REPORT

GEOLOGIC HAZARDS RECONNAISSANCE

MARTINEZ PROPERTY

ABOUT 4700 NORTH SHEEP CREEK DRIVE

EDEN, WEBER COUNTY, UTAH

Prepared for

Lonnie Martinez
2596 North 2075 West
Ogden, Utah 84404

April 12, 2019

Prepared by

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April 12, 2019

Lonnie Martinez
2596 North 2075 West
Ogden, Utah 84404

SUBJECT: Geologic Hazards Reconnaissance
Martinez Property
About 4700 North Sheep Creek Drive
Eden, Weber County, Utah

Dear Mr. Martinez:

This report presents the results of a reconnaissance-level engineering geology and geologic hazards review and evaluation conducted by Western Geologic & Environmental LLC (Western Geologic) for the Martinez Property in Eden, Utah (Figure 1 – Project Location). The Project consists of a 15.13-acre parcel identified as Weber County Assessor parcel number 22-007-0101. The site is on generally southwest-facing slopes overlooking Sheep Creek about 0.8 miles northeast of Liberty in the NE1/4 Section 17, Township 7 North, Range 1 East (Salt Lake Base Line and Meridian). Elevation of the site is 5,121 to 5,188 feet above sea level. It is our understanding that the intended development is for one single-family residential home in the north part of the parcel on a terrace overlooking Sheep Creek, which flows to the south across the western part of the site.

PURPOSE AND SCOPE

The purpose and scope of this investigation is to identify and interpret surficial geologic conditions at the site and identify potential risk from geologic hazards to the project. This investigation is intended to: (1) provide preliminary 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. No hazard-specific evaluations or subsurface exploration were conducted for this report or within the scope of our study.

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;

- 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 Bowman and Lund (2016) and 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 within the above stated scope. However, we do not include discussion of radon hazard potential, as recommended in Bowman and Lund (2016), because radon gas poses an environmental health hazard and indoor levels are heavily influenced by several post-construction, non-geologic factors. The hazard from radon should be evaluated by long-term testing following construction.

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows Sheep Creek flows southward across the western part of the property, merges with North Fork Ogden River about 0.6 miles to the south, and then flows into Pineview Reservoir in the valley (Figure 1). Two ephemeral drainages also flow across the northeast part of the property that converge east of the proposed home location, flow to the south and west across the site, and merge with Sheep Creek. These drainages head in higher slopes northeast of the site. No springs are mapped at the Project on Figure 1, but a broad area of several springs is about 800 to 1,100 feet to the east (Figure 1).

The site is in northeastern Ogden Valley, which is dominated in the valley bottom by unconsolidated lacustrine and alluvial basin-fill deposits. Slopes in the site area are generally underlain by mixed alluvial and lacustrine sediments and weathered bedrock of the Maple Canyon Formation. The Utah Division of Water Rights Well Driller Database indicates one water well is onsite and ten water wells are within 0.5 miles of the Project (Figure 1). A copy of the well drillers' report for the onsite well is included in the Appendix. Static groundwater in the onsite well is reportedly at a depth of 8 feet below the ground surface (bgs), whereas nearby wells show static groundwater depths ranging between 0 to 82 feet bgs (Figure 1). Given the above, we anticipate groundwater at the Project is generally less than 10 feet deep. However, groundwater depth at the site may vary locally, 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 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).

GEOLOGY

Surficial Geology

The site is located in northeastern Ogden Valley, a sediment-filled intermontane valley within the Wasatch Range. The Wasatch Range is 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 mapped by Coogan and King (2016) as stream alluvium on the west and southwest (unit Qal); alluvial-deltaic and lacustrine sediments on the north, middle and southeast (units Qadb and Qdlb); and fan alluvium and colluvium on the northeast and east (units Qaf, Qafy and Qac; Figure 2). The proposed home location appears to be underlain by alluvial-deltaic sediments (unit Qadb, Figure 2).

Coogan and King (2016) describe surficial geologic units in the site area on Figure 2 as follows:

> ***Qh, Qh?*** *- Human disturbances (Historical).* Mapped disturbances obscure original deposits or rocks by cover or removal; only larger disturbances that pre-date the 1984 aerial photographs used to map the Ogden 30 x 60- minute quadrangle are shown; includes engineered fill, particularly along Interstate Highways 80 and 84, the Union Pacific Railroad, and larger dams, as well as aggregate operations, gravel pits, sewage-treatment facilities, cement plant quarries and operations, brick plant and clay pit, Defense Depot Ogden (Browning U.S. Army Reserve Center), gas and oil field operations (for example drill pads) including gas plants, and low dams along several creeks, including a breached dam on Yellow Creek.
>
> ***Qal, Qal1, Qal2, Qal2?*** *- Stream alluvium and flood-plain deposits (Holocene and uppermost Pleistocene).* Sand, silt, clay, and gravel in channels, flood plains, and terraces typically less than 16 feet (5 m) above river and stream level; moderately sorted; unconsolidated; along the same drainage Qal2 is lower than Qat2 and has likely been subject to flooding, at least prior to dam building; present in broad plains along the Bear, Ogden, and Weber Rivers and larger tributaries like Deep, Cottonwood, East Canyon, Lost, and Saleratus Creeks, along Box Elder, Heiners, and Yellow Creeks, and in narrower plains of larger tributary streams; locally includes muddy, organic overbank and oxbow lake deposits; composition depends on source area, so in back valleys typically contains many quartzite cobbles recycled from the Wasatch Formation; mostly Holocene, but deposited after regression of Lake Bonneville from the late Pleistocene Provo shoreline; width in Morgan Valley is combined flood plain of Weber River and East Canyon and Deep Creeks; 6 to 20 feet (2-6 m) thick and possibly as much as 50 feet (15 m) along Weber River and thinner in the Kaysville quadrangle; greater thicknesses (>50 feet [15 m]) are reported in Morgan Valley (Utah Division of Water Rights, well drilling database), but likely include Lake Bonneville and older Pleistocene deposits.
>
> Suffixes 1 and 2 indicate ages where they can be separated, with 1 including active channels and 2 including low terraces 10 to 20 feet (3-6 m) above the Weber and Ogden Rivers, and the South Fork Ogden River that may have been in the flood plain prior to damming of these waterways. Qal2 queried in low terraces above Bear River, Saleratus Creek, and Dry Creek where deposits may not be in the flood plain.

Qaf, Qafy, Qaf3, Qaf3?, Qaf4, Qaf4?, Qaf5 - Alluvial-fan deposits (Holocene and Pleistocene). Mostly sand, silt, and gravel that is poorly bedded and poorly sorted and that is not close to late Pleistocene Lake Bonneville and is geographically in the Huff Creek and upper Bear River drainages; variably consolidated; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Qaf with no suffix used where age uncertain or for composite fans where portions of fans with multiple ages cannot be shown separately at map scale; toes of some fans have been removed by human disturbances, so their age cannot be determined.

Where possible, subdivided into relative ages, indicated by letter and number suffixes (like Qa and Qat suffixes) and relative ages only apply to the local drainage, with unit Qafy being the lowest (youngest) fans and unit 3 may or may not post-date Lake Bonneville. Relative ages of these fans are partly based on heights above present drainages at drainage-eroded edge of fan. The relative age is queried where the age is uncertain, generally due to the height not fitting into the typical order of surfaces. The various deposits listed, Qafy and Qaf3 through Qaf5, are 20 to 140 feet (6-40 m) above and west of Saleratus Creek, and also above Yellow Creek and the Bear River. Qafy fans are active, impinge on present-day floodplains, divert active streams, and overlie low terraces.

Qc - Colluvium (Holocene and Pleistocene). Unsorted clay- to boulder-sized material; includes material moved by slope wash and soil creep; composition depends on local sources; as shown generally 10 to 20 feet (3-6 m) thick; not shown where less than 10 feet (3 m) thick.

