughly the dip direction measured from unit 1b (Figure 5A). The trench was extended from the north wall of trench 1 at its west end, and used the same horizontal datum. Trench 2 exposed a sequence of in-place Norwood Formation conglomerate units generally correlative to those exposed in trench 1, although some additional units were also exposed that indicate lateral variations within the unit are customary. Overall unit contact dips showed a range of 10 to 18 degrees (Figure 6C). We infer the average dip is 15 degrees, as displayed by the base of unit 1f (Figures 6A and 6C, correlative to unit 1c in trench 1). This value is similar to the lower end of nearby strike and dip measurements on Figure 2, and the measure strike of unit 1b (Figure 5A) is also within the range of nearby measurements. No evidence for deformation was exposed in trench 2.

Trenches 3 and 4 (Figures 7 and 8) were excavated to confirm location of the landslide margin exposed in trench 1. Trench 3 was excavated southward from the south wall of trench 1 and used the same horizontal datum, whereas trench 4 was excavated further north of trench 1. Both of these trenches exposed similar stratigraphic units and relations to trench 1. The shear was exposed in trench 3 at station 0+17 feet, and trench 4 exposed the shear at station 0+4 feet. Landslide colluvium exposed in the trenches appeared correlative to that exposed in trench 1.

Test pits TP-1 and 2 were excavated south of trench 1 to evaluate subsurface conditions within the landslide deposit (Figures 4 and 9). Test pit TP-1 exposed a deformed unit of buff-colored tuffaceous sandstone (Figure 9, unit 1) not observed in any of the other trench and test pit exposures. We infer the tuffaceous sandstone is likely near surface in the slump source area and underlies the tuffaceous conglomerate units exposed elsewhere, and the block was likely incorporated in the landslide and rafted downslope during movement. Bedding within the unit showed a strike and dip measurement of S55°W 70° SE on the south wall of the test pit exposure, and N90°E 25° S on the north wall. We note that these measurements resemble slide strike and dips shown on Figure 2, which may suggest a similar failure mechanic. Test pit 2 only exposed similar colluvial units to those exposed in trench 1 to the depth explored (Figure 9), which may be because this test pit is closer to the slide margin than test pit 1 (Figure 4).

Cross Section

Figure 10B shows a cross section across the slope at the site at a scale of 1 inch equals 30 feet with no vertical exaggeration. The profile location is shown on Figure 10A, as well as the axial trend of the slump and Norwood Formation strike and dip directions based on the measurements of unit 1b in trench 1 (Figure 5A). Units and contacts are inferred based on the subsurface data discussed above. We use an overall dip of 10 degrees for contacts within the Norwood Formation, which is corrected from an average of 15 degrees to account for the difference between the profile trend and dip direction. Assuming that the tuffaceous sandstone exposed in test pit 1 is slightly below the surface in the slump source area and dips at an overall 15 degrees to the northeast, this unit would

be slightly below the depth explored in GSH's boring at the site (Figure 10B). We note that the inferred contact between the sandstone and conglomerate units in the Norwood Formation on Figure 10B is also near where the axis of the failure would intersect the profile (Figure 10A). This evidence suggests the failure may have been sourced in the tuffaceous sandstone, which the test pit 1 exposure confirms. Assuming that near-surface groundwater was perched on the sandstone and contributed to the instability, groundwater at the site may be at a depth near the tuffaceous sandstone contact around 55 feet below the ground surface. GSH's boring exposed neither groundwater nor the tuffaceous sandstone, which would be because both are slightly deeper.

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 23 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). Peak ground, 0.2 second spectral, and 1.0 second spectral accelerations (percent of gravity, %g) at the site with 10% and 2% probabilities of exceedance in 50 years are estimated in Frankel and others (2002) as follows:

41.300611º N, -111.851064º W	**10% PE in 50yr**	**2% PE in 50yr**
PGA	20.42	46.97
0.2 sec SA	48.54	112.99
1.0 sec SA	16.30	43.00

Given the above information, earthquake ground shaking is a high risk to the site. The hazard from earthquake ground shaking can be adequately mitigated by prudent design and construction.

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 trench and 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, three small drainages appear to cross various portions of the site that may have low seasonal flows. Site hydrology and runoff should therefore be addressed in the civil engineering design and grading plan for the Project.

Shallow Groundwater
No springs are shown on the topographic map for the site or were reported or observed. However, it is possible that seeps may be found in areas to the south, possibly from near-surface water perched on Norwood Formation tuffaceous sandstone. No groundwater was encountered in the boring conducted by GSH at the site, and it may be near the inferred tuffaceous sandstone contact slightly below the boring depth (Figure 10A), which would be greater than 50 feet deep. Given this, 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.

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 site straddles the margin of a slump that originated to the southwest of the property. The margin of this failure was identified in trenches 1, 3, and 4 at the site, and landslide colluvium was observed in the above trenches and in test pits TP-1 and TP-2. The failure appears to have initiated in Norwood Formation tuffaceous sandstone, which is at depth beneath the property (Figure 10B), possibly from a combination of perched groundwater, steep slopes, and marginal bedrock stability. Slopes at the site have an overall steepness of 3.1:1 (Figure 10B). Given all the above, we rate the hazard from landsliding as high. Current plans are to place the home outside of the landslide (Figure 4), thus the risk will be lower. 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. 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. The stability evaluation should take into account possible perched groundwater and fluctuating seasonal levels.

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:

- ***Excavation Inspection*** - This report does not reflect subsurface variations that may occur laterally away from an exploration trench. The nature and extent of such variations may not become evident until the course of construction, and are sometimes sufficient to necessitate structural or site plan changes. Thus, we recommend that we inspect the building footing or foundation excavation to recognize any differing conditions that could affect the performance of the planned structure.

- ***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.

- ***Excavation Backfill Considerations*** **-** The trenches and test pits may be in areas where structures could subsequently be placed. However, backfill may not have been replaced in the trenches in compacted layers. The fill could settle with time and upon saturation. Should structures be located in a trenched area, no footings or structure should be founded over the trench 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.

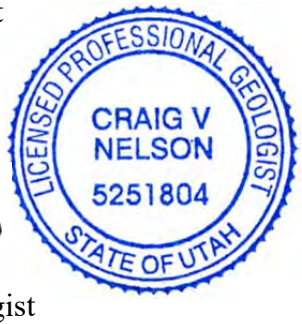
In expressing the opinions stated in this report, Western GeoLogic has exercised the degree of skill and care ordinarily exercised by a reasonable prudent environmental professional in the same community and in the same time frame given the same or similar facts and circumstances. Documentation and data 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 3. Air Photo and LIDAR (8.5”x11”)
Figure 4. Site Plan (8.5”x11”)
Figure 5A-E. Trench 1 Log (five 11”x17” sheets)
Figure 6A-C. Trench 2 Log (three 11”x17” sheets)
Figure 7. Trench 3 Log (11”x17”)
Figure 8. Trench 4 Log (11’x17”)
Figure 9. Test Pit Logs (11”x17”)
Figure 10A. Profile Location (8.5”x11”)
Figure 10B. Cross Section (11”x17”)

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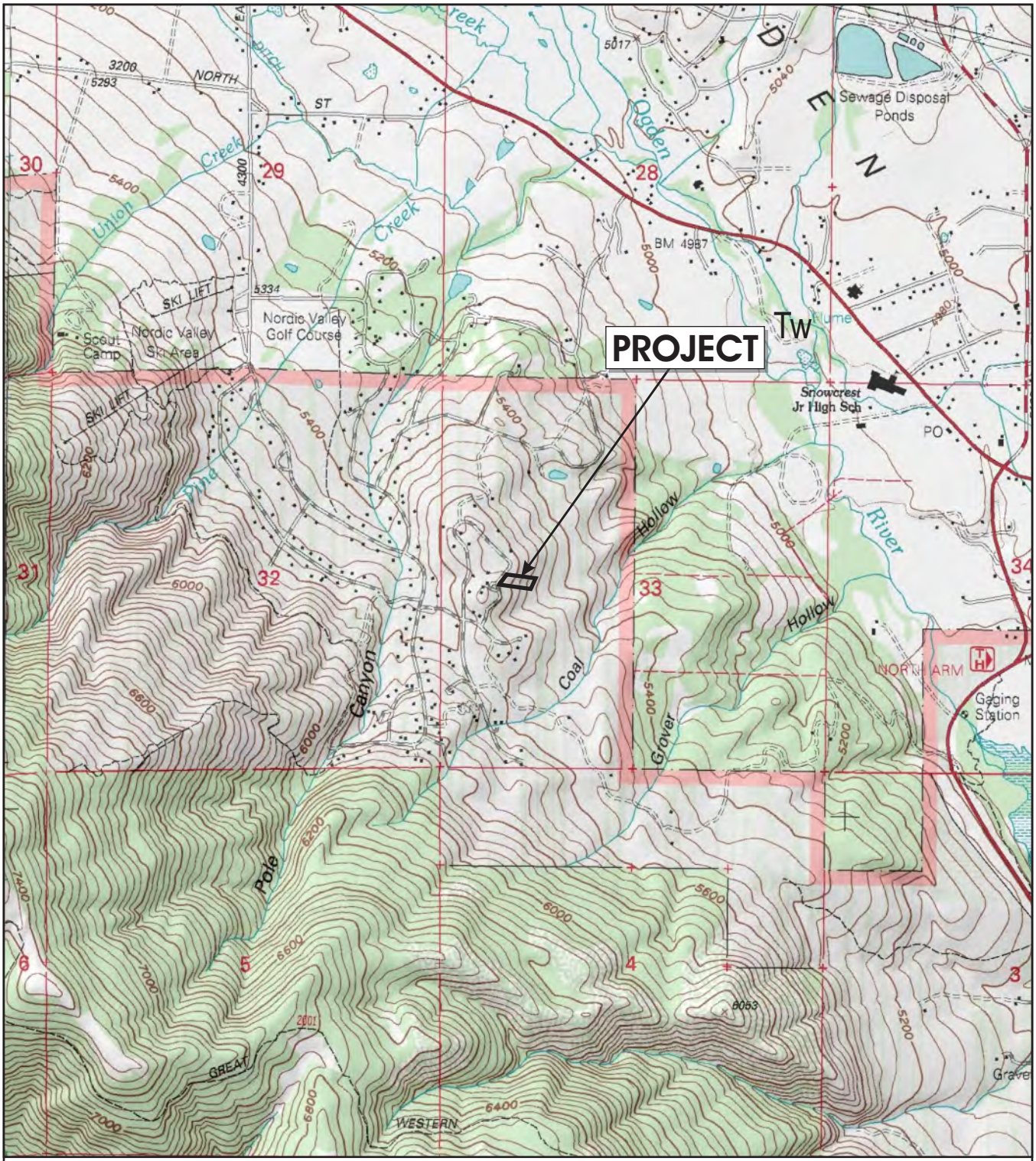


Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville, 1998;
Project location SW1/4, Section 33, T7N, R1E (SLBM); about 5,640 to 5,530 feet elevation (ASL).

