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GEOTECHNICAL STUDY
CEDAR COVE LOT 12
WEBER COUNTY, UTAH

Earthtec
Testing and Engineering, P.C.

PREPARED FOR:

MAIN LINE CONSTRUCTION
1133 N. MAIN STREET
LAYTON, UT 84041

ETE JOB NO.: 07-2202

SEPTEMBER 19, 2007

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1.0 INTRODUCTION

We understand that a single family residence is planned for lot 12 of the Cedar Cove Subdivision in Weber County, Utah as shown on the Vicinity Map, Figure 1.

This study was made to assist in evaluating the subsurface conditions and engineering characteristics of the foundation soils and in developing our opinions and recommendations concerning appropriate foundation types and floor slabs. This report presents the results of our geotechnical investigation including field exploration, laboratory testing, engineering analysis, and our opinions and recommendations. Data from the study is summarized on Figures 2 through 5 and in Table 1. A geological hazards evaluation was conducted in conjunction with this report by Western Geologic and a copy is presented in the attached appendix.

2.0 CONCLUSIONS

1. Based upon the hand augered hole excavated for this study native soils at this site generally consist of medium dense poorly graded sand with silt (SP-SM). Groundwater was not encountered in the augered hole at the time of our investigation.

2. The existing slope at the back of the lot should be graded no steeper than a 2 to 1 (horizontal to vertical). All retaining should be engineered. The structure should be set back at least 20 feet from the toe of the slope.

3. Lightly loaded spread footings founded on undisturbed native soils should provide adequate support for the proposed structure. A maximum allowable bearing capacity of 1500 psf should be used for footing design.

3.0 PROPOSED CONSTRUCTION

We understand that the planned development will consist of a single family residence. The structure will be one to two stories in height with a basement. For design purposes, it was assumed that wall loads of the structure would be on the order of 2 to 3 klf. If structural loads are different than those assumed, we should be notified and allowed to reevaluate our recommendations.

4.0 SITE CONDITIONS

The subject site is an undeveloped lot within an existing subdivision. The lot is located at the toe of a slope. The area at the toe of the slope is nearly level. Natural grades of the slope are about 30 to 40 percent. Vegetation on the lot is sparse. The site is bound by an undeveloped lot to the south, a house currently under construction to the north, a slope to the east, and a roadway to the west.

5.0 FIELD INVESTIGATION

The field investigation consisted of hand augering a test hole to a depth of 10 feet below existing site grades. The soils encountered at the site were logged by personnel from our office. Samples were obtained and returned to our laboratory for testing.

6.0 LABORATORY TESTING

The samples obtained during the field investigation were sealed and returned to our laboratory where each one was inspected to select representative samples for laboratory testing. Laboratory tests included a natural moisture determination and a grain size distribution analysis. The results of these tests are shown on Figures 2 through 5 and in Table 1, attached.

Samples will be retained at our Ogden laboratory for 30 days following the date of this report at which time they will be disposed of unless a written request for additional holding time is received prior to the disposal date.

7.0 SUBSURFACE CONDITIONS

Based upon the hand augered hole excavated for this study native soils at this site generally consist of medium dense poorly graded sand with silt (SP-SM). Groundwater was not encountered in the augered hole at the time of our investigation. A legend of the symbols used on the test hole logs is shown on Figure 4.

8.0 SITE GRADING

8.1 General Site Grading

Topsoil, man-made fill (if encountered), and soils loosened by construction activities should be removed (stripped) from the building pad and concrete flatwork areas prior to foundation excavation and placement of site grading fills. Following stripping and any additional excavation required to achieve design grades, the subgrade should be proof rolled to a firm, non-yielding surface. Soft areas detected during the proof-rolling operation, should be removed and replaced with structural fill. If the soft soils extend more than 18 inches deep, stabilization may be considered. The use of stabilization should be approved by the geotechnical engineer and would likely consist of over-excavating the area by at least 18 inches, placing a geofabric, such as Mirafi 600X, at the bottom of the excavation over which a stabilizing fill consisting of angular coarse gravel with cobbles is placed up to the design subgrade.

8.2 Structural Fill and Compaction

All fill placed below the building and concrete flatwork should be structural fill. All other fills should be considered as backfill. Structural fill should consist of native sands or an imported material. Imported soils should consist of well-graded sandy gravels with a maximum particle size of 3 inches and 5 to 15 percent fines (materials passing the No. 200 sieve). The liquid limit of the fines should not exceed 35 and the plasticity index should be below 15. All fill soils should be free from topsoils, highly organic material, frozen soil, and other deleterious materials. Structural fill should be placed in maximum 8-inch thick loose lifts at a moisture content within 2 percent of optimum and compacted to at least 95 percent of maximum density (ASTM D 1557) under the building and 90 percent under concrete flatwork. Where fill heights exceed 5 feet the level of compaction should be increased to 98 percent and full time observation by a qualified engineering technician should be considered.

8.3 Backfill

The native soils may be used as backfill in utility trenches and against the outside foundation walls. Backfill should be placed in lift heights suitable to the compaction equipment used and compacted to at least 90 percent of the maximum dry density (ASTM D 1557).

8.4 Excavations

Temporary construction excavations at the site which are less than five feet deep should have slopes no steeper than ½ to1 (horizontal to vertical). All excavations which are advanced deeper than five feet below site grades should be sloped or braced in accordance with OSHA[1] Health and Safety Standards for type C soils.

8.5 Permanent Cut and Fill Slopes

To prevent destabilizing the slopes at this site we recommend that permanent cut and fill slopes be graded no steeper than a 2 to 1 (horizontal to vertical) unless an engineered retainage system is used.

9.0 GEOLOGICAL HAZARDS

Geological hazards at this site are addressed in a report prepared by Western Geologic. The geologic report is presented in the appendix at the end of this report. Owners, contractors, and developers should read and understand the hazards presented in that report.

10.0 SLOPE STABILITY

To evaluate the stability of the slopes at the site, we performed a slope stability analysis with the XSTABLE computer program and the modified Bishop's method of slices. The slope profile used in our analysis were based on the site plan developed by Reeve & Associates and by measurements we made with hand held equipment. The profile was analyzed under both static and pseudo-static

1 Occupational Safety and Health Administration, "Occupational Safety and Health Standards - Excavations" Final Rule, 29 CFR part 1926.

conditions. The pseudo-static condition is used to evaluate the stability of the slope during a seismic event. The expected maximum bedrock acceleration from large earthquakes at this site with a 10 percent probability of exceedance in 50 years is 0.20g[2]. Since earthquake loads are cyclic loads, one half of the peak acceleration is commonly used for the pseudo-static condition and this value was used in our analysis.

Slopes with safety factors of 1.5 and 1.0 or greater for static and pseudo-static conditions, respectively, are typically considered suitable for residential development. Our analysis indicates that the slope at the site has global safety factors greater that 1.5 and 1.0 for static and pseudo-static conditions, respectively (see Figures 4 and 5). As a precaution, we recommend that the structure be placed at least 20 feet from the toe of the slope. If desired, an engineered retaining wall may be used at the toe of the slope to increase the buildable area.

11.0 SEISMIC CONSIDERATIONS

11.1 Faulting

According to the geologic hazards report prepared by Western Geologic, LLC contained in the appendix no faulting was observed. The nearest known fault is located 475 to 500 feet east of the site. (See the geologic hazards report contained in the appendix)

11.2 Seismic Design Criteria

The residential structures should be designed in accordance with the International Residential Code (IRC). The IRC designates this area as a seismic design category E.