Qac - Alluvium and colluvium (Holocene and Pleistocene). Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits too small to show at map scale; typically mapped along smaller drainages that lack flat bottoms; more extensive east of Henefer where Wasatch Formation (Tw) strata easily weather to debris that "chokes" drainages; 6 to 20 feet (2-6 m) thick. Some deposits are "perched" on benches 80 feet (25 m) and more above present-day drainages like Left Fork Heiners Creek (Heiners Creek quadrangle) and Harris Canyon (Henefer quadrangle). In the Devils Slide quadrangle, some deposits are "perched" on benches about 60 to 130 feet (18-40 m) above Quarry Cottonwood Canyon indicating the alluvium is at least partly Lake Bonneville age and older (see Qab and Qao in tables 1 and 2).

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso? - Landslide deposits (Holocene and upper and middle? Pleistocene). Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods; 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 material during emplacement; Qms may be in contact with Qms when landslides are different/distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are "perched" above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qls, Qls?, Qlsp, Qlsb, Qlsb? *- Lake Bonneville sand (upper Pleistocene).* Mostly sand with some silt and gravel deposited nearshore below and near the Provo shoreline (Qlsp) and between the Provo and Bonneville shorelines (Qlsb); Qls mapped downslope from slope break below Provo shoreline beach deposits where thin Lake Bonneville regressional sand may overlie transgressional sand; grades downslope into unit Qlf with decreasing sand content and laterally with more gravel into units Qdlp, Qdlb, and upslope with more gravel into unit Qlgb; Qls and Qlsb queried where grain size or unit identification uncertain; may be as much as 75 feet (25 m) thick, and thickest near Ogden; typically less than 20 feet (6 m) thick in Morgan Valley; may include small deltas and deltas that lack typical delta shape.

Qdlb, Qdlb? *- Transgressive and Bonneville-shoreline deltaic and lacustrine deposits (upper Pleistocene)* – Mostly sand, silty sand, and gravelly sand deposited near shore in Lake Bonneville; extensive at mouth of Weber Canyon; related to transgression to and occupation of the Bonneville shoreline with lacustrine deposits covering deltaic deposits; in Morgan Valley and near mouth of Coldwater Canyon (North Ogden quadrangle) contain more cobbles and overall more gravel; 0 to at least 40 feet (12 m) thick in Ogden and Morgan Valleys; about 400 feet (120 m) thick in bluff at the mouth of Weber Canyon. These deposits are prone to slope failures.

Qadb, Qadb? *- Transgressive and Bonneville-shoreline alluvial and deltaic deposits (upper Pleistocene).* Cobbly gravel, sand, silt, and clay deposited above (subaerial) and in Lake Bonneville (subaqueous); typically mapped where shorelines are obscure, so that line cannot be drawn between alluvial fan and delta; include rounded to subangular clasts in a matrix of sand and silt with interbeds of sand and silt; mapped above the Provo shoreline and deposited as lake transgressed to and was at the Bonneville shoreline; typically better sorted delta and lake deposits over poorly sorted alluvial-fan deposits; Qadb prominent along Deep Creek (Morgan quadrangle) and Strawberry Creek (Snow Basin quadrangle); 0 to at least 40 feet (0-12+ m) thick. Note that the Bonneville-shoreline fan-delta unit (Qadb), at 80 to 100 feet (24-30 m) above present drainages, is typically higher than the related alluvial units (Qab, Qafb) (see table 1). A fan-delta is built when an alluvial fan enters a lake or ocean and includes both the fan and the delta.

Qla, Qla? - Lake Bonneville lacustrine deposits and post- and pre-Lake Bonneville alluvial deposits, undivided (Holocene and upper? Pleistocene). Mostly poorly sorted and poorly bedded sand, silt, and clay, with some gravel; mapped where Lake Bonneville deposits are reworked by later stream action or covered by thin stream and fan deposits, and where lake deposits are thin and overlie older alluvial deposits; unit queried where may be dominantly alluvium; deposits typically eroded from shallow Norwood Formation; mostly mapped near Bonneville shoreline; also mapped in Peterson quadrangle along upper Deep Creek above Bonneville shoreline where lake deposits seem to indicate landslide dam of creek; thickness uncertain.

Qafo, Qafo? - Older alluvial-fan deposits (mostly upper Pleistocene). Incised and at least locally dissected 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); older fans are typically above the Bonneville shoreline, with an eroded bench at the shoreline; upstream and above the Bonneville shoreline, unit Qafo is topographically higher than fans graded to the Bonneville shoreline (Qafb), and is typically dissected; generally less than 60 feet (18 m) thick. In Mantua Valley, exposed thickness up to about 100 feet (30 m), but water wells (sections 26 and 27, T. 9 N., R. 1 W.) were still in gravelly to bouldery valley fill at depths of 505 and 467 feet (154 and 142 m), respectively, and red coloration that may indicate Wasatch Formation bedrock was not noted (see Bjorklund and McGreevy, 1973, p. 16).

Qafo queried where relative age is uncertain (see Qaf for details), for example in Mantua quadrangle where it is as high as Qafoe in Morgan Valley (see table 1). Qafo queried in East Canyon graben because the deposits are not dissected and some deposits mantle Qafoe (see also unit Qafm above), resulting in a reversal of relative height and only local incision. These irregular deposits are likely the result of salt movement in the East Canyon graben. Our Qafo is roughly shown to south by Bryant (1990) as Qgp (pediment gravel); farther south he showed Qoa (dissected alluvium) adjacent to the East Canyon fault, which may be the QTaf or Qafoe we mapped.

Amino-acid age estimates presented in Sullivan and Nelson (1992) imply Qafo north of Morgan considerably predates Lake Bonneville and is middle Pleistocene in age (>400 ka). However, the Bonneville shoreline is obscure on this fan, and soil-carbonate age estimates (>70-100 ka) and other amino acid age estimates (~98-155 ka) in Sullivan and others (1988) imply these older fans are related to Bull Lake glaciation (95,000 to 130,000 years old; see Chadwick and others, 1997; Phillips and others, 1997). As noted under Qao, Qafo deposits may contain two ages (levels) of alluvial surfaces that are not easily recognized in Morgan Valley but are recognized upstream in the Henefer and Lost Creek Valleys (Devils Slide quadrangle) and along the North and South Forks of Ogden River.

Qafoe-QTaf - Older eroded fan and/or pediment-mantle deposits (middle or lower Pleistocene). Gravel, sand, silt, and clay in alluvium and colluvium that cap surfaces that are partly correlative with the pre-Lake Bonneville McKenzie Flat geomorphic surface of Williams (1948) (see McCalpin, 1989); in Paradise quadrangle, McCalpin (1989) described this unit (his afo) as forming dissected surfaces 50 to 1000 feet (15-300 m) above active streams, and commonly present as a relatively thin discontinuous veneer, less than 33 feet (10 m) thick, on a surface (pediment) "cut" on Tertiary Salt Lake Formation; but our mapping, which reduces colluvium bias ("slough"), indicates the surface edges are about 100 to 400 feet (30-120 m) above adjacent drainages.

McKenzie Flat is a gently north-inclined little-dissected bench capped by these deposits in the James Peak and Paradise quadrangles, with the flat along the axis of a broad open syncline in the underlying Salt Lake Formation. Dissected surfaces on eroded remnants of these deposits dip west from the East Cache fault zone to McKenzie Flat, with dips that are nearly the same as bedding in the underlying Salt Lake Formation in the east limb of the syncline. This implies the west-dipping surfaces are capped by residual deposits rather than being tilted fan deposits, and the flat may have the same origin. Alternatively the flat and limb deposits have two different origins, fan and lag/residual, respectively. Fans on McKenzie Flat could be middle Pleistocene (McCalpin, 1989; see also Sullivan and Nelson, 1992) (Little Valley or Pokes Point lake cycle) and/or early Pleistocene (after Sullivan and others, 1988) in age; although the lower heights above the adjacent drainages fit this middle and early Pleistocene age (Qafoe), the upper limit is in the range of Quaternary-Pliocene fans (QTaf).