WESTERN GEOLOGIC

N
W E
S

0 1000 2000 feet

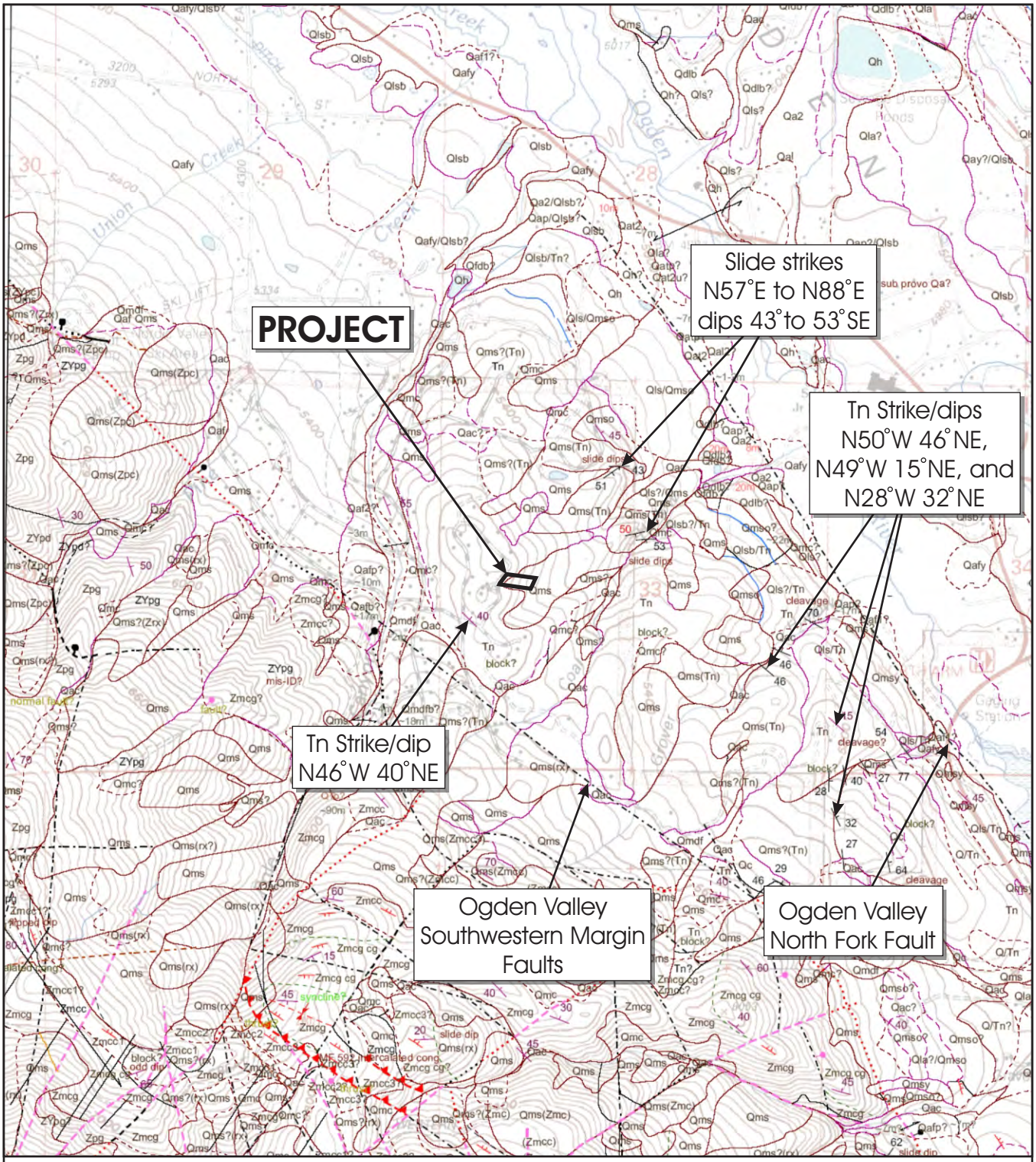
Scale 1:24,000
(1 inch = 2000 feet)

LOCATION MAP

GEOLOGIC HAZARDS EVALUATION

Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 1



Source: 2014 unpublished Utah Geological Survey mapping; strike/dip values shown in black are from Utah Geological Survey field measurements, those in purple are from U.S. Geological Survey data.

N
W E
S

0 1000 2000 feet

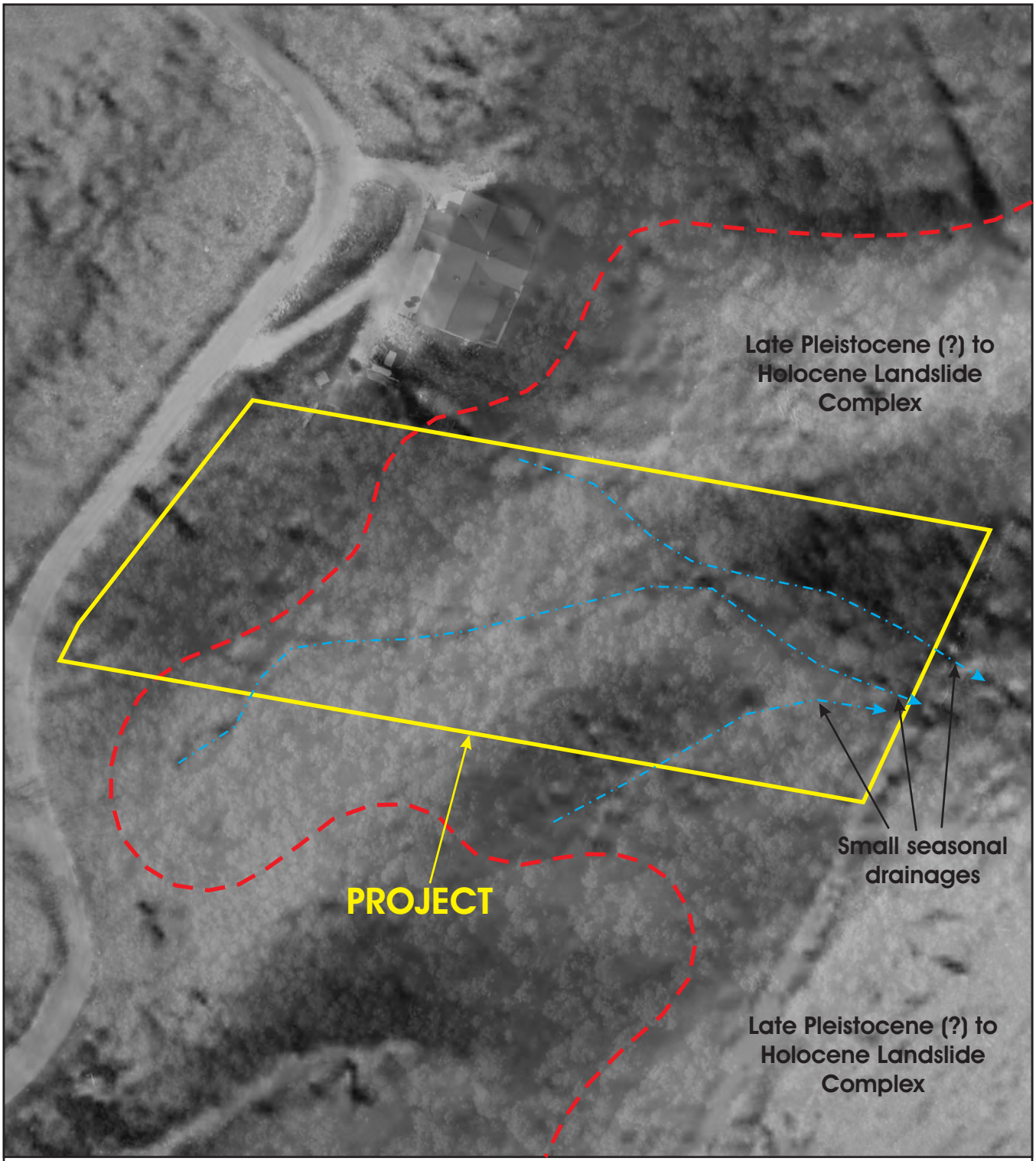
Scale 1:24,000
(1 inch = 2000 feet)

GEOLOGIC MAP

GEOLOGIC HAZARDS EVALUATION

Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 2



Base from 2012 Utah AGRC HRO 6-inch orthophotography and 2011 1-meter LIDAR Bare Earth DEM.