The site is located at approximately 41.14 degrees latitude and -111.91 degrees longitude. The IRC site value for this property is 1.18 g as shown in the table below.

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2 USGS, Earthquake Hazards Program, National Seismic Hazard Mapping Project, 2002.

Table No. 2: Design Acceleration for Short Period

S_S	F_a	Site Value
		$2/3(S_S*F_a)$
1.77 g	1.00	1.18 g

11.3 Liquefaction

Liquefaction is a phenomenon where soils lose their intergranular strength due to an increase of pore pressures during a dynamic event such as an earthquake. The potential for liquefaction is based on several factors, including 1) the grain size distribution of the soil, 2) the plasticity of the fine fraction of the soil (material passing the No. 200 sieve), 3) relative density of the soil, 4) earthquake strength (magnitude) and duration, and 5) overburden pressures. In addition, the soils must be near saturation for liquefaction to occur. According to the Utah Geologic Survey liquefaction map and the attached geologic report by Western Geologic, this site is in an area classified as having a low to moderate potential for liquefaction[3].

Due to the type of subsurface investigation conducted for this report, we are unable to perform a liquefaction analysis for this site. It is possible that there are sand lenses at this site which are susceptible to liquefaction and significant settlement in excess of one inch and lateral spreading are possible during a strong seismic event. To adequately evaluate the liquefaction potential at the site, a boring at least 40 feet deep would need to be drilled. Earthtec would be happy to provide this service upon request.

12.0 FOUNDATIONS

12.1 Footing Design

The native soils at this site are capable of supporting the proposed structure if the recommendations presented in this report are followed. The recommendations presented below should be utilized during design and construction of this project:

3 Utah Geologic Survey, Selected Critical Facilities and Geologic Hazards, Weber County, Utah

1. Spread footings founded on undisturbed native soils, or structural fill where needed, should be designed for a maximum allowable soil bearing capacity of 1500 psf. A one-third increase is allowed for short term transient loads such as wind and seismic events. Footings should be uniformly loaded.

2. Continuous footings should have minimum widths of 20 inches.

3. Exterior footings should be placed below frost depth which is determined by local building codes. Generally 30 inches is adequate in this area. Interior footings, not subject to frost, should extend at least 18 inches below the lowest adjacent grade.

4. Foundation walls on continuous footings should be well reinforced both top and bottom. We suggest a minimum amount of steel equivalent to that required for a simply supported span of 12 feet.

5. The bottom of footing excavations should be compacted with a non-vibratory compactor to densify soils loosened during excavation and to identify soft spots. If soft areas are encountered, they should be stabilized as recommended in Section 8.1.

6. Footing excavations should be observed by the geotechnical engineer prior to placement of structural fill or construction of footings to evaluate whether suitable bearing soils have been exposed and to verify that excavation bottoms are free of loose or disturbed soils.

12.2 Estimated Settlement

If footings are designed and constructed in accordance with the recommendations presented above, the risk of total settlement under static conditions exceeding 1 inch and differential settlement exceeding 0.5 inch for a 25-foot span will be low. Additional settlement should be expected during a strong seismic event.

13.0 LATERAL EARTH PRESSURES

Buried structures, such as below grade foundation walls, should be designed to resist the lateral loads imposed by the soils retained. The lateral earth pressures on the buried structures and the distribution of those pressures depends upon the type of structure, hydrostatic pressures, in-situ soils, backfill, and tolerable movements. Retaining and basement walls are usually designed with triangular stress distributions known as equivalent fluid pressure based on lateral earth pressure coefficients. Buried structures may be designed using the following ultimate values:

Condition	Lateral Pressure Coefficient	Equivalent Fluid Weight (PCF)
At Rest	0.50	65
Active	0.29	38
Passive	3.39	440

We recommend that the lateral earth pressures for walls which allow little or no wall movement be based on "at rest" conditions. Walls allowed to rotate 0.1 percent of the wall height may be designed with "active" pressures. These values assume level backfill extending horizontally for a distance at least as far as the wall height and that water will not accumulate behind walls. Backfill should be placed in accordance with the requirements discussed in Section 8.3. Lateral pressures approximately 30 percent higher will occur during backfill placement and bracing may be called for until the backfilling operation is completed.

Lateral building loads will be resisted by frictional resistance between the footings and the foundation soils and by passive pressure developed by backfill against the wall. For footings on native sand soils we recommend a friction coefficient of 0.33 be used. The lateral earth coefficients presented above are ultimate values; therefore, an appropriate factor of safety should be applied to the values presented above in lateral resistance calulations.

14.0 FLOOR SLABS

The native soils below floor slabs should be proof rolled and a minimum 4-inch thick layer of free-draining gravel should be placed immediately below the floor slab to help distribute floor loads, break the rise of capillary water, and aid in the concrete curing process. For slab design, we recommend a modulus of subgrade reaction of 150 psi/in be used. To help control normal shrinkage and stress cracking, the floor slabs should have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints. In addition we recommend utilizing crack control joints to help prevent uncontrolled crack propagation.

Special precautions should be taken during placement and curing of concrete slabs and flatwork. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures used during hot or cold weather conditions may lead to excessive shrinkage, cracking, spalling, or curling of the foundation walls and slabs. We recommend all concrete placement and curing operations be performed in accordance with American Concrete Institute (ACI) codes and practices.

15.0 SURFACE DRAINAGE

Wetting of the foundation soils will likely cause some degree of volume change within the soil and should be prevented both during and after construction. We recommend that the following precautions be taken at this site:

1. The ground surface should be graded to drain away from the structure in all directions. We recommend a minimum fall of 8 inches in the first 10 feet.

2. Roof runoff should be collected in rain gutters with down spouts designed to discharge well outside of the backfill limits.

3. Sprinkler heads, should be aimed away and kept at least 12 inches from foundation walls.

4. Provide adequate compaction of foundation backfill i.e. a minimum of 90% of ASTM D 1557. Water consolidation methods should not be used.

5. Where water concentration from surface drainage or from subsurface drains occurs, erosion protection should be provided.

6. Other precautions which may become evident during design and construction should be taken.

16.0 GENERAL CONDITIONS

The exploratory data presented in this report were collected to provide geotechnical design recommendations for this project. The test hole may not be indicative of subsurface conditions outside the study area and thus has limited value in depicting subsurface conditions for contractor bidding. If it is necessary to define subsurface conditions in sufficient detail to allow accurate bidding we recommend an additional study be conducted which is designed for that purpose.

Variations from the conditions portrayed in the test hole often occur which are sometimes sufficient to require modifications in the design. If during construction, conditions are found to be different than those presented in this report, please advise us so that the appropriate modifications can be made. An experienced geotechnical engineer or technician should observe fill placement and conduct testing as required to confirm the use of proper structural fill materials and placement procedures.

The geotechnical study as presented in this report was conducted within the limits prescribed by our client, with the usual thoroughness and competence of the engineering profession in the area. No other warranty or representation, either expressed or implied, is intended in our proposals, contracts or reports.

We appreciate the opportunity of providing our services on this project. If we can answer questions or be of further service, please call.

Respectfully;
EARTHTEC ENGINEERING, P.C.