Mullens and Izett (1964) did not map the McKenzie Flat deposits but described them as an upper 20 to 40 feet (6-12 m) of conglomerate that rests with angular unconformity on the main Salt Lake Formation conglomerate. They noted that exposures in the James Peak quadrangle, pointed out by Dr. C.T. Hardy of Utah State University, show this relationship. The angular unconformity supports a fan origin for the deposits on the north-inclined McKenzie Flat. Mullens and Izett (1964) also noted that sub-rounded boulders of quartzite derived from Precambrian and Cambrian formations are scattered on McKenzie Flat and boulders average about 1 foot (30 cm) in diameter, but some are as much as 3 feet (90 cm) in diameter.

The Precambrian (Neoproterozoic) and Cambrian quartzite boulders could be recycled from the Salt Lake Formation conglomerate, the Wasatch Formation, or be from quartzite exposures to the south in the James Peak quadrangle. The latter implies transport to the north into lower parts of Cache Valley. When the boulders were transported is more problematic, since they could be a lag from the underlying Salt Lake Formation rather than being transported during Pleistocene fan deposition.

Tn, Tn? *- Norwood Formation (lower Oligocene and upper Eocene).* Typically light-gray to light-brown altered tuff (claystone), altered tuffaceous siltstone and sandstone, and conglomerate; unaltered tuff, present in type section south of Morgan, is rare; locally colored light shades of red and green; variable calcareous cement and zeolitization; involved in numerous landslides of various sizes; estimate 2000-foot (600 m) thick in exposures on west side of Ogden Valley (based on bedding dip, outcrop width, and topography). Norwood Formation queried where poor exposures may actually be surficial deposits. For detailed Norwood Formation information see description under heading "Sub-Willard Thrust - Ogden Canyon Area" since most of this unit is in and near Morgan Valley and covers the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Cgc, Cgc? *- Geertsen Canyon Quartzite (Middle and Lower Cambrian and possibly Neoproterozoic).* In the west mostly buff (off-white and tan) quartzite, with pebble conglomerate beds; pebbles are mostly rounded light colored quartzite; contains cross bedding, and pebble layers and lenses; colors vary from tan and light to medium gray, with pinkish, orangish, reddish, and purplish hues; outcrops darker than these fresh quartzite colors; cliff forming; some brown-weathering, interbedded micaceous argillite and quartzite common at top and mappable locally; pebble to cobble conglomerate lenses more abundant in middle part of quartzite, and basal, very coarse-grained arkose locally; near Huntsville, total thickness about 4200 feet (1280 m), including upper argillite about 375 feet (114 m) thick and basal coarse-grained arkose (arkosic to feldspathic quartzite) about 300 to 400 feet (90-120 m) thick (Crittenden and others, 1971). Overall seems to be thinner near Browns Hole. Called Prospect Mountain Quartzite and Pioche Shale (argillite at top) by some previous workers.

Upper and lower parts of Crittenden and others (1971; Crittenden, 1972; Sorensen and Crittenden, 1979) are not mappable outside the Browns Hole and Huntsville quadrangles, likely because the marker cobble conglomerate and change in grain size and feldspar content reported by Crittenden and others (1971) is not at a consistent horizon; quartz-pebble conglomerate beds are present in most of the Geertsen Canyon Quartzite.

To the east on leading margin of Willard thrust sheet, the Geertsen Canyon is thinner, an estimated 3200 feet (975 m) total thickness (Coogan, 2006a-b), and may be divided into different members, though informal members to west and east are based on conglomerate lenses near member contact and feldspathic lower member (see Crittenden and others, 1971; Coogan, 2006a-b).

Lower part in west (Cgcl, Cgcl?) is typically conglomeratic and feldspathic quartzite (only up to 20% feldspar reported by Crittenden and Sorensen, 1985a, so not an arkosic), with 300- to 400-foot (90-120 m), basal, very coarse-grained, more feldspathic or arkosic quartzite; 1175 to 1700 feet (360-520 m) thick (Crittenden and others, 1971; Crittenden, 1972; Sorensen and Crittenden, 1979) and at least 200 to 400 feet (60-120 m) thinner near Browns Hole (compare Crittenden, 1972 to Sorensen and Crittenden, 1979). Unit queried where poor exposures may actually be surficial deposits.

Zmcg, Zmcg? *- Maple Canyon Formation, Lower (green arkose) member (Neoproterozoic).* Grayish-green, fine-grained arkosic (feldspathic) meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses up to 200 feet (60 m) thick; weathers darker gray to brown to greenish-gray and greenish-brown; 500 to 1000 feet (150-305 m) thick and lower thickness would eliminate the need for faulting in southwest part of Huntsville quadrangle. This unit is prone to slope failures.

Zcc, Zcc? *- Caddy Canyon Quartzite (Neoproterozoic).* Mostly vitreous, almost white, cliff-forming quartzite; colors vary and are tan, light-gray, pinkish-gray, greenish-gray, and purplish-gray, that are typically lighter shades than the Geertsen Canyon Quartzite; 1000 to 2500 feet (305-760 m) thick in west part of our map area, thickest near Geertsen Canyon in Huntsville quadrangle (Crittenden and others, 1971; Crittenden, 1972); 1500 feet (460 m) thick near South Fork Ogden River (Coogan and King, 2006); thinner, 725 to 1300 feet (220-400 m) thick, and less vitreous on leading edge of Willard thrust sheet. Lower contact with Kelley Canyon Formation is gradational with brownish-gray quartzite and argillite beds over a few tens to more than 200 feet (3-60 m) (see Crittenden and others, 1971). Where thick, this gradational-transitional zone is what is mapped as the Papoose Creek Formation. Near Geertsen Canyon, this transition zone is 600 feet (180 m) thick and was mapped with and included in the Caddy Canyon Quartzite by Crittenden and others (1971, figure 7), and in the Caddy Canyon and Kelley Canyon Formations by Crittenden (1972, see lithologic column).

Zkc, Zkc? - *Kelley Canyon Formation (Neoproterozoic).* Dark-gray to black, gray to olive-gray-weathering argillite to phyllite, with rare metacarbonate (for example basal meta-dolomite); grades into overlying Caddy Canyon quartzite with increasing quartzite; gradational interval mapped as Papoose Creek Formation (Zpc); 1000 feet (300 m) thick in Mantua quadrangle (this report), where Papoose Creek Formation is mapped separately, and reportedly 2000 feet (600 m) thick near Huntsville (Crittenden and others, 1971, figure 7), but only shown as about 1600 feet (500 m) thick to Papoose Creek transition zone by Crittenden (1972). The Kelley Canyon Formation is prone to slope failures.

Zarx - *Argillite of lower member of Maple Canyon Formation or upper member of Formation of Perry Canyon (Proterozoic)* – Greenish-gray argillite to meta-graywacke in poor exposures on east side of Ogden Valley (Zarx and Qdlb/Zarx) and on dip slope west of Ogden Valley; weathering, lack of bedding, and lack of exposures of overlying conglomerate member of Maple Canyon preclude separation of these stratigraphically adjacent units. This unit is prone to slope failures.

Zpu, Zpu? - *Formation of Perry Canyon, Upper member (Neoproterozoic).* Olive drab to gray, thin-bedded slate to argillite to phyllite to micaceous meta-siltstone to meta-graywacke to meta-sandstone in variable proportions such that unit looks like both the "greywacke-sandstone" and "mudstone" members of previous workers; unit identification based on underlying diamictite in Mantua quadrangle; rare meta-gritstone and meta-diamictite (actually conglomerate?); locally schistose; meta-sandstone contains poorly sorted lithic, quartz, and feldspar grains in silty to micaceous matrix; meta-sandstone is quartzose in outcrops on west margin of Mantua quadrangle (Crittenden and Sorensen, 1985a) and medial zone of sandstone is feldspathic east of Ogden Valley, where mapped and described as argillite member of Maple Canyon Formation by Crittenden (1972) and Sorensen and Crittenden (1979); thickness uncertain, but appears to be about 600 feet (180 m) thick on west flank of Grizzly Peak in the Mantua quadrangle and about 1000 feet (300 m) thick between Ogden Canyon and North Ogden divide. In Ogden Valley typically non-resistant and tan weathering such that gray to green to dark-gray fresh color is seldom seen except in cut slopes and excavations. This unit is prone to slope failures.