WESTERN GEOLOGIC

N
W E
S

0 40 80 feet

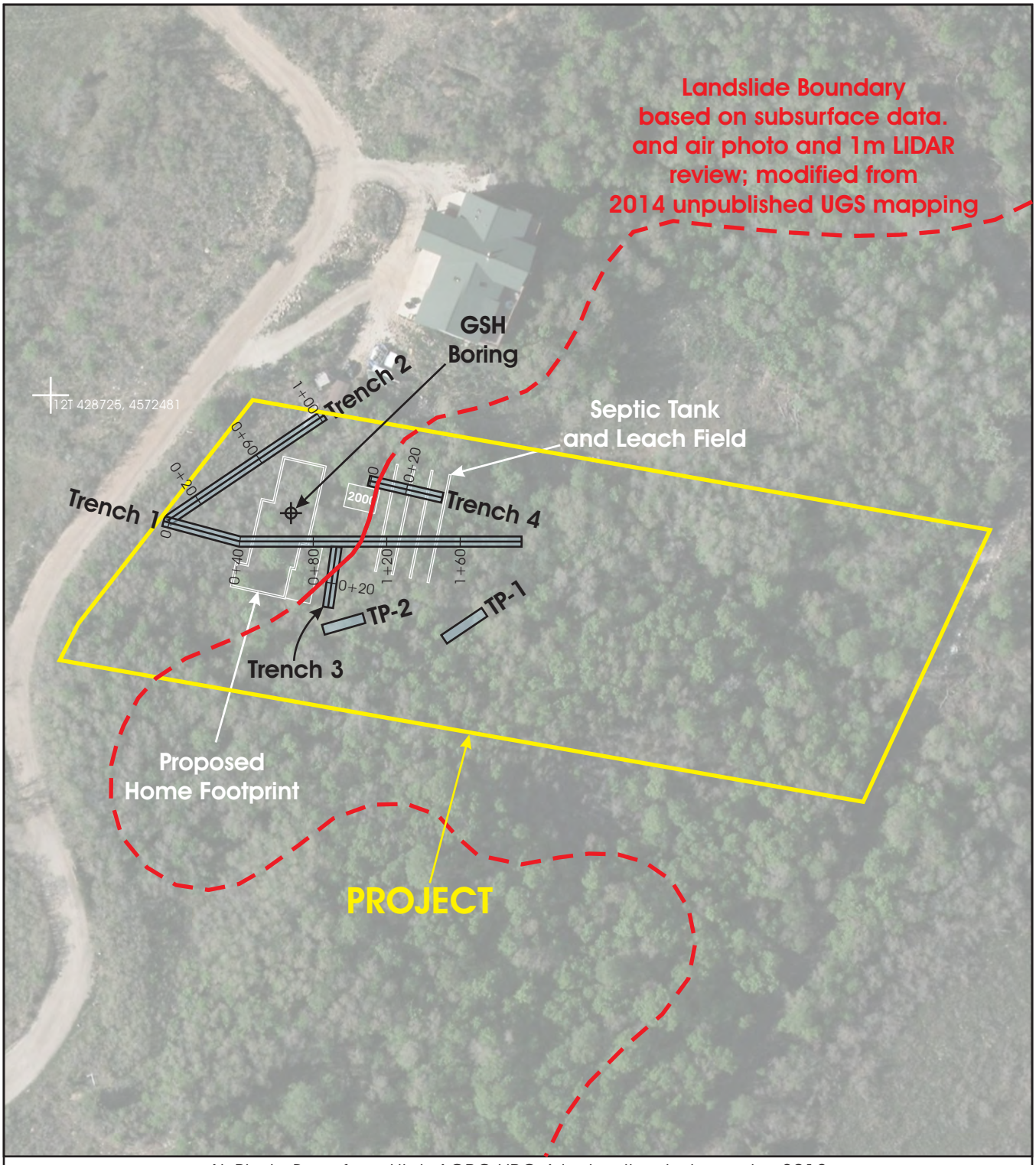
Scale 1:960
(1 inch = 80 feet)

AIR PHOTO AND LIDAR

GEOLOGIC HAZARDS EVALUATION

Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 3



Air Photo Base from Utah AGRC HRO 6-inch orthophotography, 2012

N
W E
S

0 40 80 feet

Scale 1:960
(1 inch = 80 feet)