9-18-07

Mark I. Christensen, P.E.
Project Geotechnical Engineer

3 copies sent

REV:REB

EARTHTEC TESTING & ENGINEERING

3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

750 ft Scale: 1 : 25,000 Detail: 13-0 Datum: WGS84

BASE MAP TAKEN FROM DELORME DOCS "OGDEN" QUADS

ETE Job No. 07-2202 **VICINITY MAP** **Figure 1**

TEST HOLE LOG

NO.: TH-1

PROJECT: Cedar Cove Lot 12
CLIENT: Main Line Construction
LOCATION: Near center of flat portion of lot
OPERATOR: Earthtec
EQUIPMENT: Hand Augered
DEPTH TO WATER; INITIAL ∇ :

PROJECT NO.: 07-2202
DATE: 08/30/07
ELEVATION: Not Measured
LOGGED BY: Mark Christensen
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Blows per foot	Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0		SP-SM	Poorly graded sand with silt, medium dense, slightly moist, brown										
3													
~5				X			5			6	86	8	
6													
9													

Notes: No groundwater encountered.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

LEGEND

PROJECT: Cedar Cove Lot 12
CLIENT: Main Line Construction
DATE: 08/30/07
LOGGED BY: Mark Christensen

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR SOIL DIVISIONS			USCS SYMBOL	TYPICAL SOIL DESCRIPTIONS
COARSE GRAINED SOILS (More than 50% retaining on No. 200 Sieve)	GRAVELS (More than 50% of coarse fraction retained on No. 4 Sieve)	CLEAN GRAVELS (Less than 5% fines)	GW	Well Graded Gravel, May Contain Sand, Very Little Fines
			GP	Poorly Graded Gravel, May Contain Sand, Very Little Fines
		GRAVELS WITH FINES (More than 12% fines)	GM	Silty Gravel, May Contain Sand
			GC	Clayey Gravel, May Contain Sand
	SANDS (50% or more of coarse fraction passes No. 4 Sieve)	CLEAN SANDS (Less than 5% fines)	SW	Well Graded Sand, May Contain Gravel, Very Little Fines
			SP	Poorly Graded Sand, May Contain Gravel, Very Little Fines
		SANDS WITH FINES (More than 12% fines)	SM	Silty Sand, May Contain Gravel
			SC	Clayey Sand, May Contain Gravel
FINE GRAINED SOILS (More than 50% passing No. 200 Sieve)	SILTS AND CLAYS (Liquid Limit less than 50)		CL	Lean Clay, Inorganic, May Contain Gravel and/or Sand
			ML	Silt, Inorganic, May Contain Gravel and/or Sand
			OL	Organic Silt or Clay, May Contain Gravel and/or Sand
	SILTS AND CLAYS (Liquid Limit Greater than 50)		CH	Fat Clay, Inorganic, May Contain Gravel and/or Sand
			MH	Elastic Silt, Inorganic, May Contain Gravel and/or Sand
			OH	Organic Clay or Silt, May Contain Gravel and/or Sand
HIGHLY ORGANIC SOILS			PT	Peat, Primarily Organic Matter

SAMPLER DESCRIPTIONS

- SPLIT SPOON SAMPLER (1 3/8 inch inside diameter)
- MODIFIED CALIFORNIA SAMPLER (2½ inch outside diameter)
- SHELBY TUBE (3 inch outside diameter)
- BLOCK SAMPLE
- BAG/BULK SAMPLE

WATER SYMBOLS

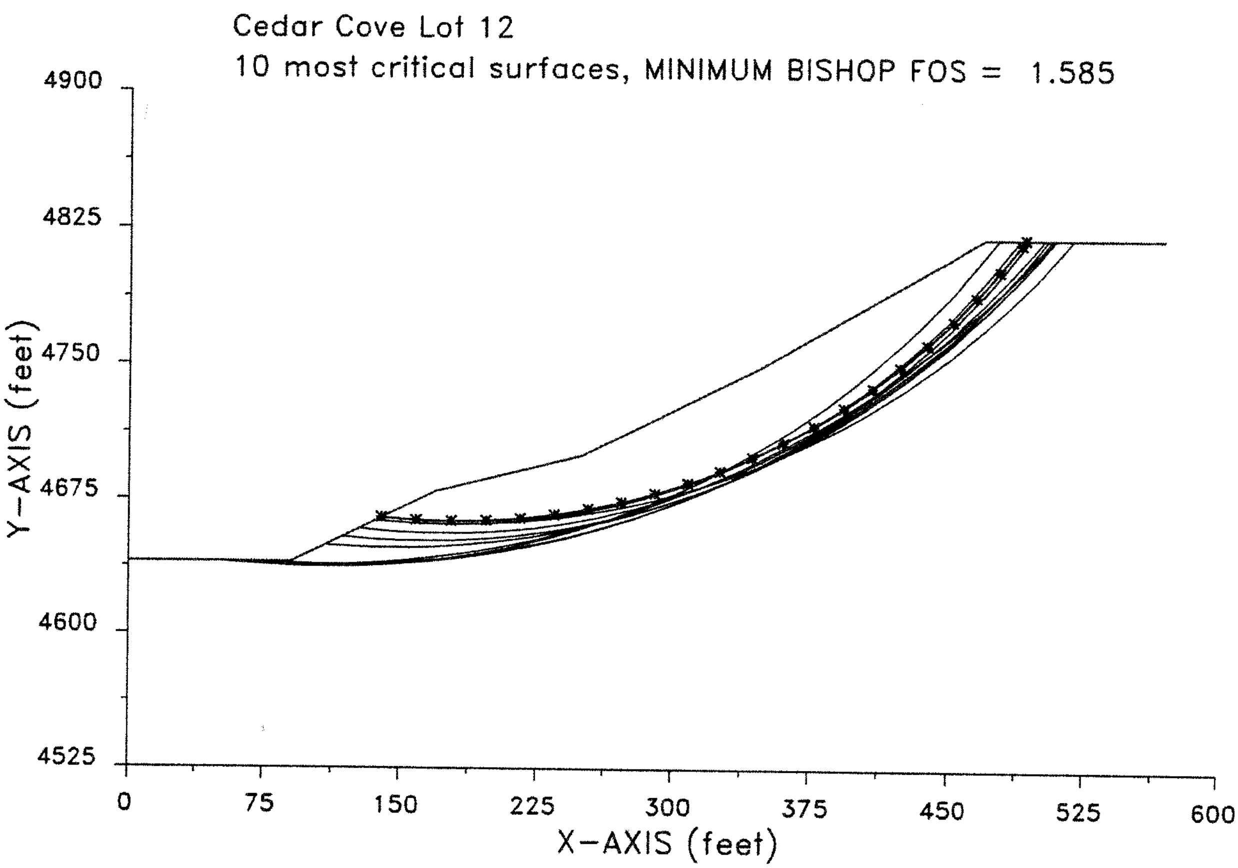
- ∇ Water level encountered during field exploration
- ▼ Water level encountered at completion of field exploration

NOTES:
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
2. Results of tests conducted on samples recovered are reported on the logs and any applicable graphs.
3. Strata lines on the logs represent approximate boundaries only. Actual transitions may be gradual.
4. In general, USCS symbols shown on the logs are based on visual methods only: actual designations (based on laboratory tests) may vary.