Citations, tables, and/or figures referenced above are not provided herein but are in Coogan and King (2016)

Seismotectonic Setting

The property is located in 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 physiographic 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 marked by 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 Utah Geological Survey Quaternary Fault Database (Black and others, 2003; January 2017 update) shows three Quaternary faults in the Project vicinity, including: (1) the Ogden Valley Northeastern Margin fault about 2.0 miles to the east, (2) the Ogden Valley Southwestern Margin faults about 2.0 miles to the southwest, and (3) the Ogden Valley North Fork fault about 0.75 miles to the southwest. All of these faults are pre-Holocene in age (Sullivan and others, 1986). The nearest active (Holocene-age) fault to the site is the Weber segment of the Wasatch fault zone about 4.3 miles to the west.

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 and sediments from Lake Bonneville are mapped underlying portions of the Project 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 emanating from 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).

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. Drainages that fed Lake Bonneville then began downcutting through stranded deltaic complexes and near-shore deposits as the lake receded. 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).

SITE CHARACTERIZATION

Empirical Observations

On April 8, 2019 Bill D. Black, P.G. of Western Geologic conducted a brief reconnaissance of the property and nearby area. Weather at the time of the site visit was clear and sunny with temperatures in the 40's (°F). A photographic record of our reconnaissance is included in the Appendix.

The site is in northeastern Ogden Valley on slopes overlooking and straddling the Sheep Creek floodplain, which flows to the south across the western part of the property. We did not directly access or observe areas of the property west of Sheep Creek. The property is generally vegetated by sage brush, grasses, oak brush and mature trees, although native vegetation in the area of the proposed home had been cleared at the time of our reconnaissance. The proposed home location (as staked at the time of our reconnaissance) is on a gentle, southwest-sloping terrace overlooking Sheep Creek above steep slopes bordering the floodplain. A distinctive topographic break marks the slope crest; this terrace crest appeared to be approximately 60 feet west of the home. Slopes below the terrace crest showed about a 2:1 (horizontal:vertical) gradient, whereas those in the terrace above the crest appeared to be about 40:1. Surficial soils appeared sandy and gravelly in the area of the proposed home, but become coarser (more cobbly and bouldery) further east. An ephemeral drainage was observed about 60 feet east of the proposed home that flows to the south and merges with a second drainage. Both of these drainages head in higher slopes northeast of the site. After they merge, the drainages flow into Sheep Creek in the south part of the property. Both ephemeral drainages and Sheep Creek were flowing at a high spring level at the time of our reconnaissance, although they are all reportedly dry by mid-summer. No evidence of seeps or springs, ongoing or prior slope instability or landslides, characteristic debris flow features, bedrock outcrops, or other geologic hazards was observed.

Air Photo Observations

Black and white aerial photography from 1997, high-resolution orthophotography from 2012, and bare earth DEM LIDAR from 2011 available from the Utah AGRC were reviewed to obtain information about the geomorphology of the Project area (Figures 3A-3C). The site straddles and overlooks the Sheep Creek floodplain, which flows southward into Ogden Valley (Figures 3A-3C). Two ephemeral drainages also flow southward and westward across the property and merge with Sheep Creek in the south part of the site (Figures 3A-3C). The proposed home is located on a gently-sloping terrace overlooking Sheep Creek between the river and northernmost ephemeral drainage (Figures 3A-3C). Steep slopes (> 30% gradient) formed by downcutting by Sheep Creek after the retreat of Lake Bonneville from Ogden Valley border the eastern side of the floodplain, as shaded in red on Figure 3C. The proposed home location is on slopes gentler than 5:1 (< 20%, as shaded in green on Figure 3C). No evidence for landsliding or other geologic hazards was observed on the air photos.

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.*

Hazard	H	M	L
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. The Utah Geological Survey Quaternary Fault Database (Black and others, 2003; January 2017 update) shows numerous class A faults within 60 miles of the Project that may pose potential seismic sources.

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. Based on 2015 IBC provisions, a site class of D (stiff soil), and a risk category of II, 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.*
(Site Location: 41.34629° N, -111.85517° W)

S_S	*0.996 g*
S_1	*0.343 g*
S_{MS} (F_a x S_S)	*1.097 g*
S_{M1} (F_v x S_1)	*0.588 g*
S_{DS} (2/3 x S_{MS})	*0.731 g*
S_{D1} (2/3 x S_{M1})	*0.392 g*
Site Coefficient, F_a	*= 1.102*
Site Coefficient, F_v	*= 1.714*
PGA, Peak Ground Acceleration	*0.397 g*

Given the above information, earthquake ground shaking poses a high risk to the site. Earthquake ground shaking is a regional hazard common to all Wasatch Front areas. The hazard is mitigated by design and construction of homes in accordance with current building codes.

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.

No evidence of active surface faulting is mapped or was evident at the site. The nearest active (Holocene-age) fault to the site is the Weber segment of the WFZ about 4.3 miles to the west. Given the above, the risk from surface faulting is 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.

Although the site is in an area of potentially strong ground shaking and groundwater appears to be about 10 feet deep, no subsurface soils likely susceptible to liquefaction appear to be present based on the drillers' report for the onsite well (Appendix). Given this, the liquefaction potential at the site appears low. Weber County hazard mapping also shows the site in an area of low liquefaction potential (code 1).

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. The site is not on the downthrown side of any active faults and the risk from tectonic subsidence is therefore 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 site elevation and distance from the nearest large body of water, the risk from seismic seiches and storm surges is 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.

Sheep Creek flows across the western part of the property and two ephemeral drainages flow across the northern and eastern parts of the site and merge with Sheep Creek to the south. The proposed home location is about 60 feet west of the northernmost ephemeral drainage on a terrace overlooking Sheep Creek. All of the above drainages were flowing at the time of our reconnaissance, although they are reportedly dry by mid-summer. Weber County hazard mapping shows an area of Federal Emergency Management Agency (FEMA) flood zone A associated with Sheep Creek in the western part of the site, although the proposed home location is in an area of zone X not subject to flooding. Zone A denotes areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Mandatory flood insurance requirements apply to zone A in communities that participate in the National Flood Insurance Program.

Given the above, the risk from stream flooding would be high for the site but only moderate to low in the area of the proposed home. Care should be taken that proper surface drainage is maintained. We therefore recommend that surface drainage and the potential for seasonal stream flooding be addressed in the Project grading plan with regard to the proposed home location. Surface hydrology should be addressed in accordance with Weber County requirements.

Shallow Groundwater

Based on evidence discussed in the Hydrology Section above, groundwater at the site is likely less than 10 feet deep but may vary seasonally, as would be expected for an alpine environment. Given the above, we rate the risk from shallow groundwater as high. The proposed home will require a foundation drainage system to ensure that proper subsurface drainage is maintained. We recommend the design be provided or reviewed (and approved) by a licensed geotechnical engineer.

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.