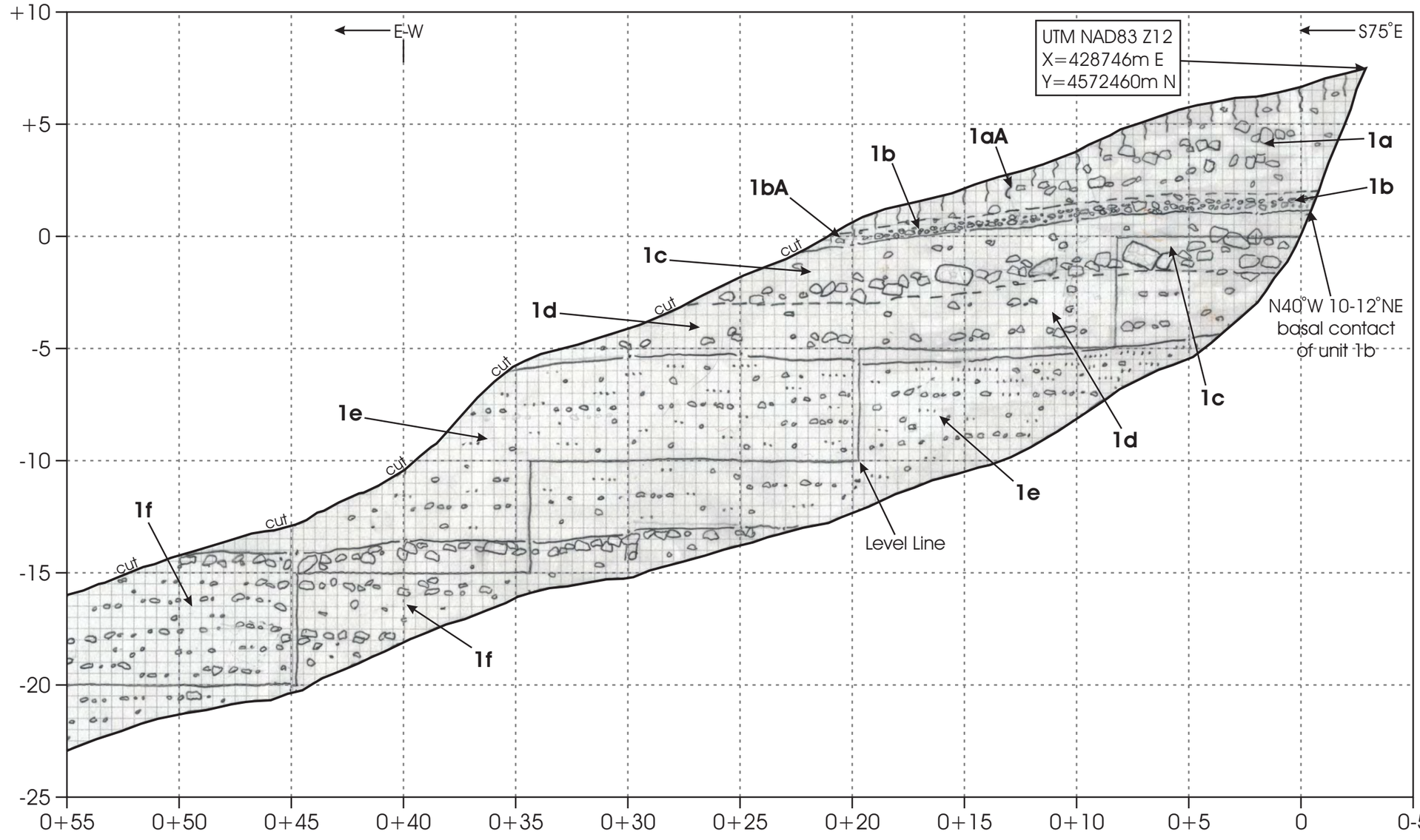
WESTERN GEOLOGIC

SITE PLAN

GEOLOGIC HAZARDS EVALUATION

Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 4



Scale in feet

See Figure 5d for unit descriptions

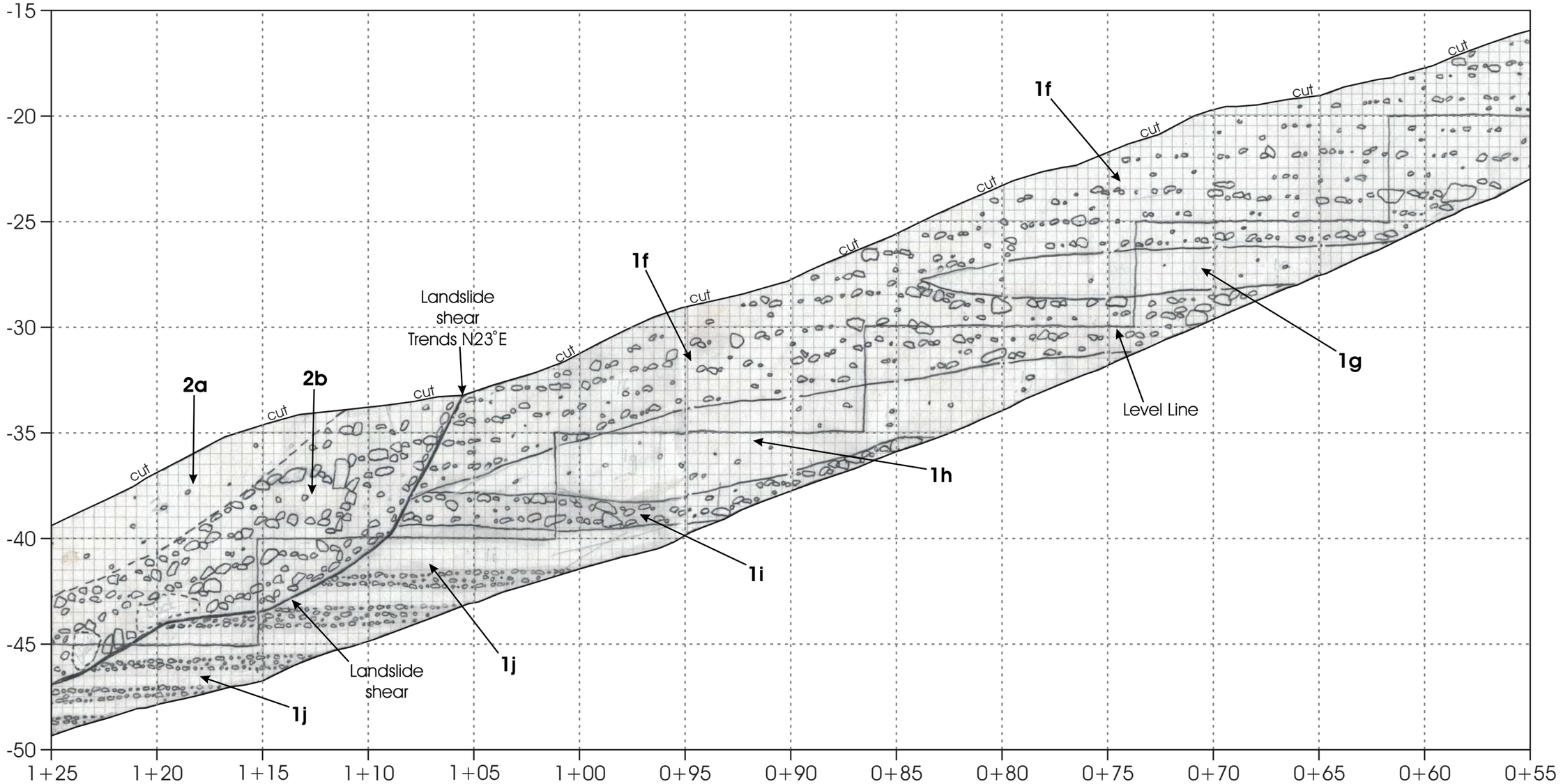
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
South Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on January 12-13, 2016
Reviewed by Craig V Nelson, P.G.

TRENCH 1 LOG, SHEET 1

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 5A



Scale in feet

See Figure 5d for unit descriptions

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

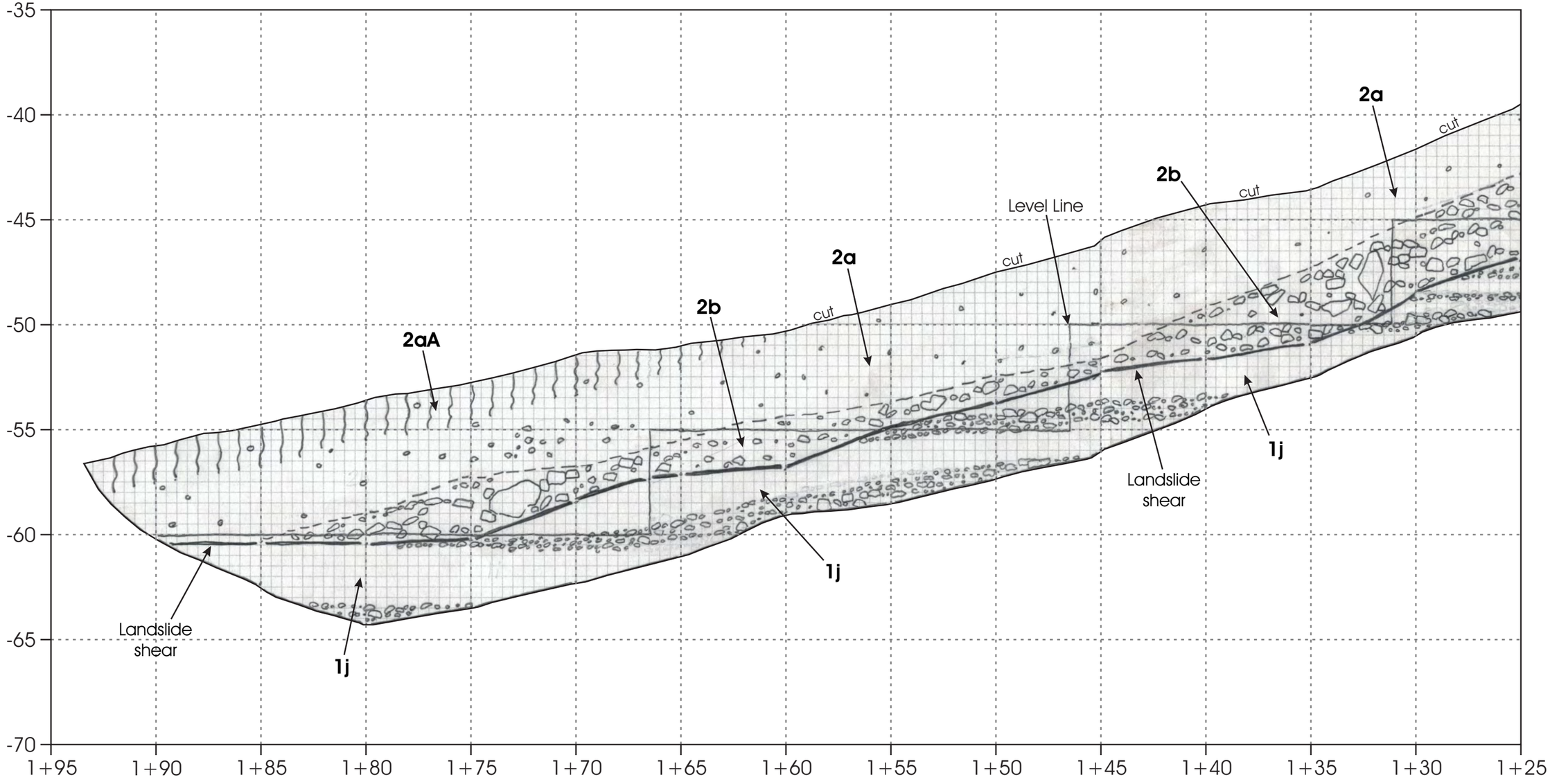
Trench logged by Bill D Black, P.G.
on January 12-13, 2016
Reviewed by Craig V Nelson, P.G.

WESTERN GEOLOGIC

TRENCH 1 LOG, SHEET 2

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 5B



Scale in feet

See Figure 5d for unit descriptions

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

Trench logged by Bill D Black, P.G.
on January 12-13, 2016
Reviewed by Craig V Nelson, P.G.

TRENCH 1 LOG, SHEET 3

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 5C

UNIT DESCRIPTIONS

Unit 1. *Weathered tuffaceous conglomerate bedrock of the Tertiary Norwood Tuff.*

1a. Pale- to pinkish-brown, massive, dense, gravelly sand to silty gravel (SW/GM); clasts mainly angular to subangular quartzite; upper part slight root penetrated.

1aA. Slightly clay and organic-riched modern A-horizon soil formed in unit 1a.

1b. Pale-grayish brown, massive, dense gravel with sand and silt (GW), clast-supported in zones.

1bA. Disturbed modern A-horizon soil formed in unit 1b, removed to east by trackhoe excavation.

1c. Brown to reddish-brown, massive, dense to very dense, clayey gravel (GM) with cobbles and large boulders; clasts mainly angular to subangular quartzite.

1d. Brown to reddish-brown, massive, dense to very dense, clayey gravel (GM) with cobbles; similar to unit 1c, but boulders rare.

1e. Reddish-brown, massive, very dense, clayey to sandy gravel (GM) with trace cobbles.

1f. Grayish- to reddish-brown, massive, dense, sandy to clayey gravel (HW/GM) with sand, cobbles, and trace boulders.

1g. Brown lean to fat clay (CL/CH) with gravel and sand; massive, dense to very dense.

1h. Brown lean to fat clay (CL/CH) with gravel and sand; massive, dense to very dense.

1i. Grayish- to reddish-brown, massive, dense, sandy to clayey gravel (HW/GM) with sand, cobbles, and trace boulders.

1j. Orange-brown lean to fat clay (CL/CH) with sand, interbedded with grayish-brown clayey gravel (GM); poorly to well bedded; dense to very dense.

Unit 2. *Landslide colluvium.*

2a. Brown, root-penetrated, massive, dense to moderately dense, sandy clay to clayey sand with trace small gravel (CL/SM);

2aA. Disturbed modern A-horizon soil formed in unit 2a, removed to west by trackhoe excavation.

