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GEOTECHNICAL STUDY
PINEVIEW @ RADFORD HILLS
HUNTSVILLE, UTAH

Earthtec
Testing and Engineering, P.C.

PREPARED FOR:

TITAN DEVELOPMENT
6085 SOUTH 900 EAST, SUITE 202
MURRAY, UT 84121

ETE JOB NO.: 06-0020

MARCH 23, 2006

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PINEVIEW ESTATES @ REDFORD HILLS
ETE JOB NUMBER: 06-0020

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4. Stabilization below buildings and in roadways may be required if shallow groundwater is encountered.

5. Unless a more stringent local code exists, the pavement section for light residential traffic should consist of 3 inches of asphaltic concrete over 11 inches of aggregate base.

3.0 PROPOSED CONSTRUCTION

It is our understanding that this project will consist of 79 one to two story, wood frame residential structures with basements. For design purposes it was assumed that structural loads would be on the order of 2 to 3 kips for wall loads, and 100 pounds per square foot for floor slab loads. For pavement design, we estimated a Daily Traffic Number (equivalent 18-k axle loading) of 5 which is typical for residential access roads. If structural loads or daily traffic conditions are different than those assumed, we should be notified and allowed to reevaluate our recommendations.

4.0 SITE CONDITIONS

The site has an undulating topography generally with slope grades ranging from 12 to 15 percent, except for the west side where lot grades range from 20 to 30 percent. West of the planned lots the grades steepen and range from 30 to 50 percent. The site is covered with vegetation, mostly scrub oak and sage brush. The property is bound by residential homes to the south, a bed and breakfast to the north, Highway 162 to the east, and U.S. forest service land to the west.

5.0 FIELD INVESTIGATION

The field investigation consisted of excavating twelve test pits to depths of 4 to 12 feet below current site grades. The approximate locations are shown on Figure 2. 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 verify field classification and to select representative samples for laboratory testing. Laboratory tests included natural moisture and density determinations, mechanical gradation, Atterberg limits, and swell/consolidation. The results of these tests are shown on Figures 3 through 14 and in Table 1, attached.

Samples will be retained in our 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 twelve test pits excavated for this study, the site is generally covered by 6 to 24 inches of organic topsoil. Soil conditions varied slightly between test pits. Test pits 1, 3, and 9 consist of medium stiff lean clay (CL) followed by medium dense silty gravel with sand (GM) that extended beyond the maximum depth investigated. Test pits 2 & 4 consist of medium stiff lean clay (CL) followed by stiff silt with sand (ML) and medium stiff sandy elastic silt (MH) which extended beyond maximum depth investigated. Test pits 6 & 8 consist of medium stiff lean and fat clays (CL & CH) on top of a layer of very closely fracturing shale bedrock that extended below the maximum depth investigated. All other test pits consisted mostly of medium stiff to stiff lean and fat clays (CL & CH) with some interbedded layers of medium dense to dense silty sand (SM). Ground water was fairly deep, greater than 10 feet except in Test Pit 2 on Lot 6 where a perched water bearing layer was encountered at a depth of 3 feet. Graphical representations of the soil and ground water conditions encountered in the test holes are shown on Figures 3 through 10, Test Pit Logs. A key to the symbols used on the Test Pit Logs can be found on Figure 15.

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 pads and below pavements and concrete flatwork prior to foundation excavation and placement of site grading fills. Following stripping and excavation to design grades, the subgrade should be proof rolled to a firm, non-yielding surface with an approved non-vibratory roller. 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 18 inches, placing a geo-fabric 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. Where near surface moisture is present, construction traffic can cause rutting and pumping of soils. Pumping areas should be stabilized.

Test pits were used at this site to identify the subsurface soils and the pits were backfilled with uncompacted native soils. The contractor should identify the pit areas. If any portion of the homes or roadways extend over a test pit then the backfill soils should be removed and replaced with structural fill.

8.2 Structural Fill and Compaction

All fill placed below the buildings, pavements and concrete flatwork should be structural fill. All other fills should be considered as backfill. The clays and silts at the site are not suitable for use as structural fill. Structural fill materials that are imported to the site should consist of well-graded 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, frosted or frozen soils, highly organic soils, debris, 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 buildings, and 90 percent under concrete flatwork and pavements.

8.3 Backfill

The native soils may be used for general grading, as backfill in utility trenches and against the outside of foundation walls in landscaped areas. Any fills which are required to support pavements or structures, including porches and walkways, should meet structural fill requirements. 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). The native soils will be difficult to moisture condition and compact.

8.4 Excavations

Excavations can be made with standard excavation equipment. Temporary construction excavations at the site which are above the water table and less than four feet deep should stand with ½ :1 (horizontal:vertical) slopes. All excavations which are advanced deeper than four feet below site grades or where water is encountered should be sloped or braced in accordance with OSHA[1] requirements for type C soil.

8.5 Permanent Cut and Fill Slopes

Cut and fill slopes should be graded no steeper than a 4 to 1 (horizontal: vertical) without **engineered** retainage. Cuts and fills should be limited as much as possible on slopes steeper than 20 percent.

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[1] OSHA Health and Safety Standards, final rule, CFR 29, Part 1926.

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.

10.0 SEISMIC CONSIDERATIONS

10.1 Faulting

A concealed trace of the West Ogden Valley fault is located on the west margin of the site. A fault location study was conducted by Western Geologic who found the risk of fault rupture to be low. See geologic report in the Appendix.

10.2 Seismic Design Criteria

The residential structures should be designed in accordance with the IRC. The IRC designates this area as a seismic design category D_2.

The site is located at approximately 41.68 degrees latitude and -111.83 degrees longitude. The IRC site value for this property is 0.88 g as shown in the table below.

Table No. 2: Design Acceleration for Short Period

S_S	F_a	Site Value
		$2/3(S_S*F_a)$
1.32 g	1.00	0.88 g

10.3 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. It should be understood that wood frame homes can withstand significant movement without collapse but liquefaction induced settlement could result in significant damage to the buildings during a large earthquake event. Based on the soil conditions encountered to the 12 feet investigated Western Geoplogic indicated that the hazard for liquefaction is low (See geologic report in the Appendix). However, the type of investigation used for this study is not sufficient to fully evaluate liquefaction potential or estimate the magnitude of liquefaction induced settlement. We would be happy to conduct a liquefaction study upon request but such a study would require drilling a hole to a depth of about 40 feet.

11.0 FOUNDATIONS

11.1 Footing Design

The native soils at this site are capable of supporting the proposed buildings with lightly loaded spread footings, provided the recommendations presented in this report are followed. The recommendations presented below should be considered in design and construction of this facility:

1. Spread footings founded on undisturbed native soils should be designed for a maximum allowable soil bearing pressure of 1500 psf which may be increased to 2000 psf if underlain by at least 18 inches of structural fill or stabilization fill.

2. Structural or stabilization fill should extend outside the footing by a distance of at least ½ the fill depth (ie. for a fill depth of 18 inches it should extend at least 9 inches beyond the footing limits).

3. Footings should be uniformly loaded.

4. Continuous footings should have minimum widths of 18 inches.

5. Exterior footings should be placed below frost depth which is determined by local building codes. Generally 36 inches is adequate in the area. Interior footings should extend at least 18 inches below the lowest adjacent final grade..

6. 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.

7. Footings should be set back from the face of any slope by a horizontal distance of at least 20 feet.

8. The bottom of footing excavations should be cleaned of all soils loosened during excavation and should be proof rolled to identify soft spots prior to construction of the footings or placement of structural fill. Soft areas encountered during the proof rolling operation should be removed and replaced with structural fill or stabilized as recommended in Section 8.1.

9. 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 whether excavation bottoms are free of loose or disturbed soils.

11.2 Estimated Settlement

If footings are designed and constructed in accordance with the recommendations presented above, the risk of total settlement 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.

12.0 SLOPE STABILITY

To evaluate the stability of the slopes on the west side of the property (lots 1 through 7), we performed slope stability analyses with the XSTABLE computer program, which utilizes the modified Bishop's method of slices. The slope profiles used in our analysis were developed from a site plan that was provided to us by Titan Development Company. The area of concern is along the west side of the property. Sections were analyzed on each lot for Lots 1 through 7. The slope profiles were analyzed under both static and pseudo-static conditions. The pseudo-static condition is used to evaluate the stability of a 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 0.28g[2]. Because earthquake loads are impact loads, one half of the peak acceleration is commonly used to model the earthquake impact in a pseudo-static analysis and this value was used in our analyses.

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 analyses were conducted based on an angle of internal friction of 18 degrees and cohesive strength of 336 psf from a direct shear analysis of a typical clay sample (see figure 34). Our analyses indicates that the slopes analyzed at the site on these seven lots do not have the recommended safety factors greater that 1.5 and 1.0 for static and pseudo-static conditions, respectively, in their current condition (see Figures 15 through 33). Development can also change existing conditions which can be unpredictable. In addition, saturation of the slopes would result in further instability. We recommend that lots 1through7 not be developed or have grading changes made unless greater slope stability is achieved through stabilization and drain systems with specific studies done for each individual lot. It has been our experience that stabilization of residential lots is generally not economically feasible.

13.0 FLOOR SLABS

A minimum 6 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. Floor slabs may be designed using a modulus of subgrade reaction of 180 psi/in. To help control normal shrinkage

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

and stress cracking the floor slabs should have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints, and placed with no less than 1 inch of concrete cover. Crack control joints can help limit uncontrolled cracking.

Special precautions should be taken during placement and curing of the concrete slabs. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures may lead to excessive shrinkage, cracking, spalling or curling of the slabs. We recommend all concrete placement and curing operations be performed in compliance with ACI[3] standards.