No landslides are mapped or were evident at the Project. Analysis of 2011 LIDAR data indicates steep slopes are at the site bordering the floodplain of Sheep Creek below the proposed home location, as shaded in red on Figure 3C. No evidence of recent or ongoing slope instability was observed in the steep slopes and the proposed home location is on gentle slopes (as shaded in green on Figure 3C) at what appears to be a safe distance from the slope crest. Given all the above, we rate the risk from landslides as low. However, we conservatively recommend that slopes west of the setback line on Figures 3A-C remain undisturbed to help ensure they remain stable. No cuts should be made in the slopes west of the setback line or fill materials emplaced on the slopes without prior geotechnical analysis. Water is a significant contributor to slope instability. Care should also therefore be taken that proper surface and subsurface 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 Project is not in an area subject to alluvial-fan flooding and no debris-flow channels, levees, or other debris-flow features were observed. We therefore rate the hazard from debris flows to the Project 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. We therefore rate the hazard from rock falls to the Project as low.

Problem Soil and Rock

The U.S. Department of Agriculture Natural Resources Conservation Service (https://websoilsurvey.nrcs.usda.gov/app/) maps the soil in the area of the proposed home as "Manila loam, 6 to 10 percent slopes." This soil is described as a well-drained, moderately low to moderately high permeability, lake terrace and mountain slope soil formed in alluvium and/or colluvium derived from sandstone and quartzite. The typical profile reportedly consists of an A horizon formed in loam and clay loam to a depth of 17 inches, and a B horizon formed in clay and clay loam to a depth of 60 inches. Weber County hazard mapping does not show any expansive soil at the Project. Given all the above, we rate the risk from problem soils as low. However, we recommend that a licensed geotechnical engineer inspect the foundation excavation to ensure that no subsurface soil conditions are present that would affect performance of the planned structure.

CONCLUSIONS AND RECOMMENDATIONS

Earthquake ground shaking, stream flooding and shallow groundwater are identified as posing a high relative risk to the Project, although risk may vary in the area of the proposed home with regard to some hazards. We recommend the following for prudent development:

- ***Seismic Design*** – All habitable structures developed at the property should be designed and constructed to current seismic building codes to reduce the risk of damage, injury, or loss of life from earthquake ground shaking.

- ***Site Hydrology*** – Surface drainage and the potential for seasonal stream flooding should be addressed in the Project grading plan with regard to the proposed home location, in accordance with all Weber County requirements. The proposed home will also require a foundation drainage system to ensure proper subsurface drainage. We recommend the design be provided or reviewed (and approved) by a licensed geotechnical engineer.

- ***Slope Disturbance*** – The slopes west of the setback line on Figures 3A-C should remain undisturbed. No modifications should be made in the slopes or fill materials emplaced on the slopes without prior geotechnical analysis. No structures should also be located west of the setback line in the event that the proposed home location changes.

- ***Geotechnical Excavation Inspection*** – A licensed geotechnical engineer should inspect the foundation excavation for the home once it is open to ensure that no subsurface soil conditions are present that would affect performance of the planned structure.

- ***Report Availability*** – This report and any subsequent reports regarding geologic conditions at the property should be made available to the architect and building contractor, as well as real estate agents and potential buyers in the event of a future sale. The 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 the authors and should not be copied, used, or modified without their express permission.

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 the Project. Should you have any questions, please call.

Sincerely,
Western Geologic & Environmental LLC

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

ATTACHMENTS

Figure 1. Location Map (8.5"x11")
Figure 2. Geologic Map (8.5"x11")
Figure 3A. 1997 Air Photo (8.5"x11")
Figure 3B. 2012 Air Photo (8.5"x11")
Figure 3C. LIDAR Analysis (8.5"x11")
Appendix. Photographic Record of Site Reconnaissance
Well Driller's Report

C:\Users\GLENDA\Documents\Western Geologic and Environmental\PROJECTS\Martinez, Lonnie\Eden, UT - Geo Haz Recon - About 4700 North Sheep Creek Drive #5135\Geologic Hazards Reconnaissance - Martinez Property - About 4700 N Sheep Creek Dr.docx

Western Geologic Project No. 5135

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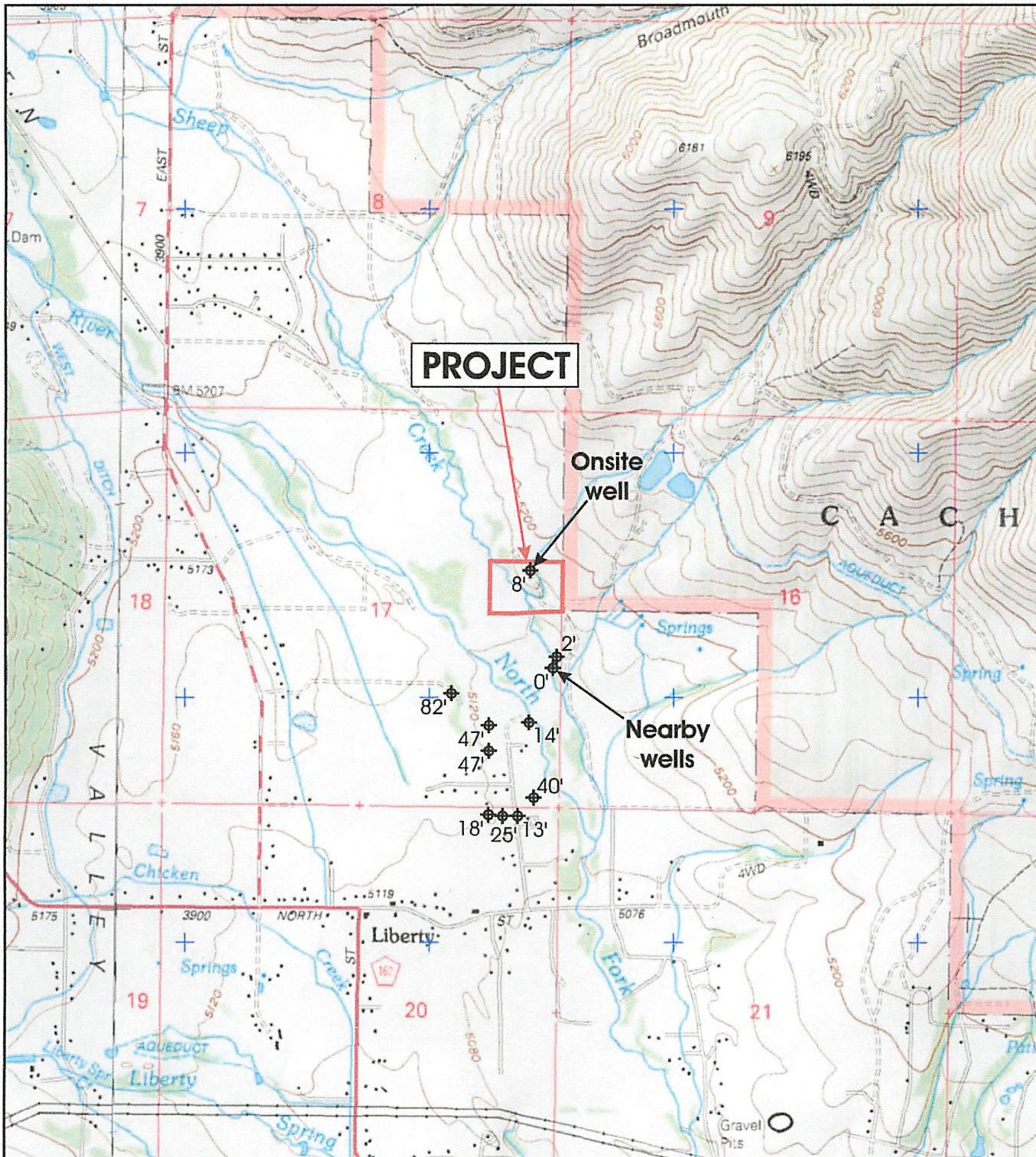


Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville, 1998;
Project location NE1/4, Section 17, T7N, R1E (SLBM).