EARTHTEC ENGINEERING

Soil Layer	Soil Type	Moist Unit Wt. (pcf)	Sat. Unit Wt. (pcf)	Cohesion (psf)	Friction Angle (degrees)
1	Sand	115	125	0	33.5

07-2202 9-18-** 11:41



GLOBAL SLOPE STABILITY

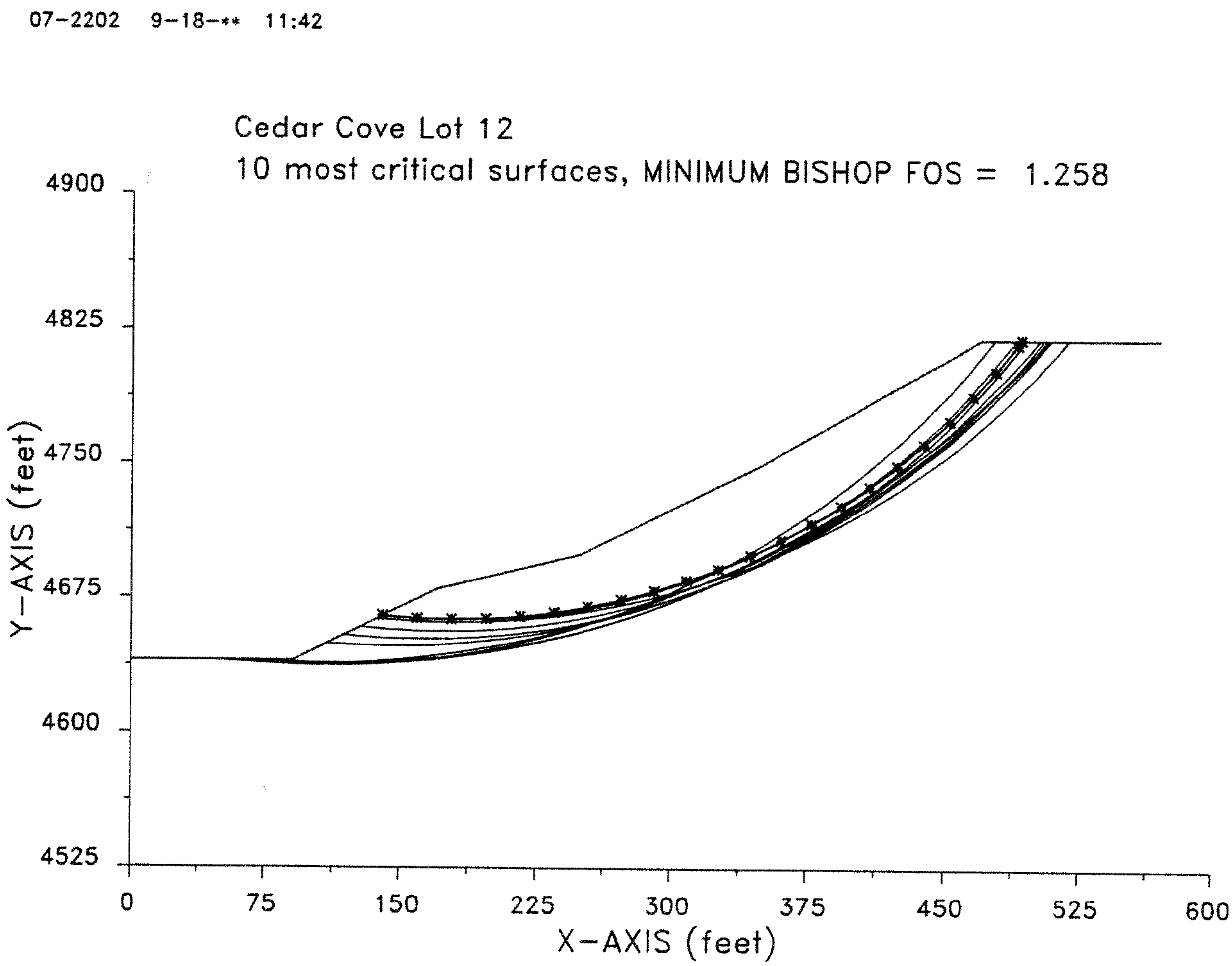
ETE JOB NO. 07-2202

FIGURE 4

EARTHTEC ENGINEERING

Soil Layer	Soil Type	Moist Unit Wt. (pcf)	Sat. Unit Wt. (pcf)	Cohesion (psf)	Friction Angle (degrees)
1	Sand	115	125	0	33.5

Horizontal Acceleration of 0.10 G



GLOBAL SLOPE STABILITY - (PSEUDO STATIC)

ETE JOB NO. 07-2202

FIGURE 5

TABLE ONE
SUMMARY OF LABORATORY DATA

TEST HOLE	DEPTH (FT)	MOISTURE (%)	(%) GRADATION			ATTERBERG LIMITS		SOIL TYPE
			GRAVEL	SAND	SILT/CLAY	LIQUID LIMIT	PI	
TH-1	5	4.5	6	86	8			Poorly graded SAND with silt (SP)

REPORT

GEOLOGIC HAZARDS RECONNAISSANCE

CEDAR COVE SUBDIVISION LOT 12

2670 BYBEE DRIVE, WEBER COUNTY, UTAH

Prepared for

Mr. Mark Christensen, P.E.
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1596 West 2650 South, Suite 108
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September 5, 2007

Prepared by

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September 5, 2007

Mr. Mark I. Christensen, P.E.
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1596 West 2650 South
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SUBJECT: Geologic Hazards Reconnaissance
Cedar Cove Subdivision Lot 12
2670 Bybee Drive
Weber County, Utah

Dear Mr. Christensen:

This report presents results of a reconnaissance-level engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for lot 12 in the Cedar Cove Subdivision at 2670 Bybee Drive in Weber County, Utah (Figure 1 – Project Location). The site is on west- to south-facing slopes overlooking the Weber River about 0.5 miles west of Broad Hollow at the western base of the Wasatch Range, in the NE¼ Section 26, Township 5 North, Range 1 West (Salt Lake Base Line and Meridian). Elevation of the site ranges between about 4,660 and 4,760 feet above sea level.

PURPOSE AND SCOPE

The purpose of the investigation was to identify and interpret surficial geologic conditions at the site and to evaluate any potential geologic hazards to the project. The following services were performed in accordance with that purpose:

- A site reconnaissance conducted by an experienced certified engineering geologist to assess the site setting and look for evidence of adverse geologic conditions, including hand excavation of one shallow test pit;
- Review of available geologic maps and reports; and
- Evaluation of available data and preparation of this report, which presents the results of our study.

The engineering geology section of this report was prepared in general accordance with the Guidelines for Preparing Engineering Geologic reports in Utah (Utah Section of the Association of Engineering Geologists, 1986).

GEOLOGY

Seismotectonic Setting

The property is located west of the western base of 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). The Basin and Range province 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). North of the Weber River, the Weber section of the Wasatch fault zone forms a complex zone of multiple west- and east-dipping fault traces, which generally converge northward into a single main west-dipping fault trace about 1,750 feet northeast of the site. The nearest faults in this zone are two east-dipping antithetic traces about 475 to 500 feet east of the property.

The site is also in the central portion of the Intermountain Seismic Belt (ISB), a generally north-south trending zone of historical seismicity along the eastern margin of the Basin and Range province extending 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; the largest of these earthquakes was a M_S 7.5 event in 1959 near Hebgen Lake, Montana. However, none of these earthquakes occurred along the Wasatch fault or other known late Quaternary faults (Arabasz and others, 1992; Smith and Arabasz, 1991). The closest of these events was the 1934 Hansel Valley (M_S 6.6) event north of the Great Salt Lake.