14.0 BASEMENT WALLS

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

Condition	Lateral Pressure Coefficient	Equivalent Fluid Weight (PCF)
At Rest	0.60	71
Active	0.49	58
Passive	1.90	224

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 0.4 percent of the wall height may be designed with “active

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[3] American Concrete Institute (ACI) Standards

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. Any surcharge load in excess of the soil weight applied to the backfill should be multiplied by the appropriate lateral pressure coefficient and be added to the soil pressure. Backfill should be placed in accordance with the requirements discussed in Section 8.3. Lateral pressures approximately 30 percent higher may 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 soils we recommend a friction coefficient of 0.26 be used. The lateral earth coefficients presented above are ultimate values; therefore, an appropriate factor of safety should be applied in resistance calculations.

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 structures 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 backfill with a minimum 90% density (ASTM D 1557). Water consolidation methods should not be used.

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

16.0 SUBSURFACE DRAINAGE

Although groundwater was only encountered in one test pit, this area is prone to perched water seams in wet seasons and years from surface water infiltration. In addition the soils at this site classify in Group II. Based on International Residential Code 2003, Section R405, homes constructed in group II soils must have a foundation drain. Therefore, we recommed foundation drains on all homes that have basements.

The recommendations presented below should be followed during design and construction of basements in the development:

1. The foundation drain should consist of a 4 inch diameter, slotted pipe encased in at least 12 inches of free draining gravel. The geotechnical engineer should inspect foundation excavations. If seeps are noted or conditions indicate there is a likelyhood of seasonal perched water then the gravel should extend up the foundation wall above the area of concern. If desired, the gravel extending up the walls may be replaced by a fabricated drain panel such as Mirafi Micro drain, or equivalent. A filter fabric should separate the drain gravel from the native soils. The pipe should be graded to drain to a storm drain or other free gravity outfall unless provisions for pumped sumps are made.

2. The highest point of the 4 inch perforated pipe within the foundation drain should be placed at least 8 inches below the top of the floor slab. The pipe should be graded to drain (minimum 2 percent grade) to a storm sewer or other free gravity outlet unless pump sumps are used.

3. Connections through the foundation should be made between the subfloor gravel and the foundation drain. The connections should be made in such a way to allow any water collected below the floor slabs to gravity flow to the foundation drain.

4. Clean outs should be installed so that the foundation drains may be cleaned as necessary.

17.0 PAVEMENTS

We understand that a flexible pavement is desired for the access roads in this development. Unless a more stringent local code is required, we recommend a pavement section consisting of 3 inches of asphaltic concrete over 11 inches of untreated aggregate base. The design recommendations were based on an assumed CBR value of 3, AASHTO design methods and the following assumptions:

1. The subgrade is prepared by proof rolling to a firm, non-yielding surface and soft areas are stabilized as discussed in Section 8.1;
2. Site grading fills below the pavements meet structural fill material and placement requirements as defined in section 8.2;
3. Asphaltic concrete should meet Weber County requirements for secondary roads and aggregate base should meet UDOT specification requirements;
4. Aggregate base is compacted to at least 95 percent of maximum dry density (ASTM D 1557);
5. Asphaltic concrete is compacted to at least 96 percent of the laboratory Marshal mix design density (ASTM D 1559);
6. Traffic loads, estimated based on the type of use, are as discussed in Section 3.0 of this report; and
7. Pavement design life of 20 years.

In access roads there is a potential of rutting and/or pumping and the depth of disturbance is proportional to the moisture content in the soil, the load applied to the ground surface, and the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the ground surface by using lighter equipment, by working in dry times of the year, or by providing a working surface for the equipment. If rutting or pumping occurs traffic should be stopped in the area of concern. In areas where pumping occurs the soil should either be allowed to sit until pore pressures dissipate (several hours to several days) and the soil firms up, or be removed and replaced with granular material. If construction scheduling does not allow time for rutting or pumping soils to dry out, or if unstable conditions extend more than 18 inches deep, the stabilization procedures discussed above should be used.

The pavement section presented above is designed for standard residential traffic and not for frequent heavy wheel loads that can occur during development, such as from concrete trucks, excavation equipment and lumber trucks. If the roads are paved prior to completion of the development some pavement damage and reduced pavement life should be expected. Damage can be limited by providing alternate access for construction traffic or using an asphalt treated aggregate as a wearing surface with the asphalt surface coarse installed after construction is essentially complete. We would be happy to provide you with a pavement section designed for the construction traffic, upon request.

18.0 GENERAL CONDITIONS

The exploratory data presented in this report were collected to provide geotechnical design recommendations for this project. Test pits were widely spaced and may not be indicative of subsurface conditions between the test pits or outside the study area and thus have 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 pits 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. If the city inspector assigned to this project is competent in inspect the subsurface conditions, the inspector may designate when conditions warrant an inspection by an engineer.

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 TESTING AND ENGINEERING, P.C.

Robert E. Barton, P.E.
Principal Geotechnical Engineer

ROBERT E BARTON
No. 168431
4-Mar-6.

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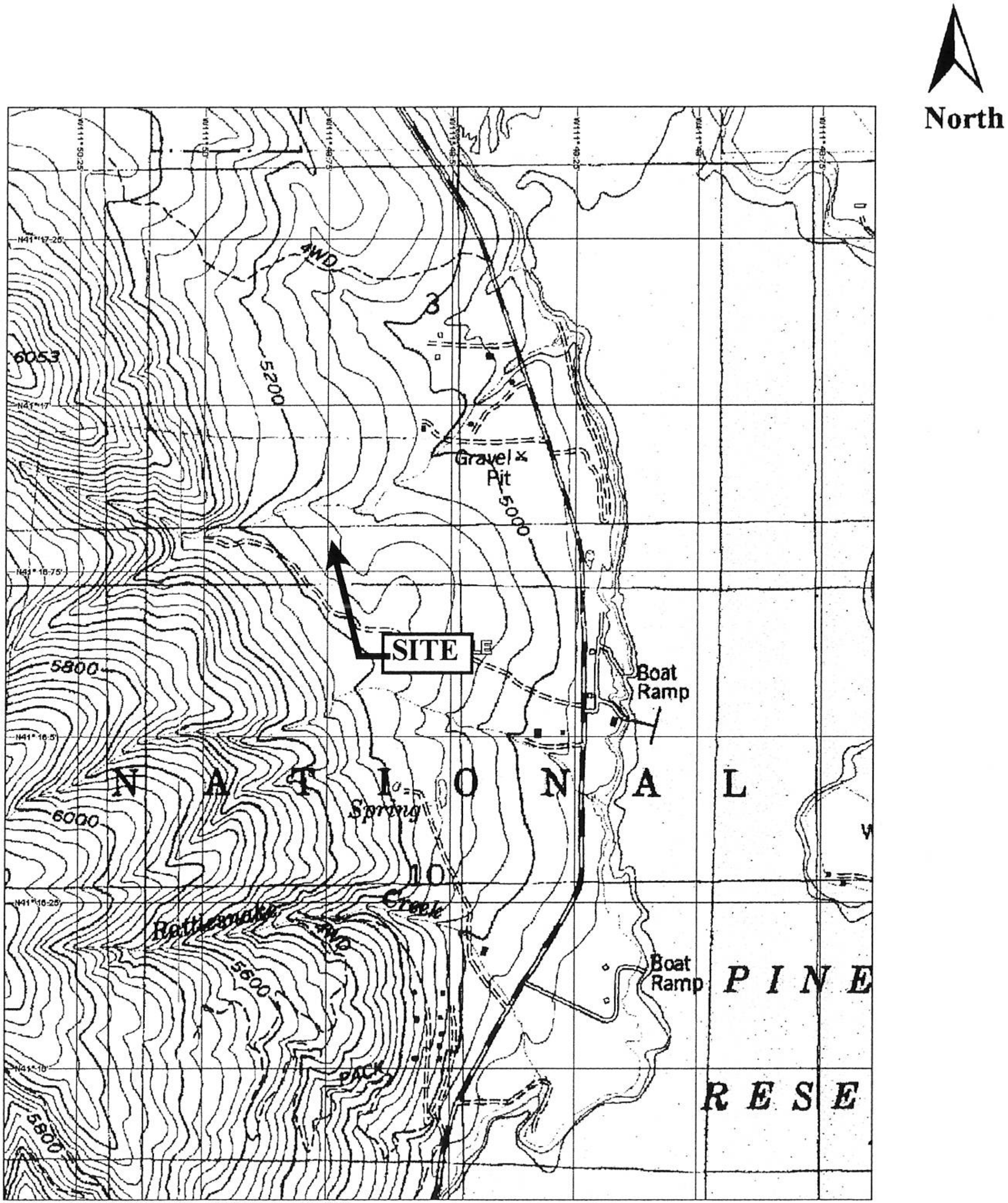