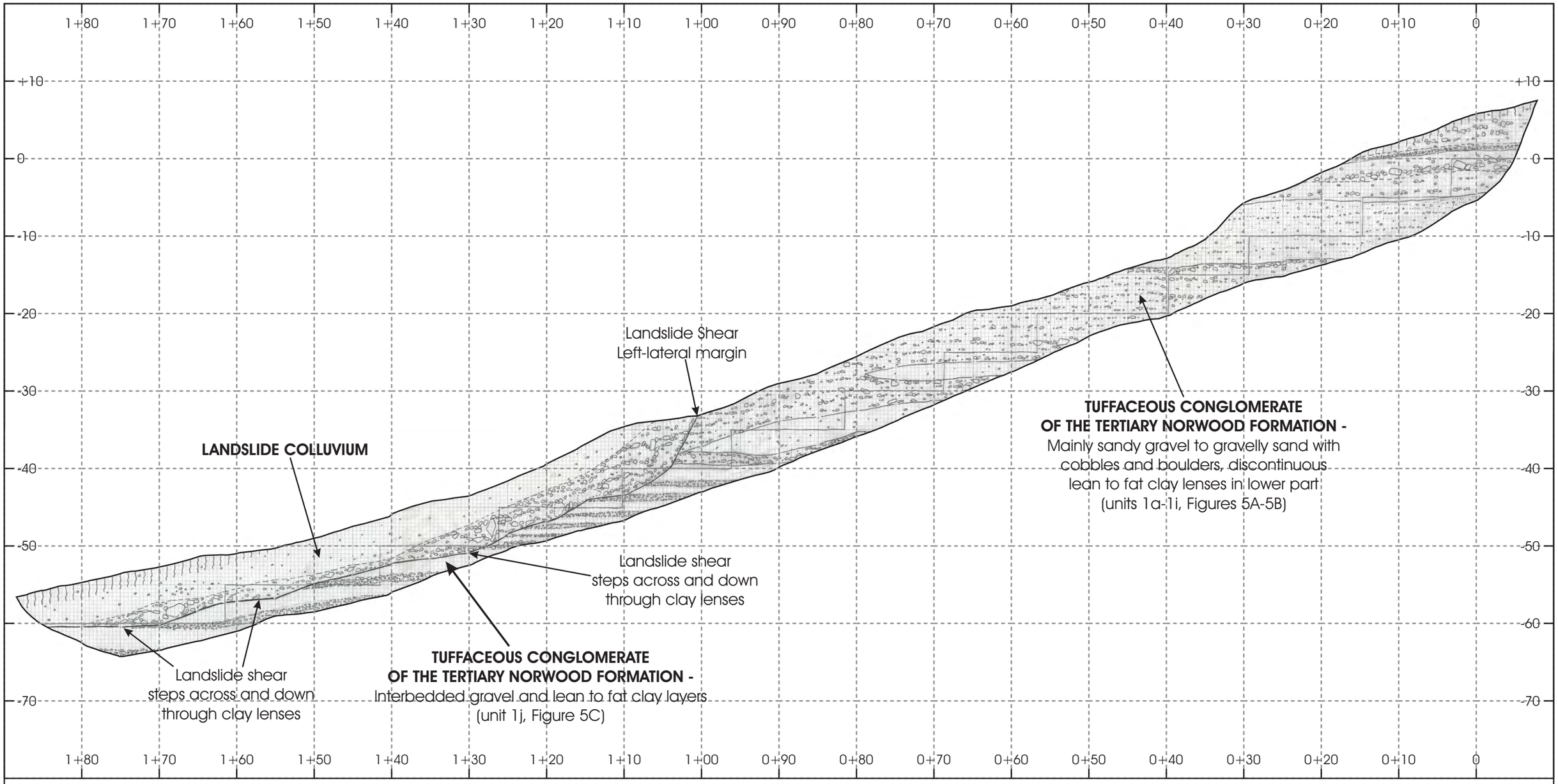
2b. Brown to reddish-brown, dense, massive, sandy clay to clayey sand (CL/SM) with gravel, cobbles, and trace boulders.

WESTERN GEOLOGIC

TRENCH 1 UNIT DESCRIPTIONS

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 5D



Scale in Feet

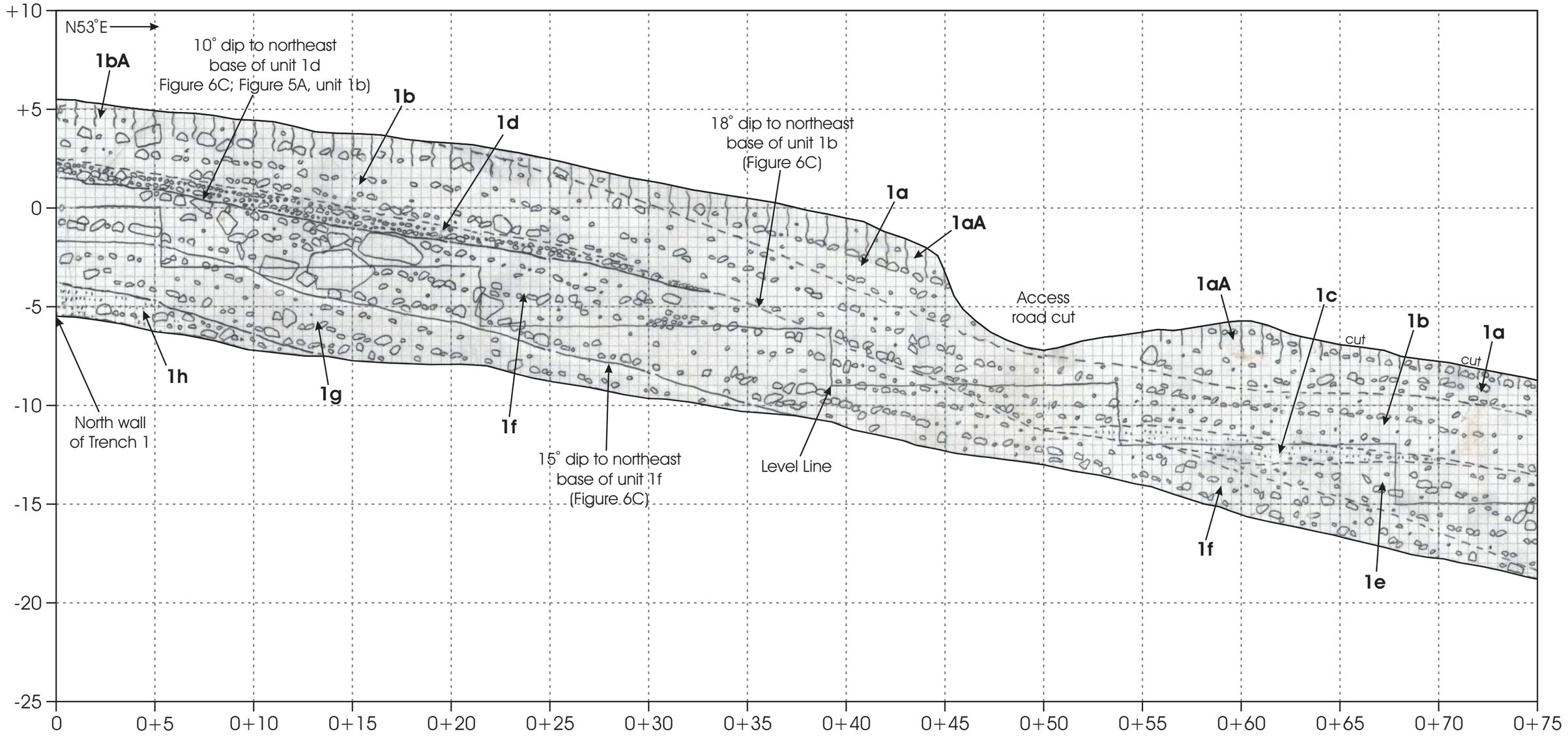
WESTERN GEOLOGIC

SCALE: 1 inch = 12.5 feet
(no vertical exaggeration)
South Wall Logged, West to East

TRENCH 1 LOG OVERVIEW

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 5E



Scale in feet

See Figure 6b for unit descriptions

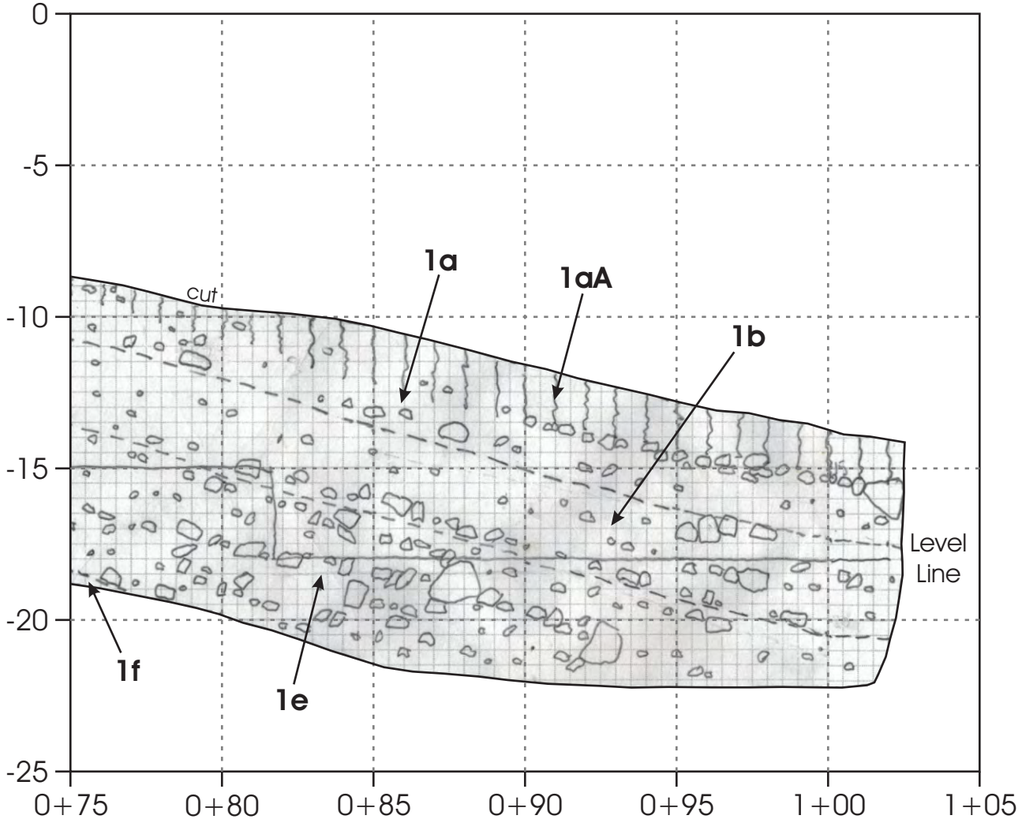
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Wall Logged, West to East

Trench logged by Bill D Black, P.G.
on February 3-4, 2016
Reviewed by Craig V Nelson, P.G.