Unconsolidated Deposits

The site is located within the Wasatch Front Valley System, a deep sediment-filled, structural basin flanked by two uplifted range blocks; the Wasatch Range to the east, and the Lakeside Mountains to the west. The site is located below the (highest) Bonneville shoreline of Lake Bonneville. Surficial geology at the site was mapped by Yonkee and Lowe (2004) as older Holocene landslide deposits (unit Qms2, Figure 2). The hatched scarp on Figure 2 north of the site marks an embayment in the deltaic sediments characteristic of a prehistoric earthflow. Such failures are commonly found in the downcut slopes bordering the Weber River floodplain in the area. However, the bedded deltaic sediments observed in the eastern part of the site suggest that not all the site is in unit Qms2.

Yonkee and Lowe (2004) describe surficial units in the site vicinity (Figure 2), from youngest to oldest in age, as follows:

Qms1 -- *Younger landslide deposits, Holocene.* Unsorted, unstratified mixtures of gravel, sand, silt, and clay redeposited by slides, slumps, and flows; deposits display distinctly hummocky topography and fresh scarps, and are currently or have been recently active; many of these deposits are within older slide complexes.

Qaf1 -- *Younger alluvial-fan deposits, Holocene.* Mixture of gravel and sand deposited by streams, and diamicton deposited by debris flows; forms fans having distinct levees and channels at mouths of mountain-front canyons; exposed thickness less than 6 meters (20 ft).

Qac – *Colluvium and alluvium, undivided.* Pebble to boulder gravel and clay- to boulder-rich diamicton; includes hillslope colluvium, small fans, stream alluvium, and small landslide deposits; mapped along some vegetated canyon areas in Wasatch Range; thickness probably less than 15 meters (50 ft) in most areas.

Qms2 -- *Older landslide deposits, Holocene.* Unsorted, unstratified mixtures of mostly sand, silt, and clay redeposited by single to multiple slides, slumps, and flows; deposits display hummocky topography but lack fresh scarps and are mostly inactive; deposits found mostly along moderate slopes where rivers and streams have incised into finer grained lacustrine and deltaic deposits; unit also includes slides of boulder-rich diamicton that reactivated parts of older slide complexes in the Wasatch Range.

Qaf3 -- *Alluvial-fan deposits, Bonneville regressive.* Mixture of gravel and sand deposited by streams, and diamicton deposited by debris flows; contains mostly angular to subrounded clasts plus some recycled, well-rounded lacustrine clasts; forms fans having subdued morphology that are graded to the Provo or other regressive shorelines and are incised by modem stream channels; exposed thickness less than 9 meters (30 ft).

Qd3 -- *Deltaic deposits, Bonneville regressive.* Main part of unit includes foreset beds of rhythmically interlayered, gently inclined, fine to medium sand and silt, and topset beds of clast-supported, moderately to well-sorted, pebble and cobble gravel and gravelly sand; gravels contain rounded to subrounded clasts; deposited when Lake Bonneville was at and regressing from Provo shoreline; forms large, gently westward-inclined surface that was locally reworked along regressive shorelines; total thickness locally as much as 30 meters (100 ft). Unit also includes moderately to well-sorted, pebble and cobble gravel in smaller terraces more than 30 meters (100 ft) above modem stream level that are graded to delta deposits and shorelines above the Gilbert level; exposed thickness of terrace gravels up to 6 meters (20 ft).

Qlg4 -- *Lacustrine gravel-bearing deposits, Bonneville transgressive.* Clast-supported, moderately to well-sorted, pebble to cobble gravel, with some silt to sand in interfluve areas and away from mountain front; gravels contain rounded to subrounded clasts, and some sub angular clasts derived from reworking of mass-wasting and alluvial-fan deposits; deposited in higher energy environments along shorelines and small fan deltas as Lake Bonneville was transgressing; grades westward away from shorelines into fine-grained lacustrine deposits (Qlf4); total thickness locally as much as 60 meters (200 ft).

Qlf4 *-- Lacustrine fine-grained deposits, Bonneville transgressive.* Intervals of calcareous clay to silt, and intervals of rhythmically interbedded fine to medium sand and silt near mouth of Weber Canyon; deposited in deeper water environments, and as delta bottomset beds during transgression of Lake Bonneville; total thickness, including subsurface deposits, locally as much as 150 meters (500 ft).

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). Sediments related to Lake Bonneville comprise much of the unconsolidated deposits in the site vicinity.

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. The lake remained at this 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 then 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). The highest Bonneville shoreline is about 2,500 feet east of the site on Figure 2.

SITE RECONNAISSANCE

On August 29, 2007 Mr. Bill D. Black of Western GeoLogic conducted a brief reconnaissance of the property and surrounding area. Weather at the time of the site reconnaissance was clear and sunny with temperatures in the 90's (°F). The site is on west- to south-facing slopes overlooking the Weber River floodplain about 0.8 miles northwest of the mouth of Weber Canyon. Sparse native vegetation is at the site, and generally consists of low grasses and sage brush with scattered oak brush and a few cedar trees. The site straddles a low ridge on the north and east sides of Bybee Drive that is mantled by sandy surficial sediments. The western part of the property along Bybee Drive is nearly flat, but slopes steepen to the east to around an overall steepness of about 2.5 to 3:1 (horizontal to vertical). Interbedded gravelly sand and silt deltaic lenses are exposed in the south-facing slopes in the eastern part of the site. To evaluate subsurface conditions in the west-facing slope, we hand excavated one roughly 3.5-foot-deep test pit at the slope base east of Bybee Drive. It is our understanding this area will be the proposed home location. The test pit exposed poorly to well-bedded sands resembling the nearby bedded deltaic sediments.

Digital orthophoto aerial photography (National Aerial Photography Program; frames NAPP 10103 100, NAPP 10103 102, NAPP 10103 81, and NAPP 10103 98; October 1997, 4.64 meters RMS; and U.S. Geological Survey high resolution urban photography, Salt Lake City, September 2003, 0.3 meter resolution) was reviewed to obtain information about the geomorphology of the site and surrounding area (Figure 3). The site is on a south-facing terrace on the northeastern edge of the Weber delta, and straddles the eastern margin of a prehistoric earthflow in the terrace (Figure 3). This area has old river terraces that are part of a discontinuous landslide complex along the Weber delta from Weber Canyon to Washington Terrace. The river terraces are remnants of the former Weber River floodplain stranded by downcutting through the Weber delta after the retreat of Pleistocene Lake Bonneville. The deltaic sediments forming the terraces have experienced instability from a variety of causes in both prehistoric and historic time. Undeformed, sub-horizontal deltaic beds were observed in the eastern part of the site during our reconnaissance, and are visible on Figure 3 to the east. Undeformed deltaic sands were also observed in our hand excavation, and are on Figure 3 in the prehistoric landslide to the north. The above evidence suggests the site straddles the margin of the zone of depletion of the landslide where the deltaic sediments failed and flowed downslope to a lower accumulation (depositional) zone to the west and southwest. Steeply west and south-dipping beds were observed in lot 13 (Western GeoLogic, 2007) to the south that may be deformed, intact blocks at the landslide margin. A wide zone of several discontinuous west- and east-dipping, generally north-trending fault traces associated with the Wasatch fault zone is also east of the property (Figure 3). The nearest traces are two east-dipping antithetic faults about 475 to 500 feet to the east. No other geologic hazards are evident on the air photos or were observed at the site.