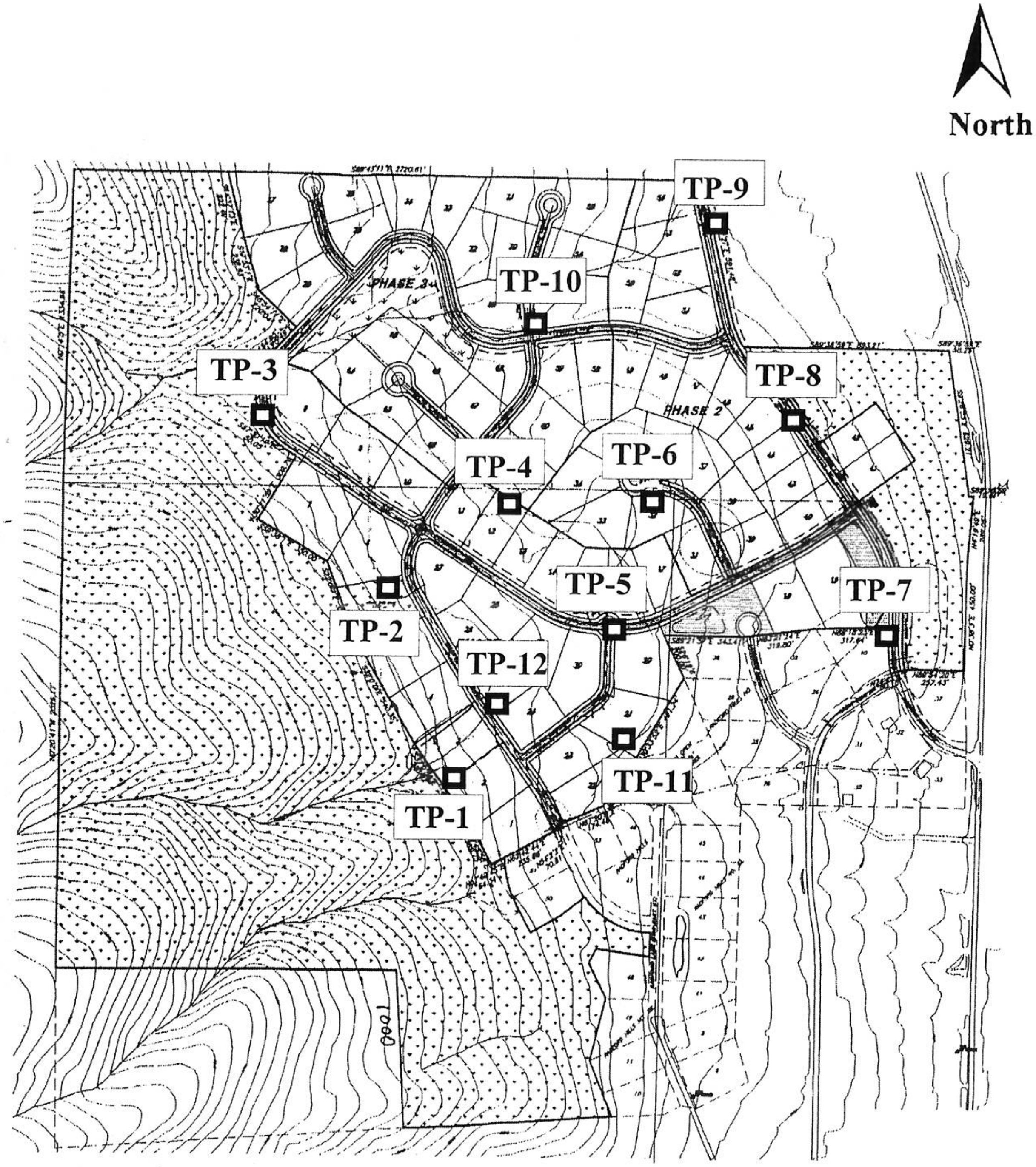
3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

350 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84

BASE MAP TAKEN FROM USGS "HUNTSVILLE" QUAD

ETE Job No. 06-0020 **VICINITY MAP** **Figure 1**

EARTHTEC ENGINEERING



BASE MAP PROVIDED BY TITAN DEVELOPMENT.

SITE PLAN SHOWING LOCATION OF TEST HOLES

ETE Job No. 06-0020 **Figure 2**

TEST PIT LOG

NO.: TP-1

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	⁘	TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY, MOIST, BLACK									
1	▨		LEAN CLAY, MEDIUM STIFF, MOIST, BLACK									
	▨	CL		☒								
2	▨											
3	⚬		SILTY GRAVEL WITH SAND, MEDIUM DENSE, MOIST, MEDIUM BROWN									
4	⚬											
5	⚬	GM										
6	⚬											
	⚬			☒		6			62	29	9	
7												
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

LOG OF TESTPIT 06-0020.GPJ EARTHTEC.GDT 3/20/06

PROJECT NO.: 06-0020

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FIGURE NO.: 3

TEST PIT LOG

NO.: TP-2

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ : 3 ft.

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨	TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, BLACK									
1	▨	CL	LEAN CLAY WITH SAND, MEDIUM STIFF, WET, MEDIUM BROWN WITH IRON OXIDE STAINING									
2	▨			☒								
3	▨		▽									
4	▨											
5	▨											
6	▨	CH	FAT CLAY, MEDIUM STIFF, MOIST, OLIVE									
7	▨											
8	▨			☒	77	29	45	73	1	10	89	DS
9	▨											
10	▨											
11												
12												
13												
14												
15												

Notes:

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

PROJECT NO.: 06-0020

Earthtec Testing and Engineering, P.C.

FIGURE NO.: 4

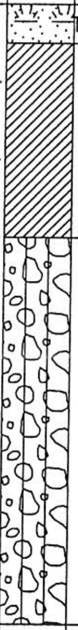
LOG OF TESTPIT 06-0020.GPJ EARTHTEC.GDT 3/20/06

TEST PIT LOG

NO.: TP-3

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :



Depth (Ft.) 0	Graphic Log	USCS	Description	Samples	Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
		TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH GRAVEL, MOIST, DARK BROWN									
1 2 3		CL	LEAN CLAY WITH GRAVEL, MEDIUM STIFF, MOIST, DARK BROWN	☒								
4 5 6 7 8		GM	SILTY GRAVEL WITH COBBLE, DENSE, SLIGHTLY MOIST, MEDIUM BROWN	☒								
9 10 11 12 13 14 15												

Notes: No groundwater encountered.

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

TEST PIT LOG

NO.: TP-4

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0			ORGANIC TOPSOIL: LEAN CLAY, MOIST, DARK BROWN									
1		TOPSOIL										
2												
3		CL	LEAN CLAY, MEDIUM STIFF, MOIST, OLIVE WITH IRON OXIDE STAINING	☒								
4												
5			SILT WITH SAND, STIFF, MOIST, MEDIUM BROWN									
6												
7		ML		☒	100	18	8	36	1	16	83	
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

LOG OF TESTPIT 06-0020.GPJ EARTHTEC.GDT 3/20/06

TEST PIT LOG

NO.: TP-5

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ **:**

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ **:**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0–2		TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, DARK BROWN									
2–8		SM	SILTY SAND WITH COBBLE, MEDIUM DENSE, MOIST, MEDIUM BROWN									
5				☒								
8–12		CH	FAT CLAY, MEDIUM STIFF, MOIST, OLIVE WITH IRON OXIDE STAINING									
10				☒	83	32	43	64	0	12	88	
12–15												

Notes: No groundwater encountered.

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

PROJECT NO.: 06-0020

Earthtec Testing and Engineering, P.C.

FIGURE NO.: 7

TEST PIT LOG
NO.: TP-6

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	░	TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, DARK BROWN									
1	▨	CL	LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, DARK BROWN	☒								
2	▩	BEDROCK	SHALE BEDROCK, OLIVE, VERY CLOSELY FRACTURED, MODERATELY STRONG									
3	▩			☒								
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

Tests Key

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

PROJECT NO.: 06-0020

Earthtec
Testing and Engineering, PC

FIGURE NO.: 8

TEST PIT LOG

NO.: TP-7

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ∇:

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0		TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, MEDIUM BROWN									
1		CL	LEAN CLAY WITH SAND, WITH COBBLE AND BOULDERS, MEDIUM STIFF, MOIST, MEDIUM BROWN	☒								
2		SM	SILTY SAND WITH COBBLES AND BOULDERS, DENSE, MOIST, REDDISH BROWN									
3												
4												
5												
6												
7				☒								
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

TEST PIT LOG

NO.: TP-8

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	░	TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, DARK BROWN									
1	▨	CL	LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, DARK BROWN									
2	▨	CH	FAT CLAY, MEDIUM STIFF, MOIST, MEDIUM BROWN									
3	▨											
4	▨											
5	▨			☒	84	37	26	55	1	26	73	
6	▨											
7	▩	BEDROCK	SHALE BEDROCK, OLIVE, SLIGHTLY WEATHERED, VERY CLOSELY FRACTURED, WEAK									
8	▩			☒								
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

PROJECT NO.: 06-0020

Earthtec
Testing and Engineering, P.C.

FIGURE NO.: 10

TEST PIT LOG
NO.: TP-9

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0		TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, DARK BROWN									
1		CL	LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, DARK BROWN									
2		GM	SILTY GRAVEL WITH SAND, DENSE, MOIST, REDDISH BROWN									
3												
4												
5												
6												
7				☒								
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

PROJECT NO.: 06-0020

Earthtec
Testing and Engineering, P.C.

FIGURE NO.: 11

TEST PIT LOG

NO.: TP-10

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽ :

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▒	TOPSOIL	ORGANIC TOPSOIL LEAN CLAY WITH SAND, MOIST, BLACK									
1	▨	CL	LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, BLACK									
2	▨	CL	SANDY LEAN CLAY, MEDIUM STIFF, MOIST, MEDIUM BROWN									
3	▨			☒								
4	▨											
5	▥	MH	SANDY ELASTIC SILT, MEDIUM STIFF, MOIST, OLIVE									
6	▥											
7	▥			☒								
8	▥					32	23	77	1	41	58	
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

Tests Key

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

TEST PIT LOG

NO.: TP-11

PROJECT: Pineview Estates at Redford Hills
CLIENT: Titan Development
LOCATION: See Figure 2
OPERATOR: MS CONSTRUCTION
EQUIPMENT: CAT 322B
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 06-0020
DATE: 01/23/06
ELEVATION:
LOGGED BY: BRUCE NIELSEN
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	░	TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY, MOIST, DARK BROWN									
1	▨		LEAN CLAY, MEDIUM STIFF, MOIST, MEDIUM BROWN									
2	▨	CL		☒								
3	▨											
4	▨		LEAN CLAY, MEDIUM STIFF, MOIST, OLIVE									
5	▨											
6	▨	CL		☒								
7	▨											
8												
9												
10												
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

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

PROJECT NO.: 06-0020

Earthtec
Testing and Engineering, P.C.