LOCATION MAP

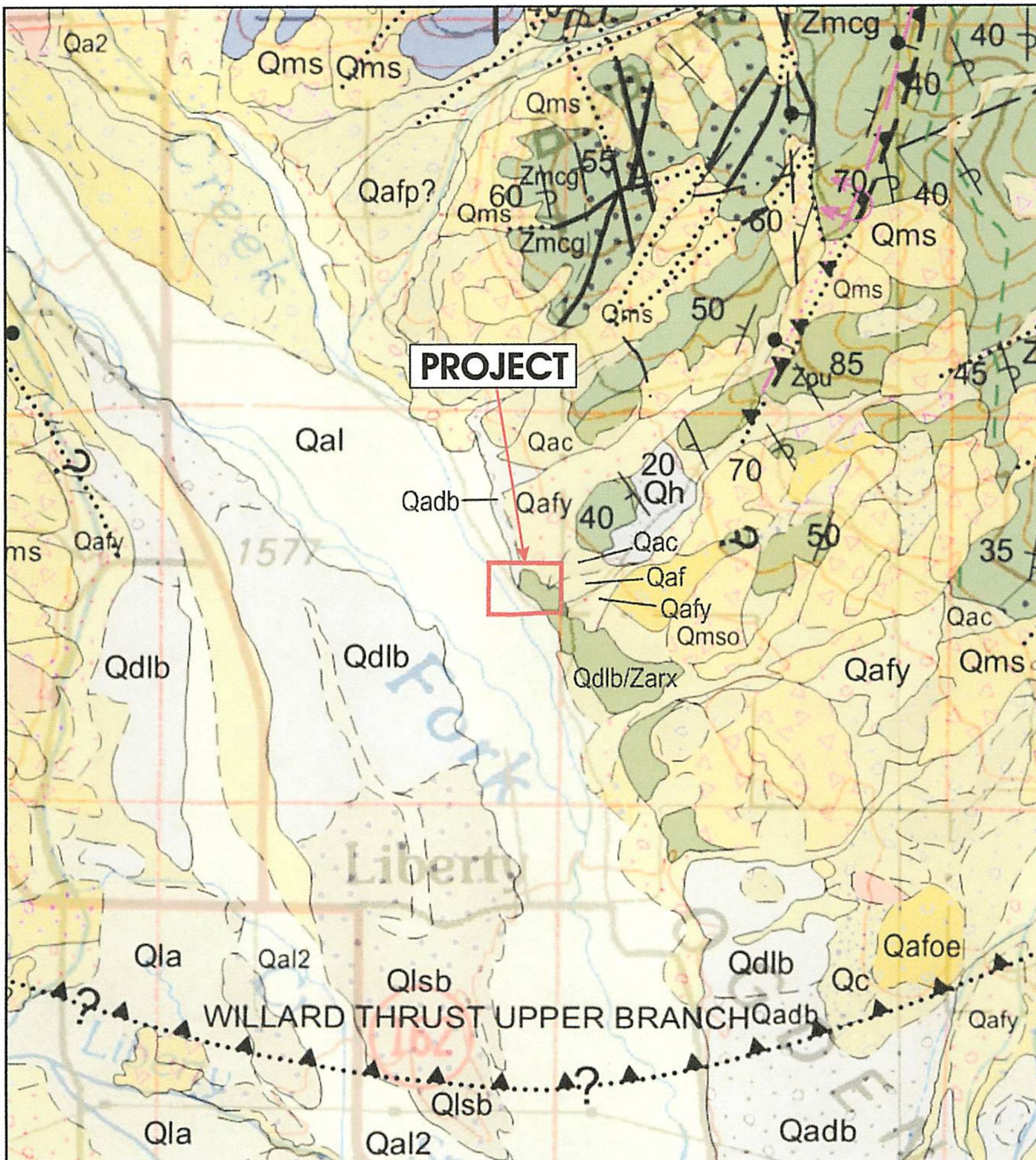
GEOLOGIC HAZARDS RECONNAISSANCE

Martinez Property
About 4700 North Sheep Creek Drive
Liberty, Weber County, Utah

FIGURE 1

0 1000 2000 feet
Scale 1:24,000
(1 inch = 2000 feet)

WESTERN GEOLOGIC



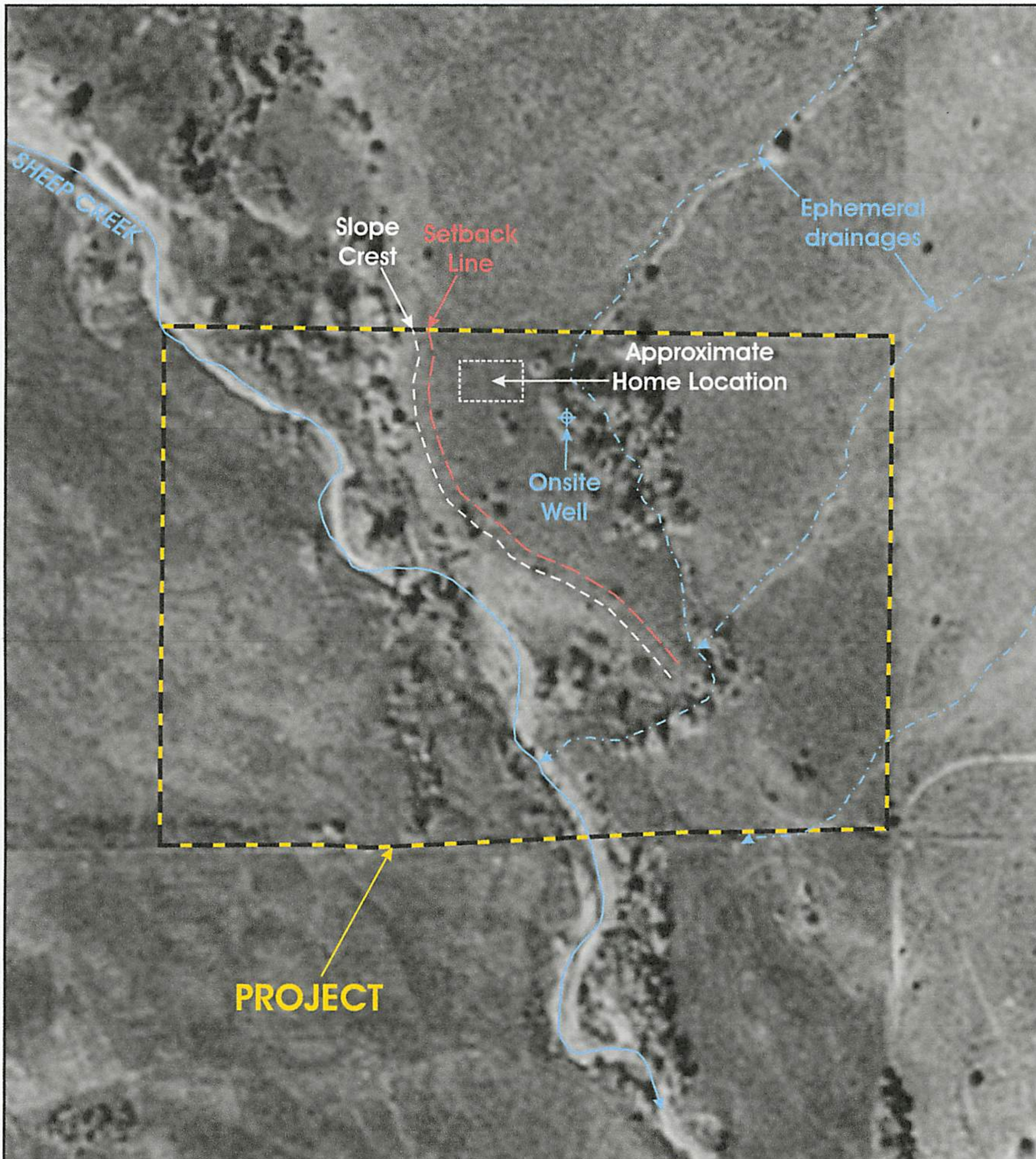
Source: Coogan and King (2016), original map scale 1:100,000.
See text for explanation of nearby surficial geologic units.