TRENCH 2 LOG, SHEET 1

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 6A



Scale in feet

UNIT DESCRIPTIONS

Unit 1. *Weathered tuffaceous conglomerate bedrock of the Tertiary Norwood Tuff.*

1a. Brown silty sand (SM) with cobbles and trace boulders, root penetrated, upper part organic rich, poorly bedded to massive with discontinuous cobbly layers; not exposed in Trench 1.

1aA. Modern A horizon soil formed in unit 1a, disturbed at access road and to east.

1b. Pale- to pinkish-brown, massive, dense, gravelly sand to silty gravel (SW/GM); clasts mainly angular to subangular quartzite; correlates to unit 1a in Trench 1.

1bA. Slightly clay and organic-riched modern A-horizon soil formed in unit 1a.

1c. Pale-brown sand (SW) with lesser gravel; possible paleo-channel deposit; not exposed in Trench 1.

1d. Pale-grayish brown, massive, dense gravel with sand and silt (GW), clast-supported in zones; similar stratigraphic position and possibly correlative to unit 1c above; correlates to unit 1b in Trench 1.

1e. Reddish-brown sandy gravel (GW) with silt, cobbles, and boulders; not exposed in Trench 1.

1f. Brown to reddish-brown, massive, dense to very dense, clayey gravel (GM) with cobbles and large boulders; clasts mainly angular to subangular quartzite; correlates to unit 1c in Trench 1.

1g. Brown to reddish-brown, massive, dense to very dense, clayey gravel (GM) with cobbles; similar to unit 1c, but only trace boulders; correlates to unit 1d in Trench 1.

1h. Reddish-brown, massive, very dense, clayey to sandy gravel (GM) with trace cobbles; correlates to unit 1e in Trench 1.

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

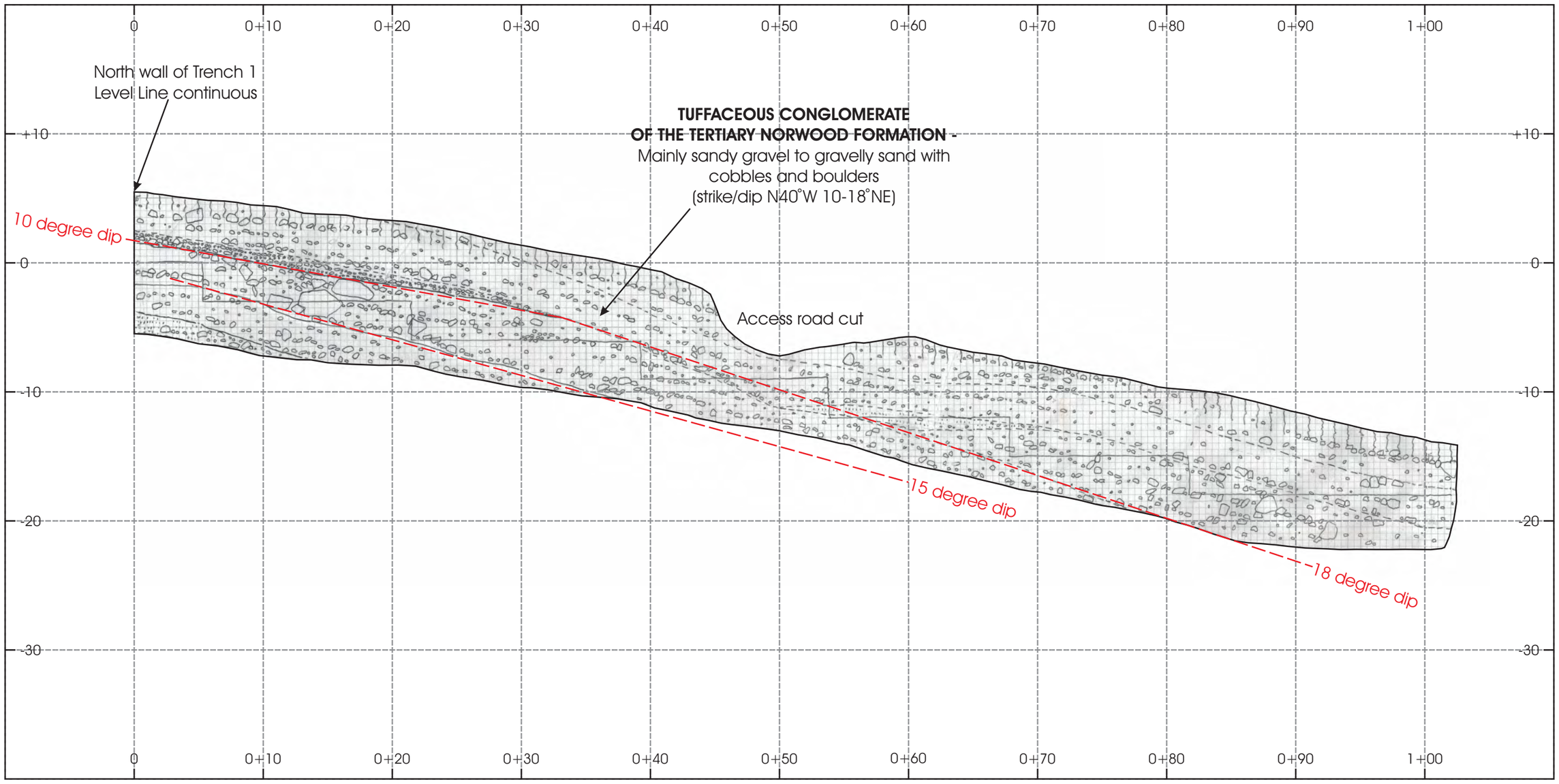
Trench logged by Bill D Black, P.G.
on February 3-4, 2016
Reviewed by Craig V Nelson, P.G.

WESTERN GEOLOGIC

TRENCH 2 LOG, SHEET 2

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 6B



Scale in Feet

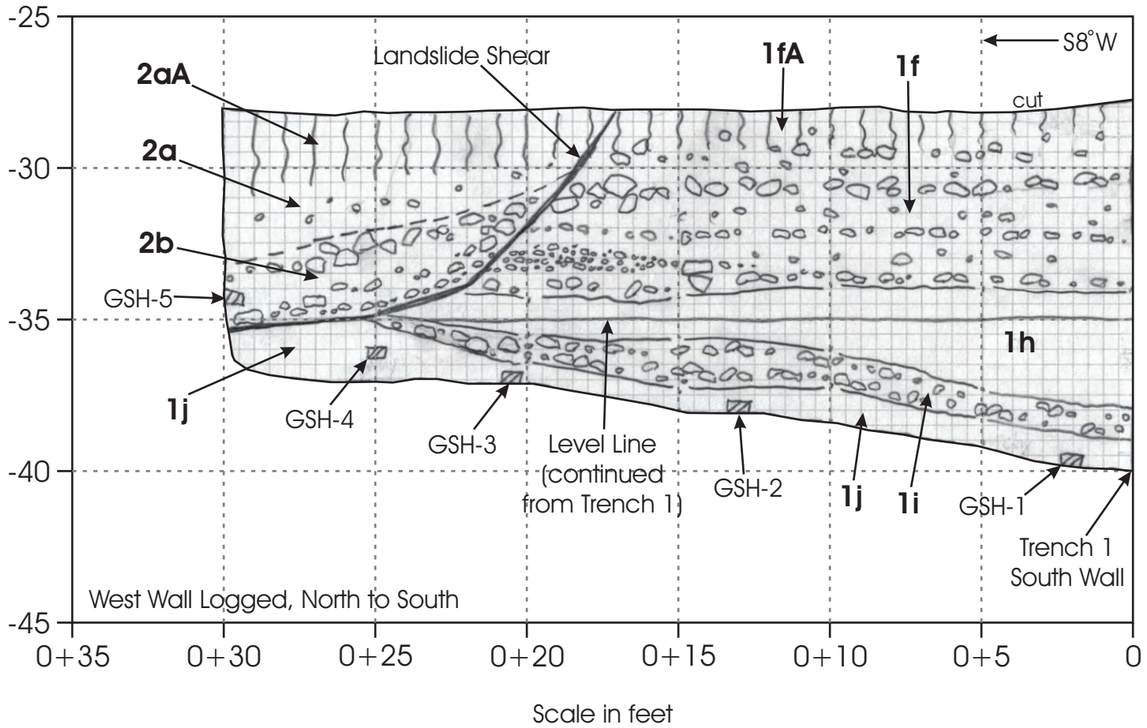
WESTERN GEOLOGIC

SCALE: 1 inch = 8 feet
(no vertical exaggeration)
North Wall Logged, West to East

TRENCH 2 LOG OVERVIEW

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 6C



TRENCH 3 UNIT DESCRIPTIONS

Unit 1. *Weathered tuffaceous conglomerate bedrock of the Tertiary Norwood Tuff.*

1f. Grayish- to reddish-brown, massive, dense, sandy to clayey gravel (HW/GM) with sand, cobbles, and trace boulders.