FIGURE NO.: 13

TEST PIT LOG

NO.: TP-12

PROJECT:	Pineview Estates at Redford Hills	**PROJECT NO.:**	06-0020
CLIENT:	Titan Development	**DATE:**	01/23/06
LOCATION:	See Figure 2	**ELEVATION:**	
OPERATOR:	MS CONSTRUCTION	**LOGGED BY:**	BRUCE NIELSEN
EQUIPMENT:	CAT 322B		
DEPTH TO WATER; INITIAL ▽:		**AT COMPLETION ▼:**	

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0		TOPSOIL	ORGANIC TOPSOIL: LEAN CLAY WITH SAND, MOIST, DARK BROWN									
1	▨	CL	LEAN CLAY, MEDIUM STIFF, MOIST, DARK BROWN									
2	▨	CL	LEAN CLAY, MEDIUM STIFF, MOIST, REDDISH BROWN									
3	▨											
4	▨	CL	LEAN CLAY, STIFF, MOIST, REDDISH BROWN									
5	▨			☒								
6	▨											
7	▨	CL	LEAN CLAY, STIFF, MOIST, REDDISH BROWN AND OLIVE									
8	▨											
9	▨			☒								
10	▨											
11												
12												
13												
14												
15												

Notes: No groundwater encountered.

Tests Key

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

PROJECT NO.: 06-0020

Earthtec Testing and Engineering, P.C.

FIGURE NO.: 14

LEGEND

PROJECT:	Pineview Estates at Redford Hills	**DATE:**	
CLIENT:	Titan Development	**LOGGED BY:**	

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

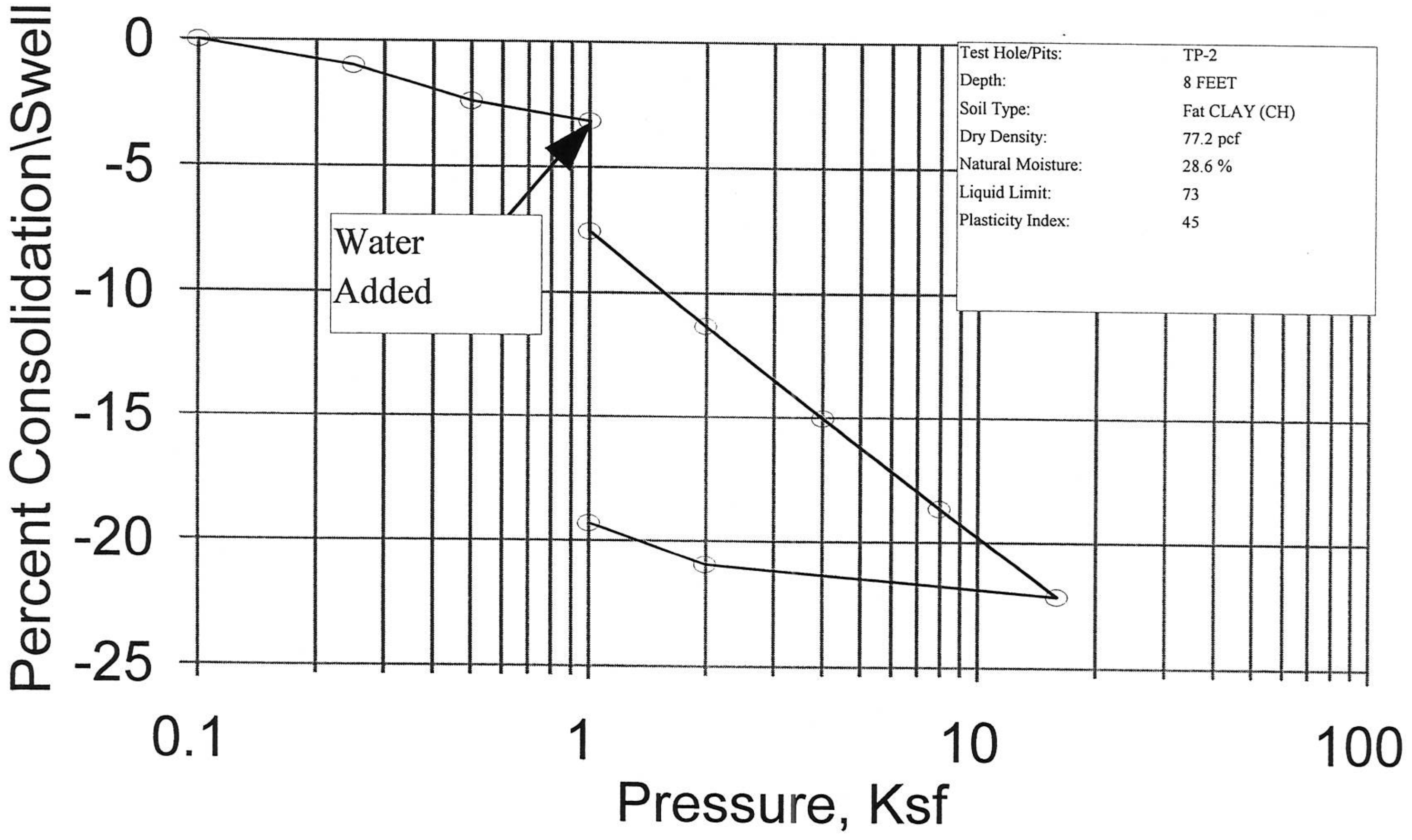
▽	Water level encountered during field exploration
▼	Water level encountered at completion of field exploration

NOTES:

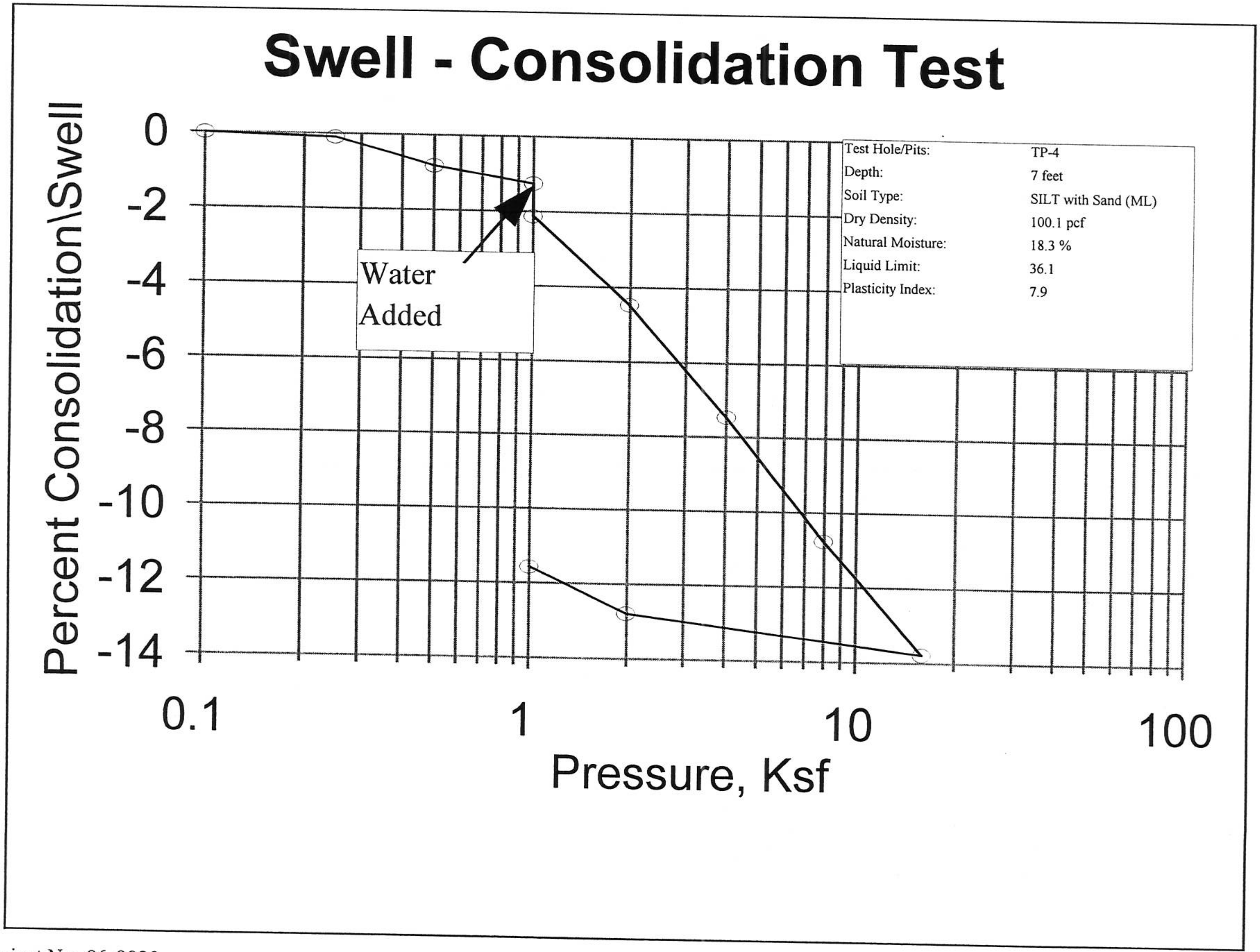
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
2. Results of tests conducted on samples recovered are reported on the logs and any applicable graphs.
3. Strata lines on the logs represent approximate boundaries only. Actual transitions may be gradual.
4.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

PROJECT NO.: 06-0020	Earthtec Testing and Engineering, P.C.	**FIGURE NO.:** 15

Swell - Consolidation Test



Test Hole/Pits:	TP-2
Depth:	8 FEET
Soil Type:	Fat CLAY (CH)
Dry Density:	77.2 pcf
Natural Moisture:	28.6 %
Liquid Limit:	73
Plasticity Index:	45



Test Hole/Pits:	TP-4
Depth:	7 feet
Soil Type:	SILT with Sand (ML)
Dry Density:	100.1 pcf
Natural Moisture:	18.3 %
Liquid Limit:	36.1
Plasticity Index:	7.9