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

GEOLOGIC MAP

GEOLOGIC HAZARDS RECONNAISSANCE
Martinez Property
About 4700 North Sheep Creek Drive
Liberty, Weber County, Utah

FIGURE 2



Source: Utah AGRC 1997 Digital Orthophoto, 1 m resolution.

Scale 1:2,400
(1 inch = 200 feet)

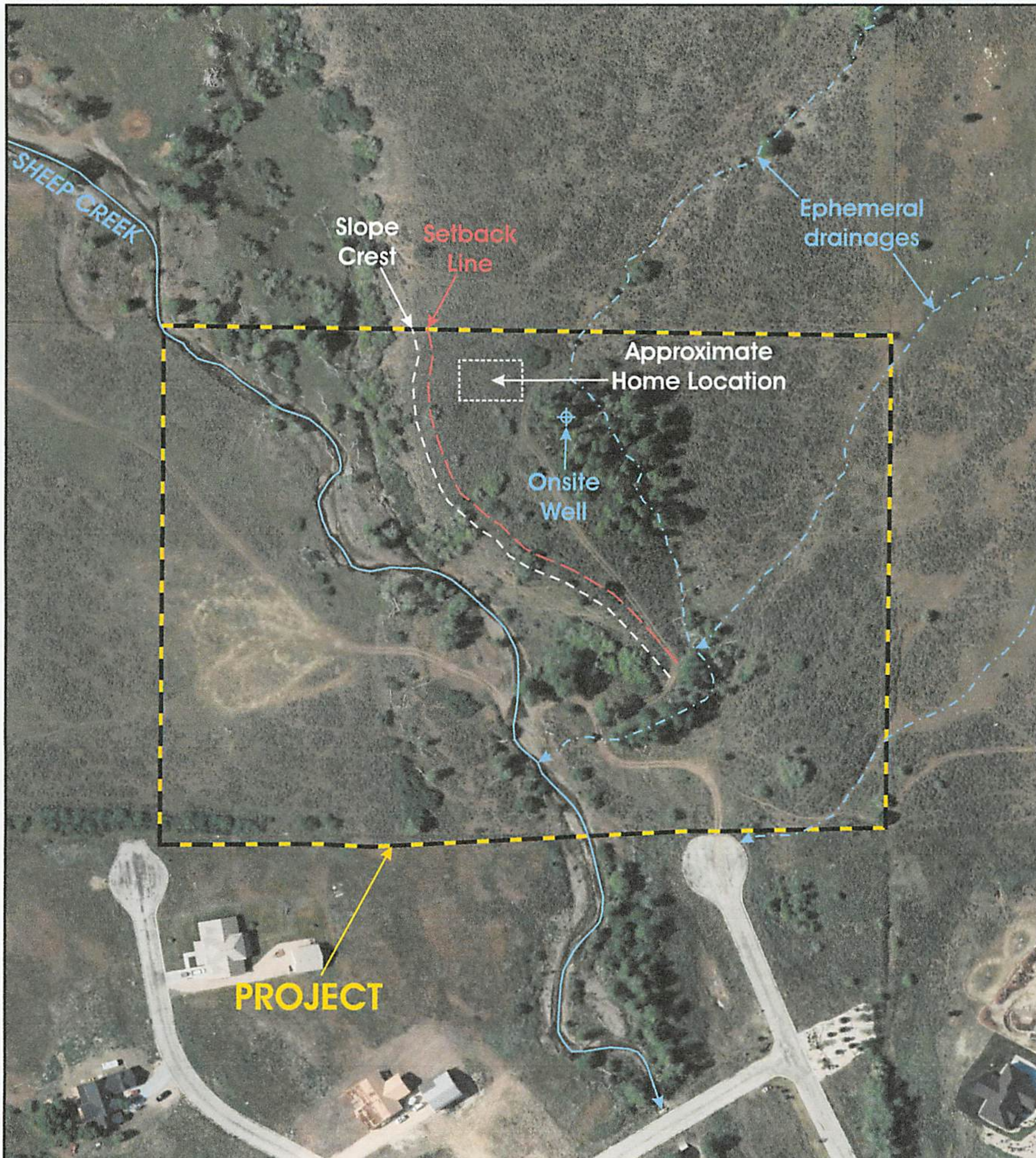
WESTERN GEOLOGIC

1997 AERIAL PHOTO

GEOLOGIC HAZARDS RECONNAISSANCE

Martinez Property
About 4700 North Sheep Creek Drive
Liberty, Weber County, Utah

FIGURE 3A



Source: Utah AGRC, 2012 High Resolution Orthophoto, 12.5 cm resolution.

WESTERN GEOLOGIC

N W E S

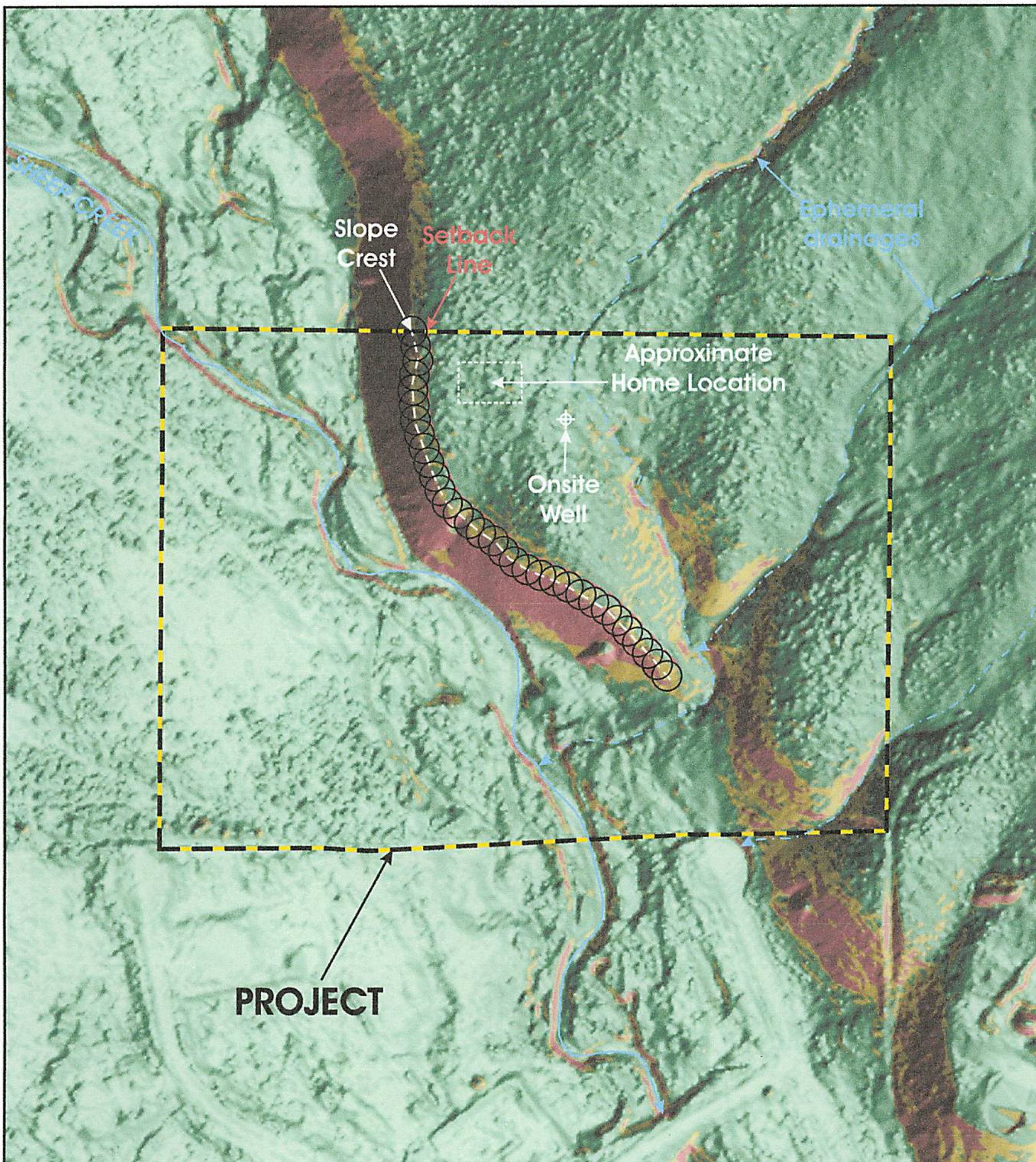
0 100 200 feet

Scale 1:2,400
(1 inch = 200 feet)

2012 AIR PHOTO

GEOLOGIC HAZARDS RECONNAISSANCE
Martinez Property
About 4700 North Sheep Creek Drive
Liberty, Weber County, Utah

FIGURE 3B



Source: Utah AGRC, 2011 LIDAR Bare Earth DEM, 1 m resolution; slope gradients <20% shaded in green, 20-30% in yellow, and >30% in red.