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Ogden Quadrangle shows no surface-water impoundments or streams at the property. Hamre Spring is shown on the topographic map about 1,450 feet northeast of the site. No springs, seeps, or wetland areas were observed in the site vicinity in our field reconnaissance, and slopes at the site appeared very dry.

The subsurface hydrology in the area is dominated by the East Shore aquifer system. This aquifer system is comprised of a shallow, unconfined water table zone, and the deeper, often confined, Sunset and Delta aquifers (Feth and others, 1966). The depth to the shallow unconfined aquifer varies somewhat depending on topography and climatic and seasonal fluctuations. It is influenced by seepage from irrigation systems, and infiltration from precipitation and urban runoff. The Sunset aquifer (typical depth 250-400 feet) and Delta aquifer (typical depth 500-700 feet) provide water that generally meets the standards for public drinking water supply. Based on topography the regional groundwater flow is expected to be to the west and then south into the Weber River floodplain.

Elevation of the shallow aquifer varies somewhat based on seasonal and climatic fluctuations. No evidence of groundwater was observed in the slopes at the site, and depth to groundwater is unknown but is likely greater than 30 feet. However, perched groundwater conditions may be found above less permeable, fine-grained lacustrine sediments underlying the site.

GEOLOGIC HAZARDS

Assessment of potential geologic hazards and the resulting risks imposed is critical in determining the suitability of the site for development. A discussion and analysis of geologic hazards follows.

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, and Salt Lake segments of the Wasatch fault zone; the East Great Salt Lake fault zone; the Morgan Fault; the West Valley 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 (PGA), 0.2 second spectral (SA), and 1.0 second spectral accelerations (in % gravity) at the site with 10% and 2% probabilities of exceedance in

50 years are estimated in Frankel and others (2002) as follows:

41.1430° N, 111.9115° W	**10% PE in 50 yr**	**2% PE in 50 yr**
PGA	19.71	**61.15**
0.2 sec SA	47.90	**141.02**
1.0 sec SA	**17.01**	**58.23**

Given the above information, earthquake ground shaking is a risk to the subject site. The hazard from earthquake ground shaking can be adequately mitigated by design and construction of homes in accordance with appropriate building codes. The International Building Code (IBC) and the International Residence Code (IRC) specify these design requirements based on the seismic design category of a structure, which is in turn based on the seismic use group and severity of design ground motions. Design ground motions (spectral response accelerations) are additionally affected by the site class, which is based on soils present at the site and their engineering properties. A U.S. Geological Survey java applet is available at ***http://earthquake.usgs.gov/research/hazmaps/design/*** to calculate various ground motion parameters based on applicable building codes currently in force. The project geotechnical engineer, in conjunction with the developer, should determine the seismic design category and associated earthquake-resistant design requirements.

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 either as a large, singular scarp, or several smaller ruptures comprising a fault zone. Ground displacement from surface fault rupture can cause significant damage or even collapse to structures located across a rupture zone.

The nearest mapped faults to the site are two discontinuous, east-dipping antithetic traces of the Weber section of Wasatch fault zone about 475 to 500 feet east of the eastern site boundary on Figure 3. No evidence of surface faulting such as fault scarps or lineaments was evident at the property or on air photos. However, at this distance, the eastern roughly 25 feet of the site would be in the Surface Fault Rupture Special Study Zone on Weber County Planning maps where trenching studies would be needed. Given that the proposed home location is in the western part of the lot, we do not anticipate surface fault rupture will be a concern.

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, ground water conditions, and presence of susceptible soils.

Loose, sandy sediments were observed in the slopes at the site that could be susceptible to liquefaction. However, liquefaction potential is also dependant on groundwater depth, which is likely greater than 30 feet deep. Based on the above, the existing hazard from liquefaction at the site should be low. However, the site straddles the eastern margin of a prehistoric earthflow that could be a liquefaction-induced failure from a past earthquake. Given sediments conducive to liquefaction and possibility for perched water levels, we recommend liquefaction hazards be addressed in the geotechnical engineering report for the site.

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 located about 500 feet west of the Wasatch fault zone, and at this distance the property may experience a few degrees of seismic tilting. However, tectonic subsidence is not a life-safety issue, and is not typically considered for single-family dwellings.

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 very 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 drainages are shown crossing the site on Figure 1 or were observed in our reconnaissance. Based on the above, the risk from stream flooding should be low. However, sheet and rill flow may be a seasonal concern from the steep slopes at the site. Therefore, site hydrology and runoff should be addressed by the civil engineering design for the development.

Shallow Groundwater

No springs are shown on the topographic map for the Ogden quadrangle at the site, and no springs, seeps, or wetland areas were observed in our reconnaissance. Groundwater at the site is likely greater than 30 feet deep, although perched conditions above less-permeable sediments may be beneath the site. Groundwater depth can also fluctuate based on seasonal and climatic variations in up-gradient runoff infiltration, and may decrease as water is added from sources such as landscape irrigation. We do not anticipate shallow groundwater will pose a significant concern to the proposed development. Recommendations regarding shallow groundwater should be provided in the geotechnical engineering evaluation for the lot as needed.

Landslide 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 ground-water 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 eastern margin of a prehistoric earthflow. Well-defined head scarps of this landslide are below the existing homes north of the property on Figure 3. Well-bedded lacustrine deltaic sediments are exposed in slopes in the eastern part of the site, and bedded deltaic sands were also observed in our hand excavation in the west-facing slopes at the proposed home location (Figure 3). Deformed and steeply dipping beds were observed on lot 13 to the south that may be intact failure blocks of this slide at its margin. Slopes in the eastern part of the site and to the north show no evidence of ongoing deformation and appear currently stable. The surficial and air photo evidence suggest that the site is in a zone of depletion where sediments failed and moved downslope to the southwest to a lower (depositional) accumulation zone.

Based on all of the above, the risk from landslides in the western part of the site is high; the eastern part of the site would have a lower hazard. We therefore recommend a geotechnical engineering slope-stability evaluation be conducted prior to building. Recommendations to reduce the risk of landsliding, including setbacks or engineered mitigation measures, should be provided if the factors of safety are deemed unsuitable. Care should also be taken that site grading does not destabilize the toes of the slopes without prior geotechnical analysis and grading plans, and that no ponded water is allowed to remain on the slopes that may reduce stability.

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. The site is not in any mapped alluvial deposits or drainages, and no evidence of debris-flow features such as levees or terminal lobes was observed in our reconnaissance. Based on the above, the hazard from debris flows at the site is rated as low.

Rock Fall

The site is not below outcrops of bedrock that could provide a source for rock falls, and no boulders from rock fall were observed at the surface of the site. Based on this, the hazard from rock falls is rated as low.

Snow Avalanche

A hazard from snow avalanches may exist due to proximity of the site to mountainous areas with south-, west- and north-facing slope aspects. Based on the distance of the site from the mountain front, the risk from snow avalanche is very low.