Figure 17

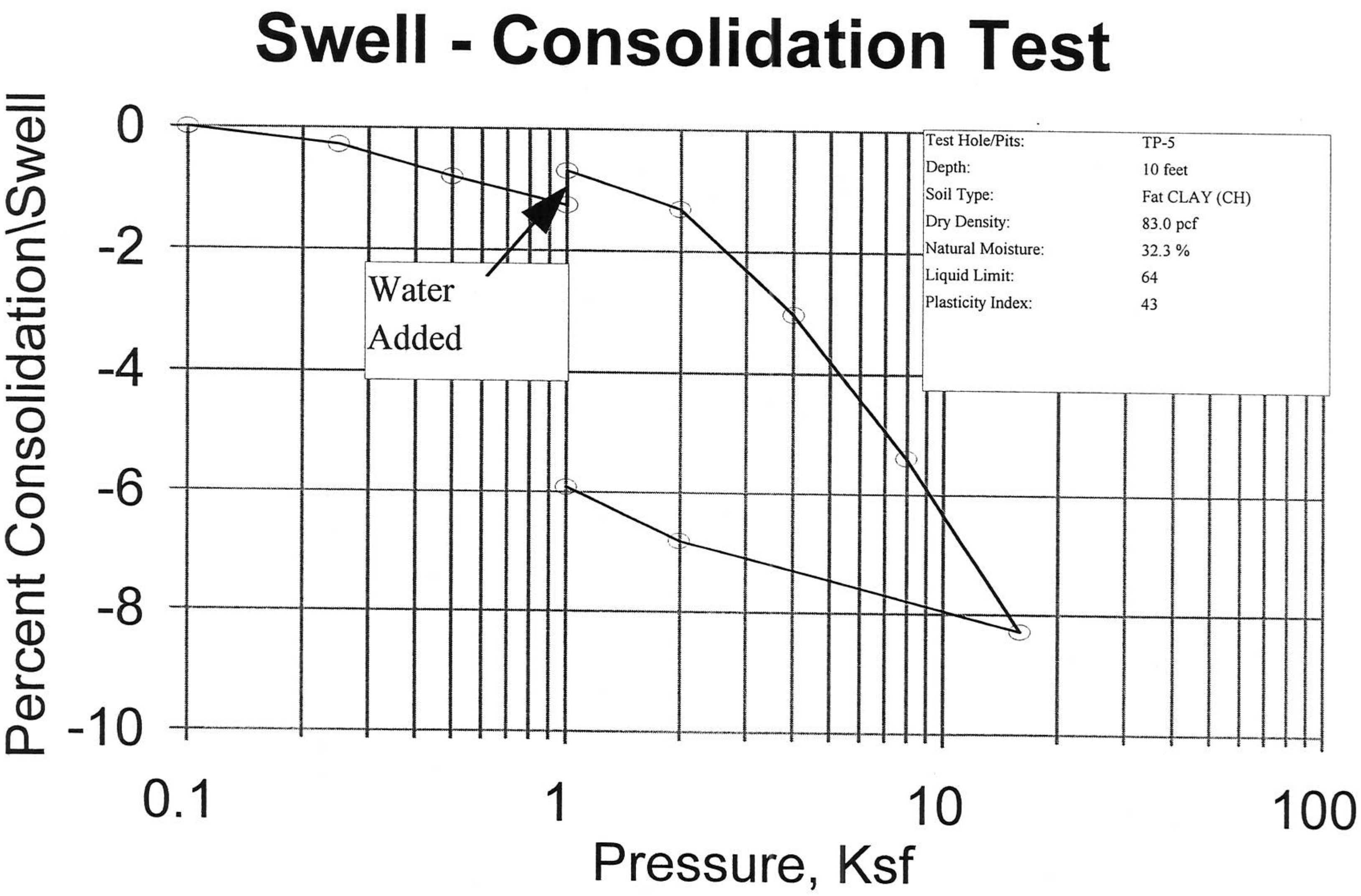
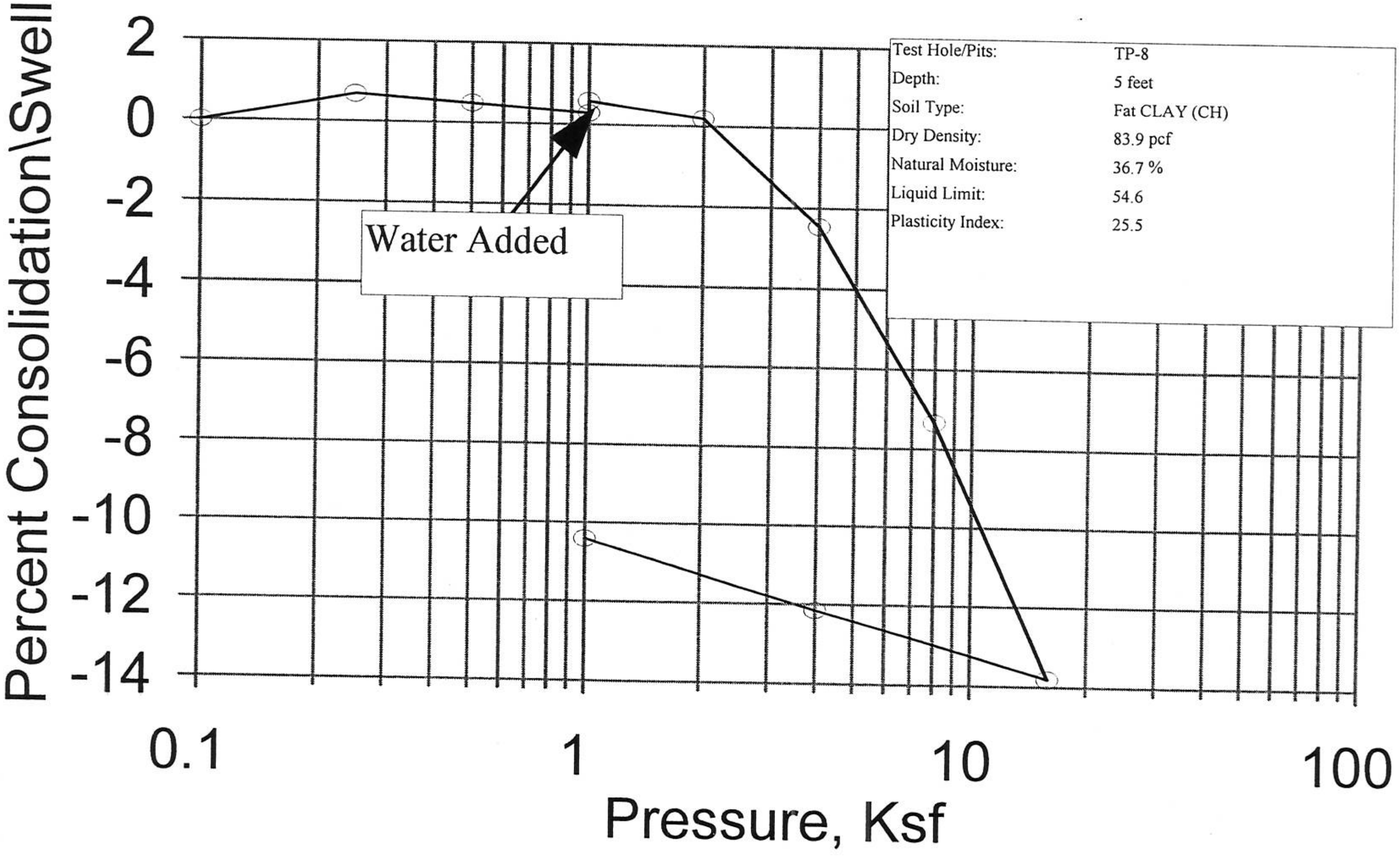

Swell - Consolidation Test
Percent Consolidation\Swell
0
-2
-4
-6
-8
-10
0.1
1
10
100
Pressure, Ksf
Water Added
Test Hole/Pits: TP-5
Depth: 10 feet
Soil Type: Fat CLAY (CH)
Dry Density: 83.0 pcf
Natural Moisture: 32.3 %
Liquid Limit: 64
Plasticity Index: 43