WESTERN GEOLOGIC

N W E S

0 100 200 feet

Scale 1:2,400
(1 inch = 200 feet)

LIDAR ANALYSIS

GEOLOGIC HAZARDS RECONNAISSANCE

Martinez Property
About 4700 North Sheep Creek Drive
Liberty, Weber County, Utah

FIGURE 3C

Photographic Record of Site Reconnaissance
Martinez Property – About 4700 North Sheep Creek Drive
Eden, Weber County, Utah

Photo 1. West view of proposed home location at property.

Photo 2. View overlooking Sheep Creek.

Photographic Record of Site Reconnaissance
Martinez Property – About 4700 North Sheep Creek Drive
Eden, Weber County, Utah

Photo 3. Slopes overlooking Sheep Creek at crest.

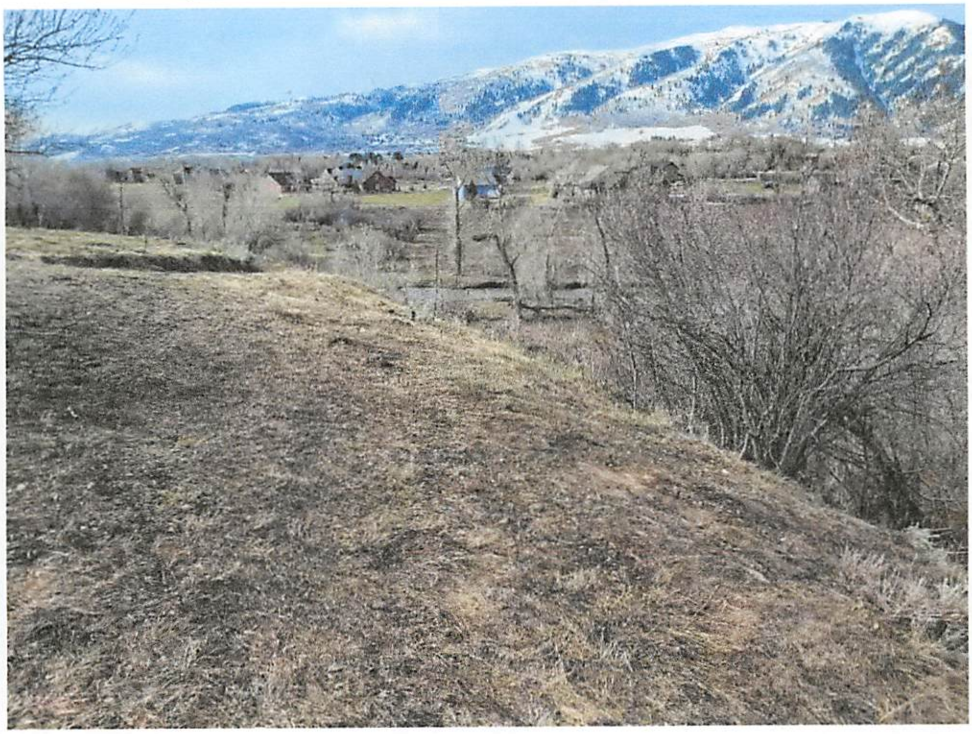


Photo 4. Slopes below crest

Photographic Record of Site Reconnaissance
Martinez Property – About 4700 North Sheep Creek Drive
Eden, Weber County, Utah

Photo 5. Ephemeral drainage flowing south east of home location.

Photo 6. Onsite well.

Photographic Record of Site Reconnaissance
Martinez Property – About 4700 North Sheep Creek Drive
Eden, Weber County, Utah

Photo 7. Sheep Creek.

Photo 8. Typical surficial soils.

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

Exchange Application: E5616 (35-13157)

WIN: 441413

Owner *Note any changes*

Lonnie and Jennifer Martinez
2596 N 2075 W
Ogden, UT 84404

Contact Person/Engineer: ______

Well Location *Note any changes*

N [illegible] W ~~498~~ 398 from the E4 corner of section 17, Township 7N, Range 1E, SL B&M

526 424

Location Description: (address, proximity to buildings, landmarks, ground elevation,local well #)

Drillers Activity Start Date: 11-10-17 Completion Date: 12-14-17

Check all that apply: [X] New [ ] Repair [ ] Deepen [ ] Clean [ ] Replace [ ] Public Nature of Use: ______

If a replacement well, provide location of new well. ______ feet north/south and ______ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	32	12	Cable	Water
32	122	8	Cable	Water

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture,degree of weathering, hardness, water quality, etc.)
0	5										✓		Black	top soil
5	40				✓				✓	✓			Brown	
40	85				✓			✓					Brown	
85	87				✓		✓		✓				Brown	
87	100	✓			✓			✓					Brown	
100	120	✓			✓			✓	✓				Brown	

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Static Water Level

Date ______ Water Level 8 feet Flowing? [ ] Yes [✓] No

Method of Water Level Measurement Probe If Flowing, Capped Pressure ______ PSI

Point to Which Water Level Measurement was Referenced Top of Casing Elevation ______

Height of Water Level reference point above ground surface 2' feet Temperature ______ degrees [ ] C [ ] F

Well Log

Construction Information

DEPTH (feet)		CASING			DEPTH (feet)		☐SCREEN ☑PERFORATIONS ☐OPEN BOTTOM		
FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	FROM	TO	SCREEN SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
+2	120'	A53B Steel	.25	8	113	118	1/8"	6"	3

Well Head Configuration: Well Cap Access Port Provided? ☑Yes ☐No

Casing Joint Type: Welded Perforator Used: torch

Was a Surface Seal Installed? ☑Yes ☐No Depth of Surface Seal: 30 feet Drive Shoe? ☑Yes ☐No

Surface Seal Material Placement Method: tremie (Pumped)

Was a temporary surface casing used? ☑Yes ☐No If yes, depth of casing: 30 feet diameter: 12 inches

DEPTH (feet)		SURFACE SEAL / INTERVAL SEAL / FILTER PACK / PACKER INFORMATION		
FROM	TO	SEAL MATERIAL, FILTER PACK and PACKER TYPE and DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	30	Neat Cement	25 bags	5.5 gal per sack

Well Development and Well Yield Test Information

DATE	METHOD	YIELD	Units Check One GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
12-7-17	Surge, Bail, pump	20	✓		64	72 hrs

Pump (Permanent)

Pump Description: 15 SQE10-250 Grundfos Horsepower: 1 Pump Intake Depth: 85 feet

Approximate Maximum Pumping Rate: 18 GPM Well Disinfected upon Completion? ☑Yes ☐No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary Circumstances, abandonment procedures. *Use additional well data form for more space.*

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SALT LAKE

Well Driller Statement

This well was drilled and constructed under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name KELLER DRILLING AND PUMP LLC License No. 881
(Person, Firm, or Corporation. Print or Type)

Signature Adam Keller Date 12-28-17
(Licensed Well Driller)