Radon

Radon comes from the natural (radioactive) breakdown of uranium in soil, rock, and water and can seep into homes through cracks in floor slabs or other openings. The site is located in a "Moderate" radon-hazard potential area (Black and Solomon, 1996). A moderate hazard rating indicates that indoor radon concentrations would likely be between 2 to 4 picocuries per liter of air, which is below the action level recommended by the Environmental Protection Agency. Long-term indoor tests near the site by the Utah Division of Radiation Control show concentrations of from 1.6 to 15.0 picocuries per liter of air (Black and Solomon, 1996). Actual indoor radon levels can be affected by non-geologic factors such as building construction, maintenance, and weather. Indoor testing following construction is the best method to characterize the radon hazard and determine if mitigation measures are required.

Swelling and Collapsible Soils

Surficial soils that contain certain clays can swell or collapse when wet. No evidence of potential swelling and collapsible soils was observed at the site. Sediments at the site appear to consist mainly of sand with lesser silt and gravel. However, a geotechnical engineering evaluation should be performed during the subdivision approval process to address soil conditions and provide specific recommendations for site grading, subgrade preparation, and footing and foundation design

Volcanic Eruption

No active volcanoes, vents, or fissures are mapped in the region. Based on this, no volcanic hazard likely exists at the site and the risk to the project is low.

CONCLUSIONS AND RECOMMENDATIONS

Geologic hazards posing a potential risk to the site are earthquake ground shaking, surface fault rupture, liquefaction, and landslides. Sheet and rill flow may also pose a seasonal concern. The following recommendations are provided to address these hazards at the property:

- Proposed homes should be designed and constructed to current seismic standards to reduce the potential ground-shaking hazard.

- 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;
    3. Evaluate and provide recommendations regarding liquefaction and, if needed, shallow groundwater; and
    4. Evaluate stability of slopes at the site, including providing recommendations such as setbacks and/or engineered mitigation measures to reduce the landslide risk if the factors of safety are deemed unsuitable.

- Site hydrology and runoff should be addressed in the civil engineering design for the development to reduce the risk of localized sheet and rill flow.

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.

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 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

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Associate Engineering Geologist

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Reviewed by:

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Principal Engineering Geologist

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STATE OF UTAH

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ATTACHMENTS

Figure 1. Location Map
Figure 2. Geologic Map
Figure 3. Air Photo

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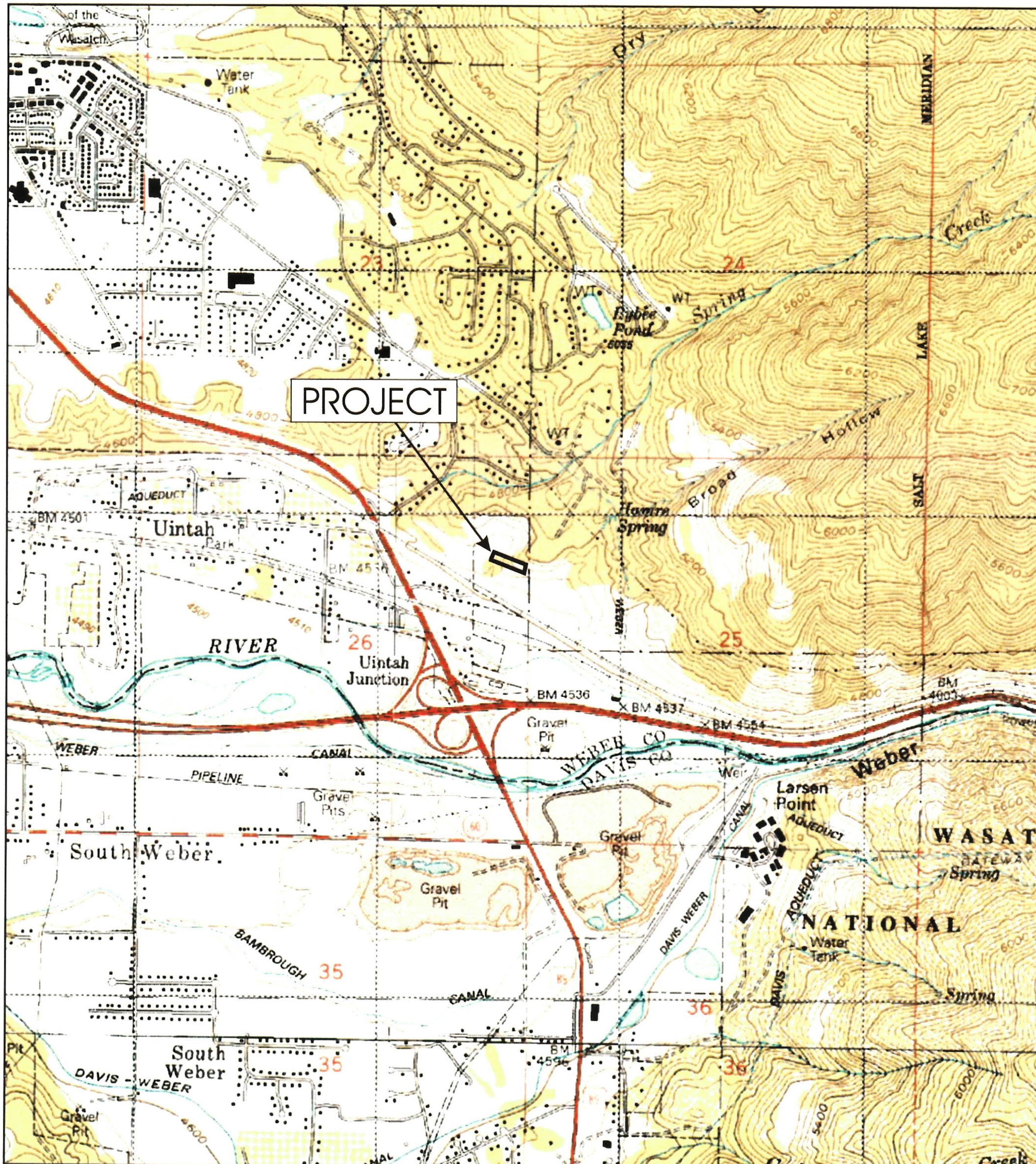


Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, UT - Ogden and Kaysville 1992.