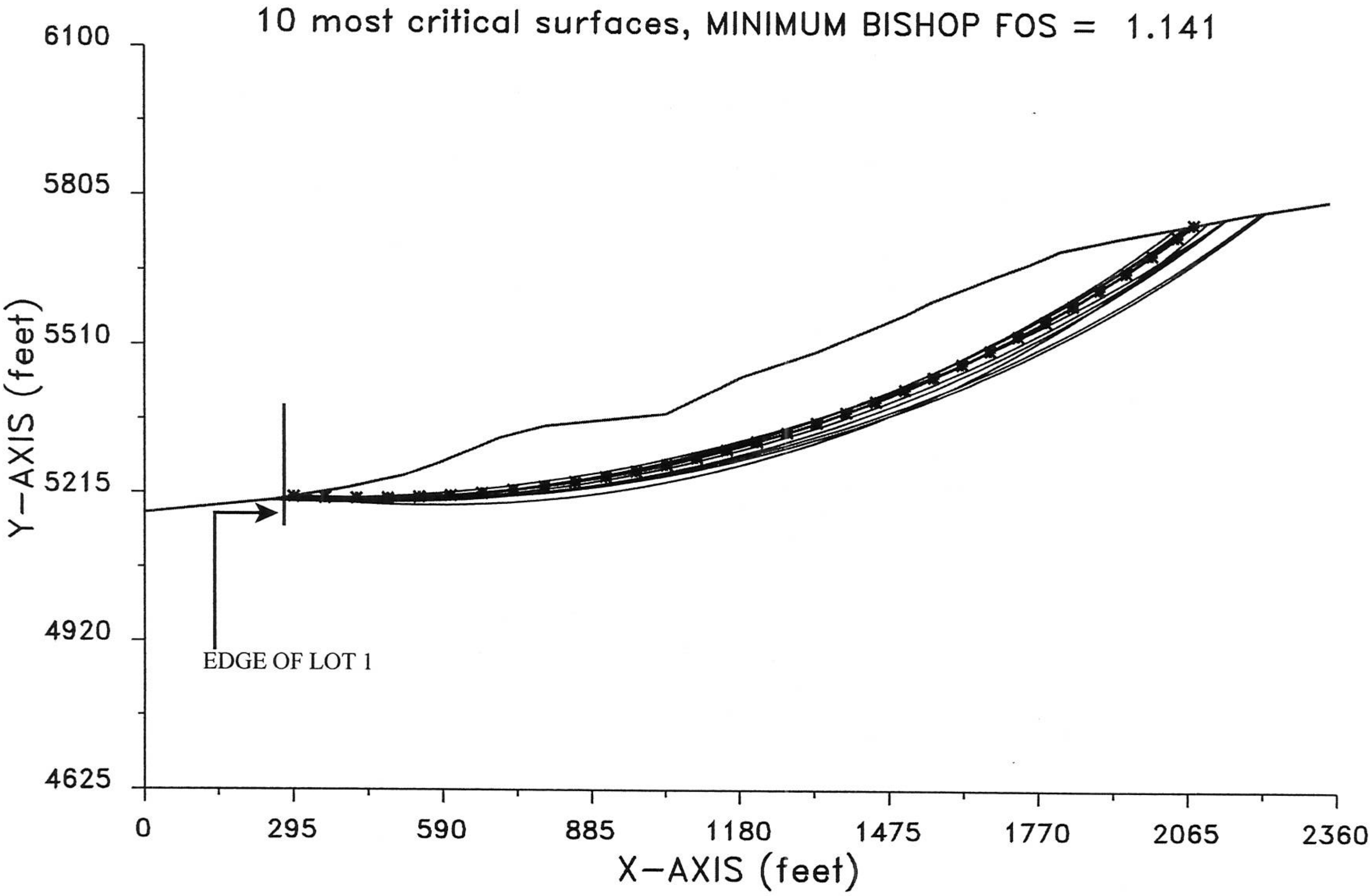
Figure 18

Swell - Consolidation Test



Test Hole/Pits:	TP-8
Depth:	5 feet
Soil Type:	Fat CLAY (CH)
Dry Density:	83.9 pcf
Natural Moisture:	36.7 %
Liquid Limit:	54.6
Plasticity Index:	25.5