1fA. Partly disturbed modern A-horizon soil formed in unit 1f.

1h. Brown lean to fat clay (CL/CH) with gravel and sand; massive, dense to very dense.

1i. Grayish- to reddish-brown, massive, dense, sandy to clayey gravel (HW/GM) with sand, cobbles, and trace boulders.

1j. Orange-brown lean to fat clay (CL/CH) with sand, interbedded with grayish-brown clayey gravel (GM); poorly to well bedded; dense to very dense.

2a. Brown, root-penetrated, massive, dense to moderately dense, sandy clay to clayey sand with trace small gravel (CL/SM);

2aA. Disturbed modern A-horizon soil formed in unit 2a, removed to west by trackhoe excavation.

2b. Brown to reddish-brown, dense, massive, sandy clay to clayey sand (CL/SM) with gravel, cobbles, and trace boulders.

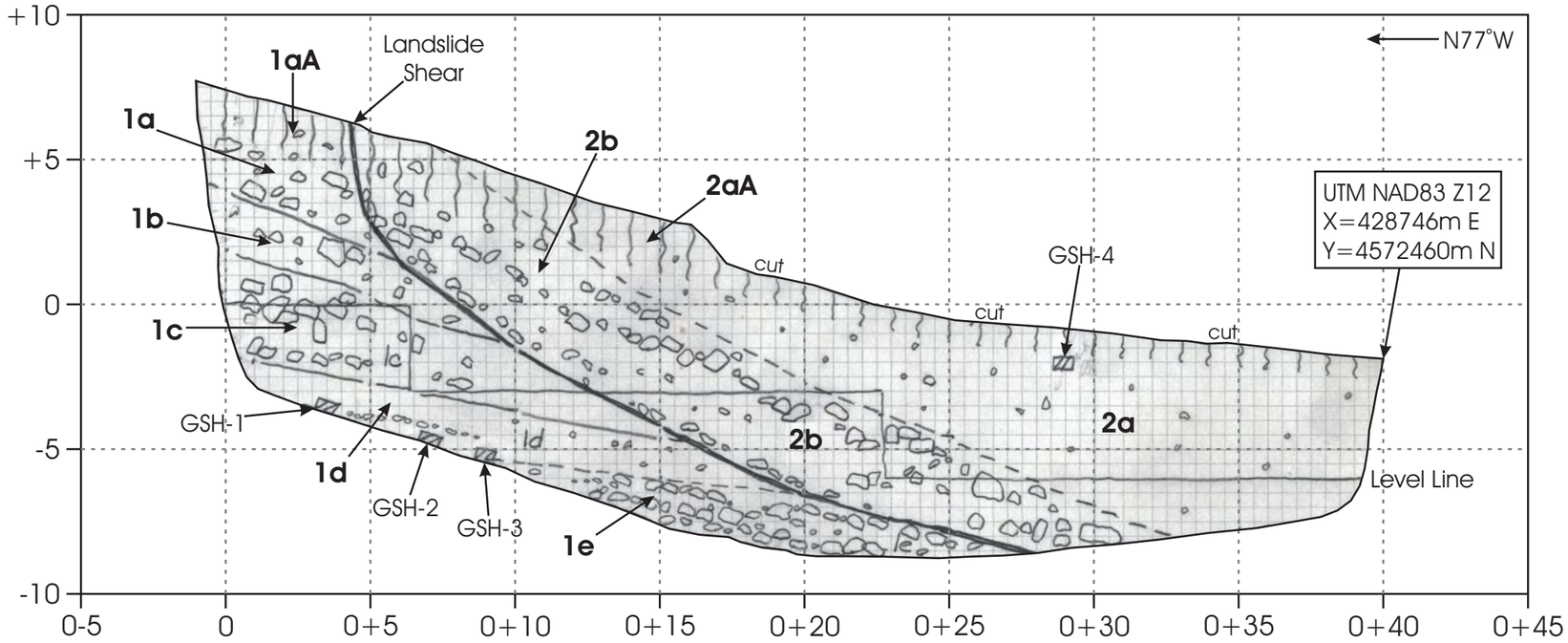
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
West Wall Logged, North to South

Trench logged by Bill D Black, P.G.
on February 5, 2016
Reviewed by Craig V Nelson, P.G.

TRENCH 3 LOG

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 7



Scale in feet

TRENCH 4 UNIT DESCRIPTIONS

Unit 1. *Weathered tuffaceous conglomerate bedrock of the Tertiary Norwood Tuff.*

1a. Pinkish-brown, dense, massive, sand with silt and gravel (SW).

1aA. Modern A-horizon soil formed in unit 1a.

1b. Reddish-brown, dense, massive, gravelly clay with sand (GM)

1c. Orange-brown, dense, massive, clayey sandy gravel (GM) with cobbles.

1d. Orange-brown, dense, poorly bedded to massive, lean to fat clay (CL/CH) with gravel lenses.

1e. Pale-brown, dense, sandy gravel (GW) with silt and cobbles; some clayey zones; clasts angular to subrounded quartzite.

Unit 2. *Landslide colluvium.*

2a. Brown, moderate density, clayey sand (SM) with silt and trace gravel; upper part root penetrated.

2aA. Partly disturbed modern A-horizon soil formed in unit 2a.

2b. Brown to pinkish-brown, massive, moderate to high density, silty to clayey sand (SM) with gravel and cobbles.

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

Trench logged by Bill D Black, P.G.
on February 5, 2016
Reviewed by Craig V Nelson, P.G.

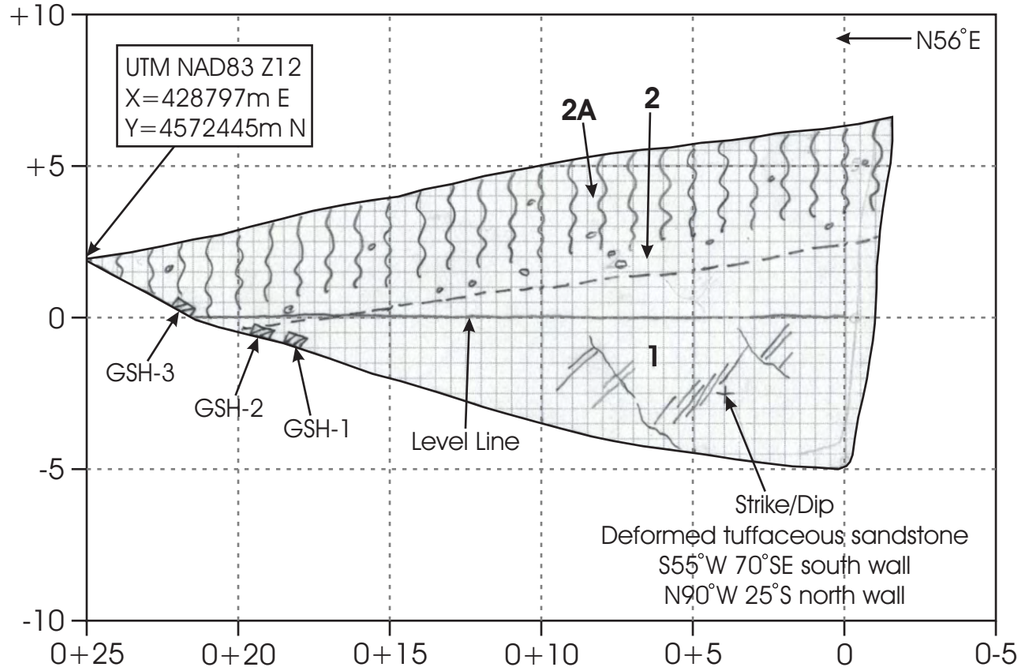
WESTERN GEOLOGIC

TRENCH 4 LOG

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 8

TEST PIT 1



Scale in feet

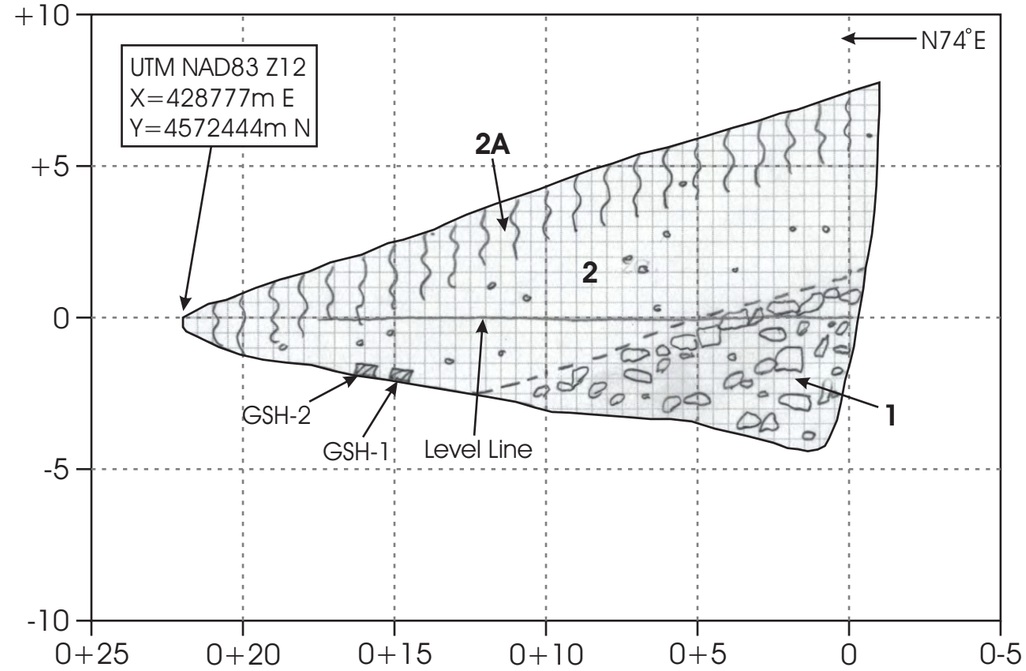
UNIT DESCRIPTIONS

Unit 1. *Landslide colluvium* - deformed block of tuffaceous sandstone of the Tertiary Norwood Tuff; pale-olive-brown to buff, highly fractured, well-bedded, clayey sandstone; iron oxide staining along root penetrations; bedding subvertical in some zones.