WESTERN GEOLOGIC

N W E S

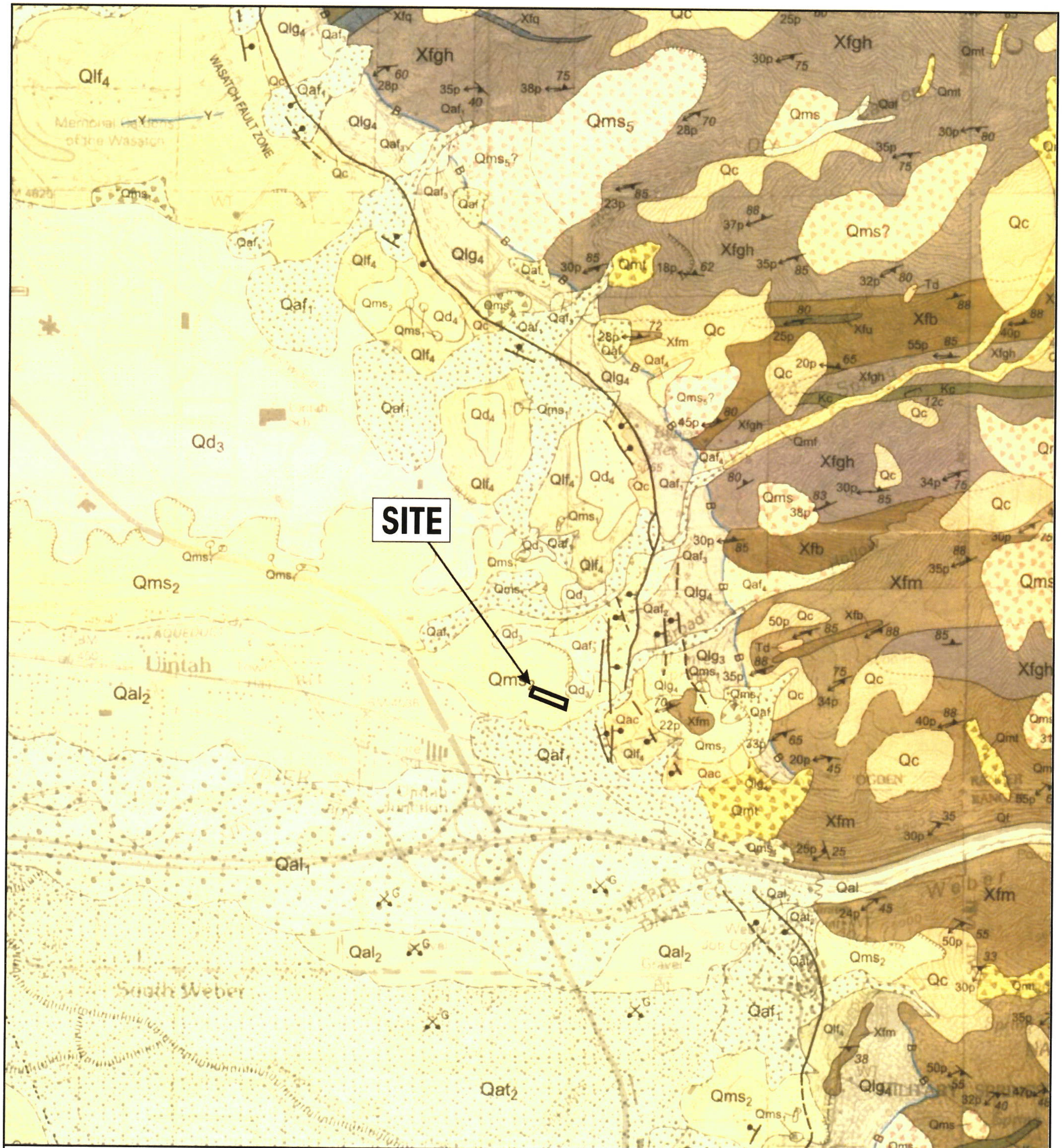
0 1000 2000 feet

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

LOCATION MAP

GEOLOGIC HAZARDS RECONNAISSANCE
Cedar Cove Subdivision Lot 12
2716 Bybee Drive
Weber County, Utah

FIGURE 1



Source: Yonkee and Lowe (2004). See text for explanation of geologic units.

WESTERN GEOLOGIC

N
W E
S

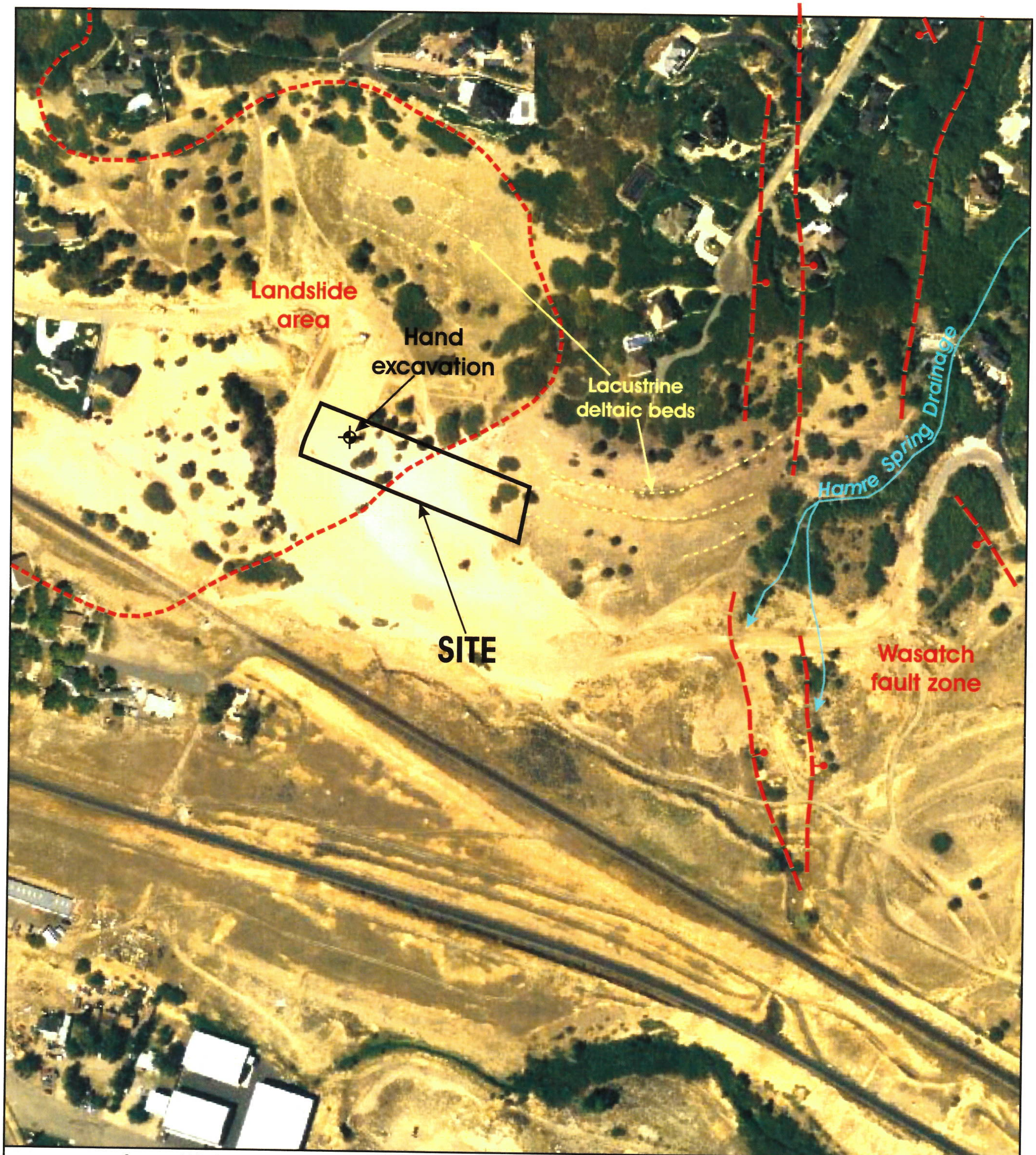
0 1000 2000 feet

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

GEOLOGIC MAP

GEOLOGIC HAZARDS RECONNAISSANCE
Cedar Cove Subdivision Lot 12
2716 Bybee Drive
Weber County, Utah

FIGURE 2



Source: U.S. Geological Survey high resolution urban photography, Salt Lake City, 2003, 0.3 meter resolution; fault and landslide mapping modified from Yonkee and Lowe (2004).

WESTERN GEOLOGIC

N W E S

0 150 300 feet

Scale 1:3,600
(1 inch = 300 feet)

AERIAL PHOTO

GEOLOGIC HAZARDS RECONNAISSANCE
Cedar Cove Subdivision Lot 12
2670 Bybee Drive
Weber County, Utah

FIGURE 3