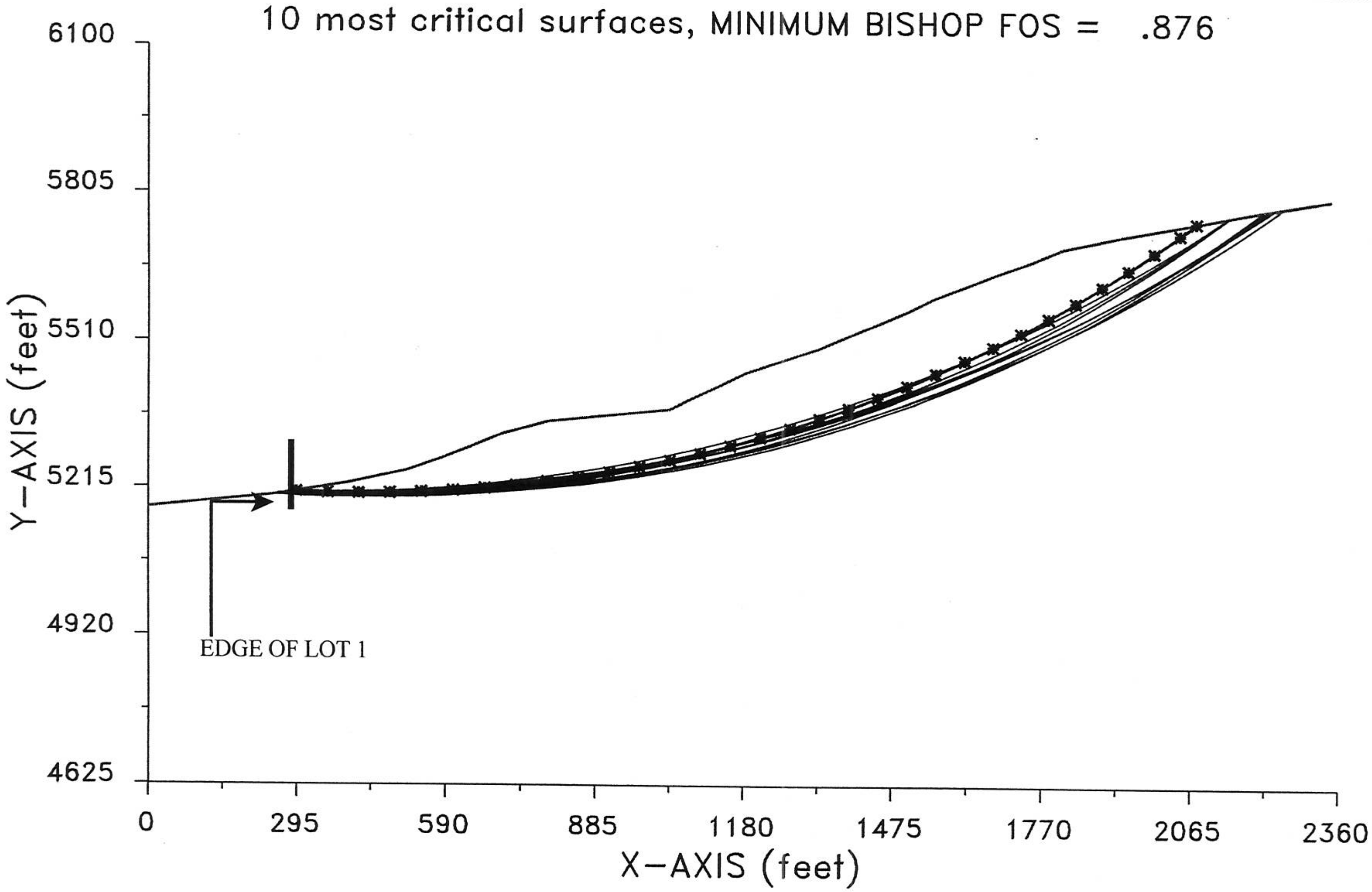
Figure 19



STABILITY ANALYSIS STATIC SLOPE- LOT 1

Figure 20

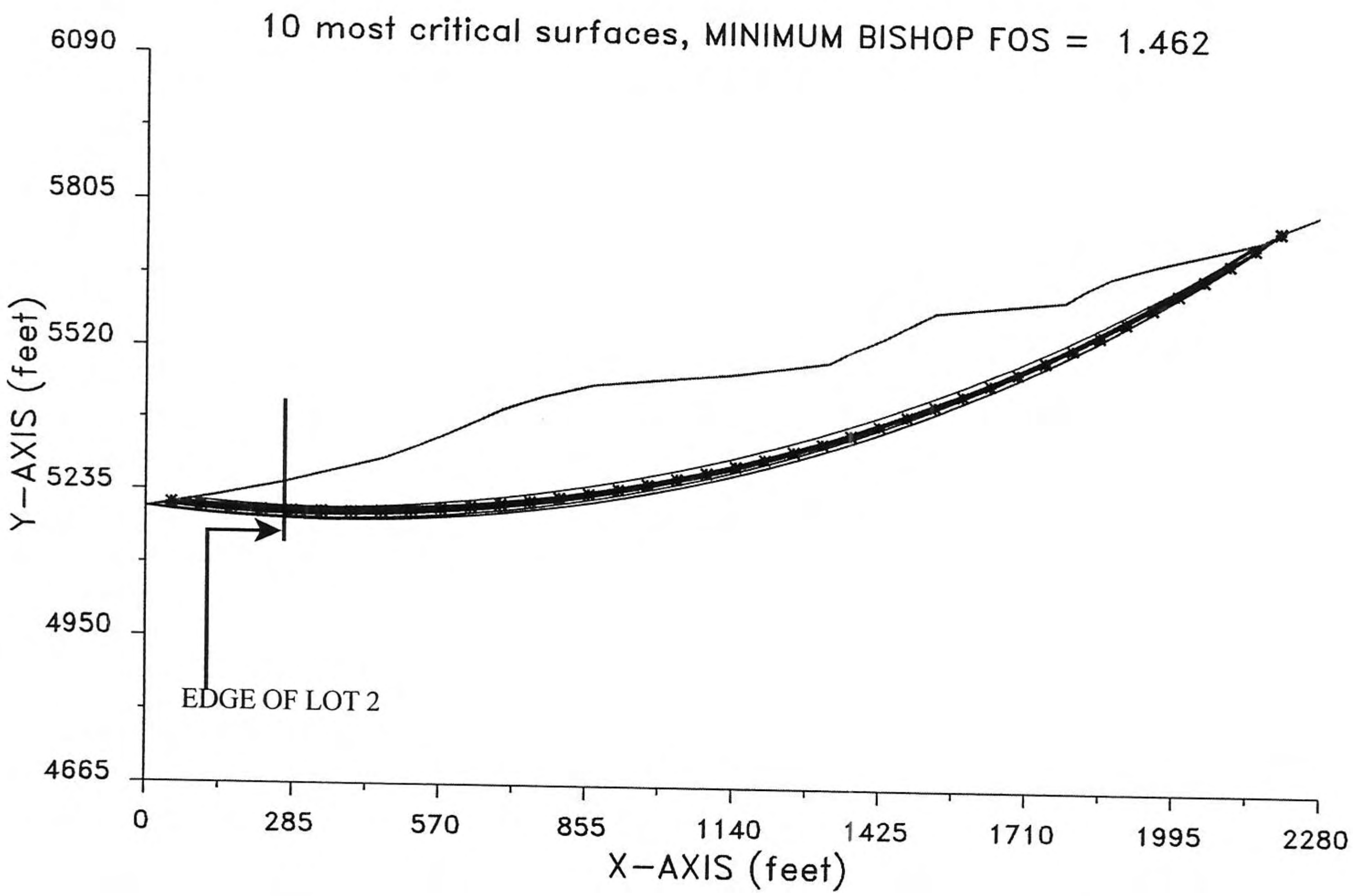
EARTHTEC TESTING AND ENGINEERING



STABILITY ANALYSIS WITH SEISMIC EVENT - LOT 1

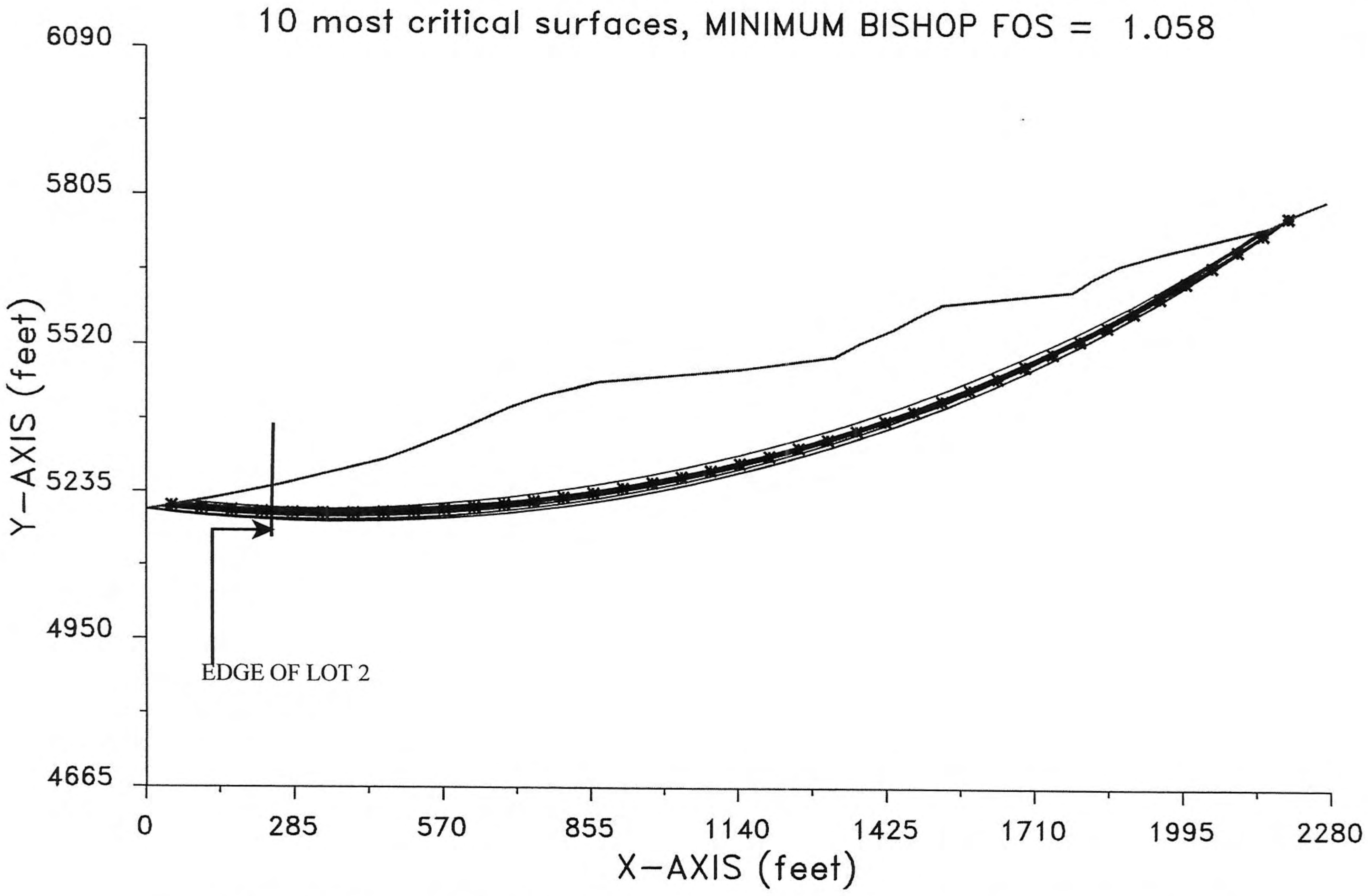
ETE Job No. 06-0020

Figure 21



STABILITY ANALYSIS STATIC SLOPE- LOT 2

EARTHTEC TESTING AND ENGINEERING

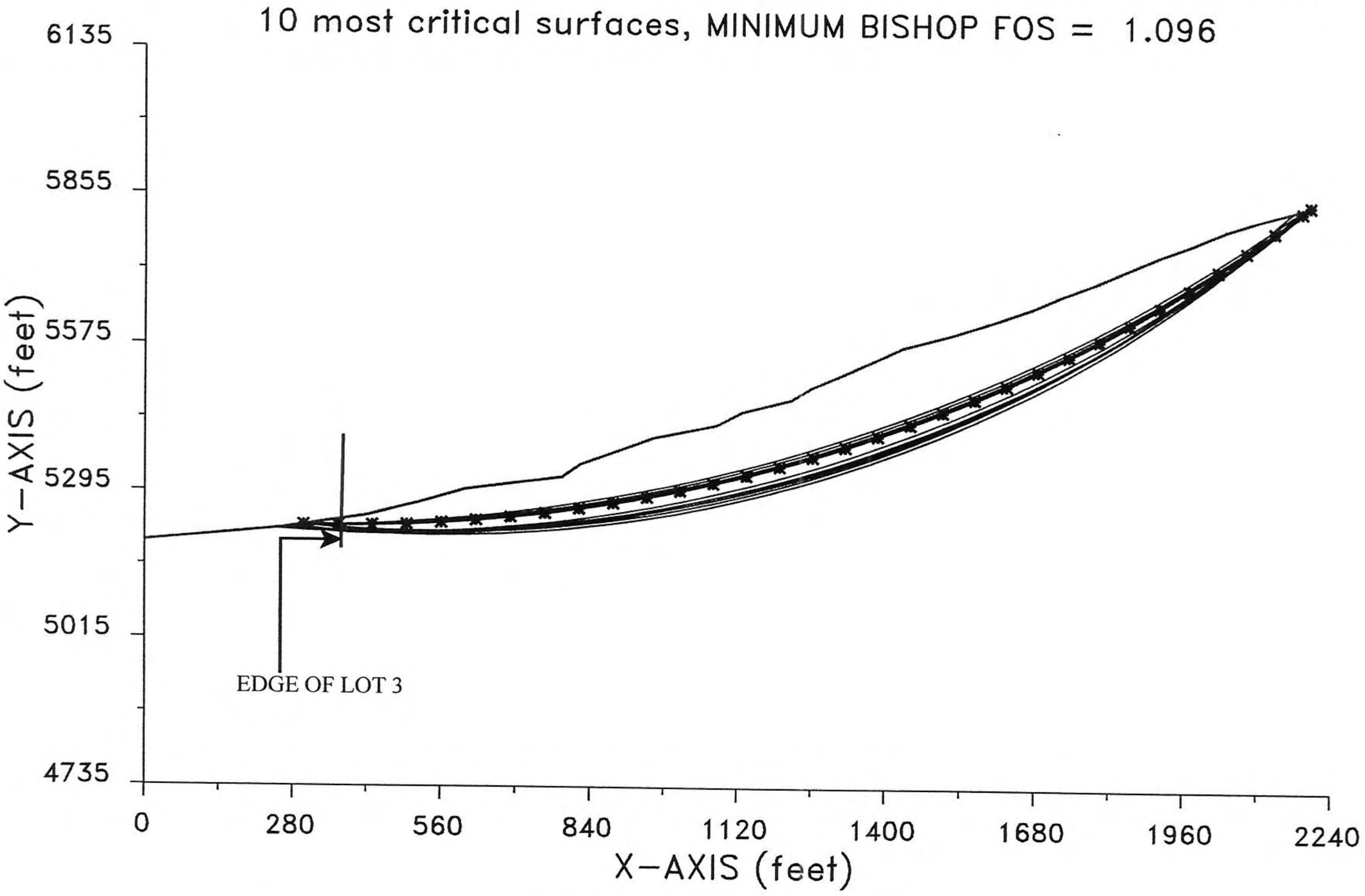