Unit 2. *Landslide colluvium* - reddish-brown to brown, massive, dense, sandy lean to fat clay (CL/CH) with trace gravel; resembles unit 2a in Trench 1.

2A. Modern A-horizon soil formed in unit 2.

TEST PIT 2



Scale in feet

UNIT DESCRIPTIONS

Unit 1. *Landslide colluvium* - brown to reddish-brown, dense, massive, sandy clay to clayey sand (CL/SM) with gravel, cobbles, and trace boulders; resembles unit 2b in Trench 1.

Unit 2. *Landslide colluvium* - brown, root-penetrated, massive, dense, sandy lean to fat clay (CL/CH) with trace small gravel; resembles unit 2a in Trench 1.

2A. Modern A-horizon soil formed in unit 2.

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

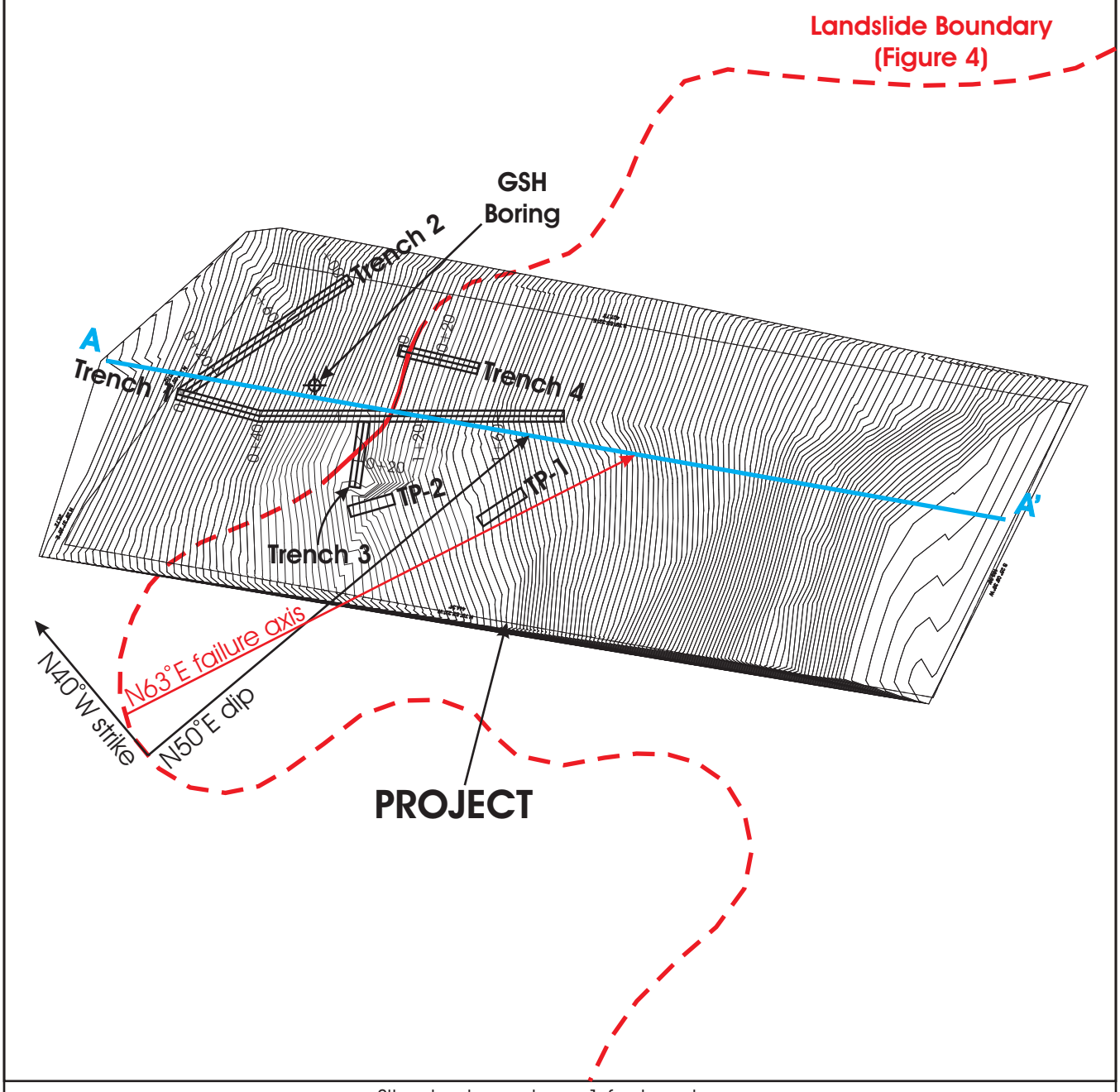
Trench logged by Bill D Black, P.G.
on January 14, 2016
Reviewed by Craig V Nelson, P.G.

WESTERN GEOLOGIC

TEST PIT LOGS

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 9



Site plan base shows 1-foot contours.

N
W E
S

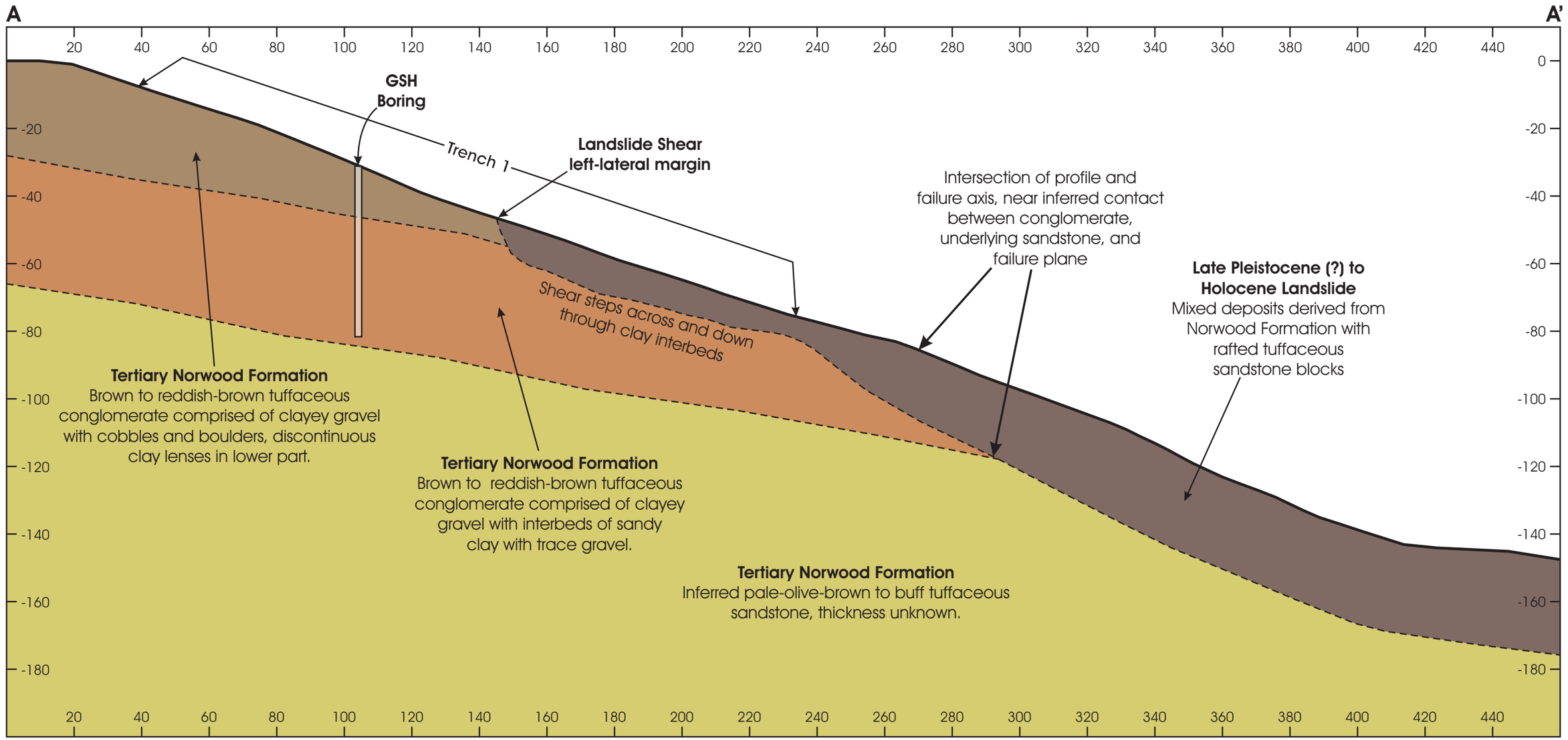
0 40 80 feet

Scale 1:960
(1 inch = 80 feet)

PROFILE LOCATION

GEOLOGIC HAZARDS EVALUATION
Lot 23 Big Sky Estates No. 1
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 10A



Scale in Feet

WESTERN GEOLOGIC

SCALE: 1 inch = 30 feet
No vertical exaggeration
Contacts based on subsurface data and are inferred in unexplored areas and at depth

CROSS SECTION

GEOLOGIC HAZARDS EVALUATION
Lot 23, Big Sky Estates Phase I
2292 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 10B