STABILITY ANALYSIS WITH SEISMIC EVENT- LOT 2

ETE Job No. 06-0020

Figure 23

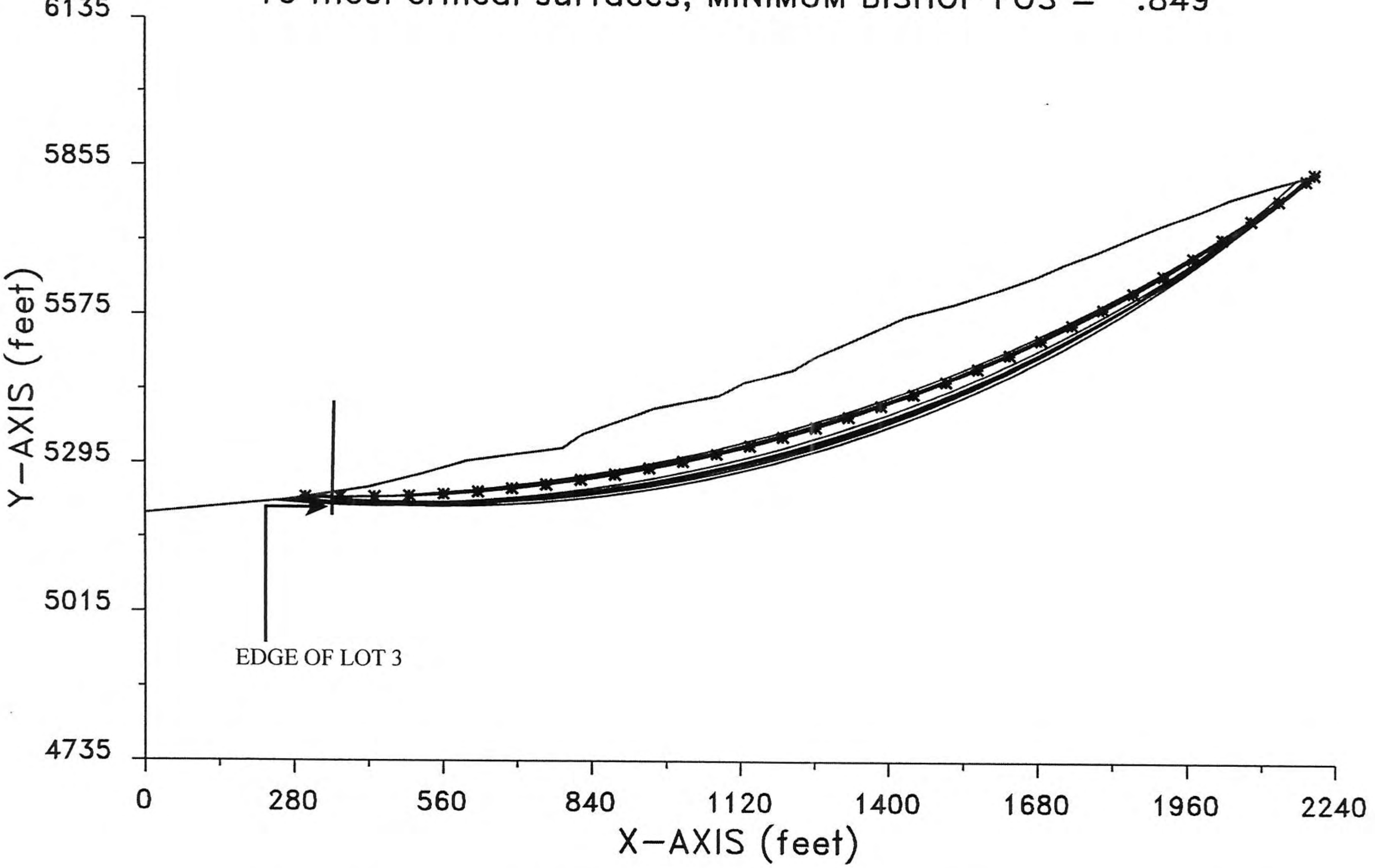
EARTHTEC TESTING AND ENGINEERING



STABILITY ANALYSIS STATIC SLOPE- LOT 3

Figure 24

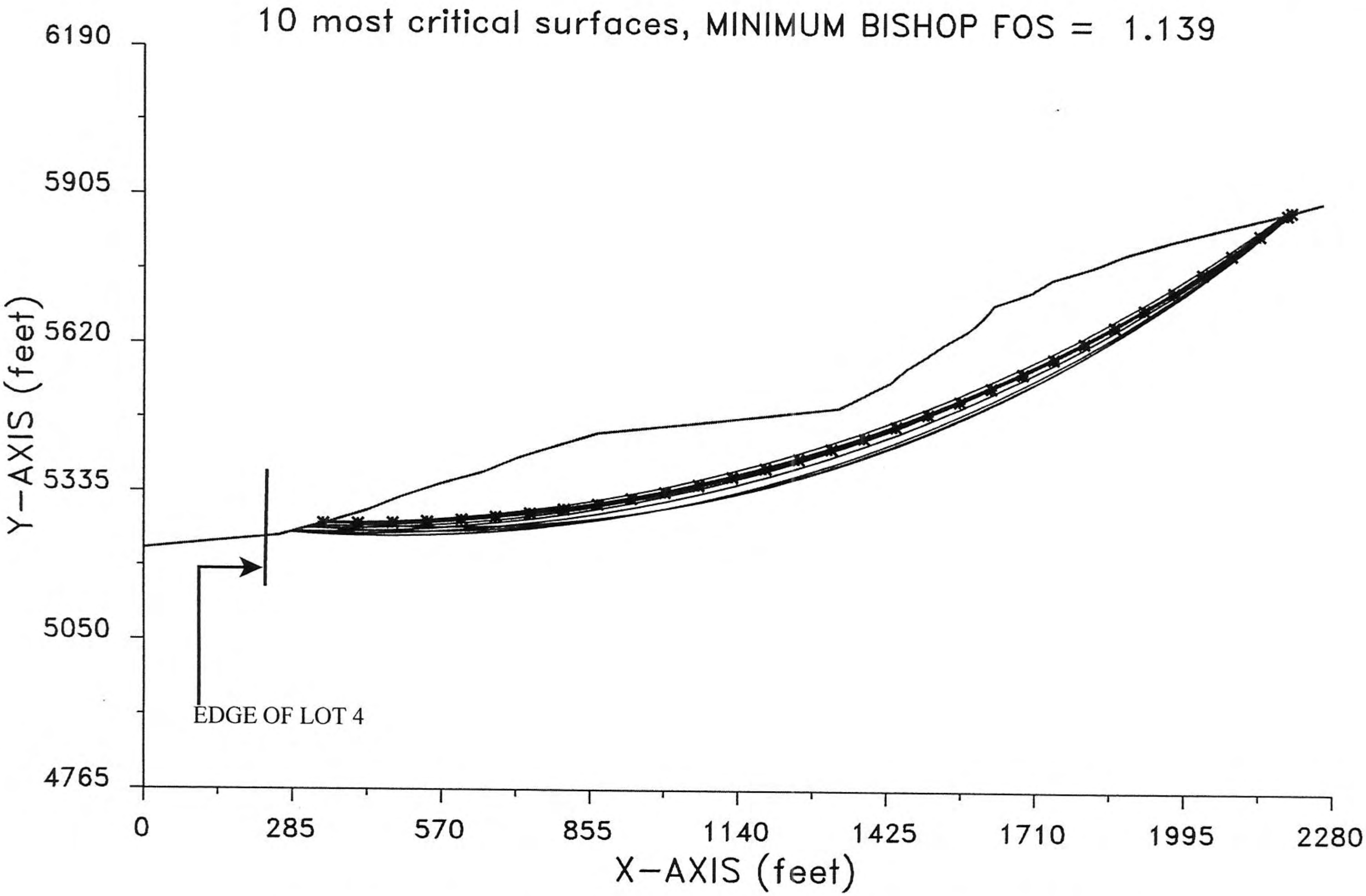
10 most critical surfaces, MINIMUM BISHOP FOS = .849



STABILITY ANALYSIS WITH SEISMIC EVENT-LOT 3

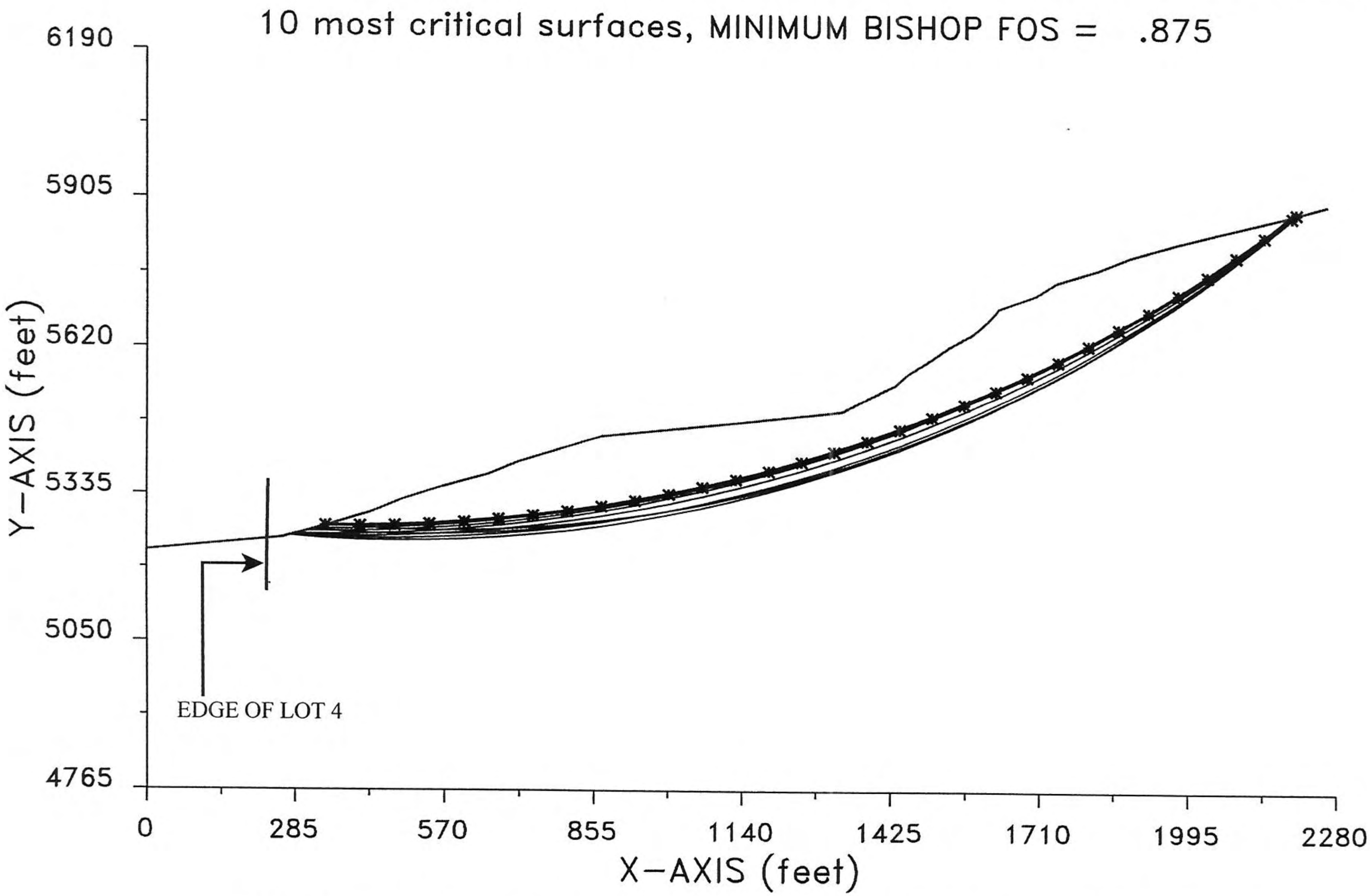
Figure 25

10 most critical surfaces, MINIMUM BISHOP FOS = 1.139

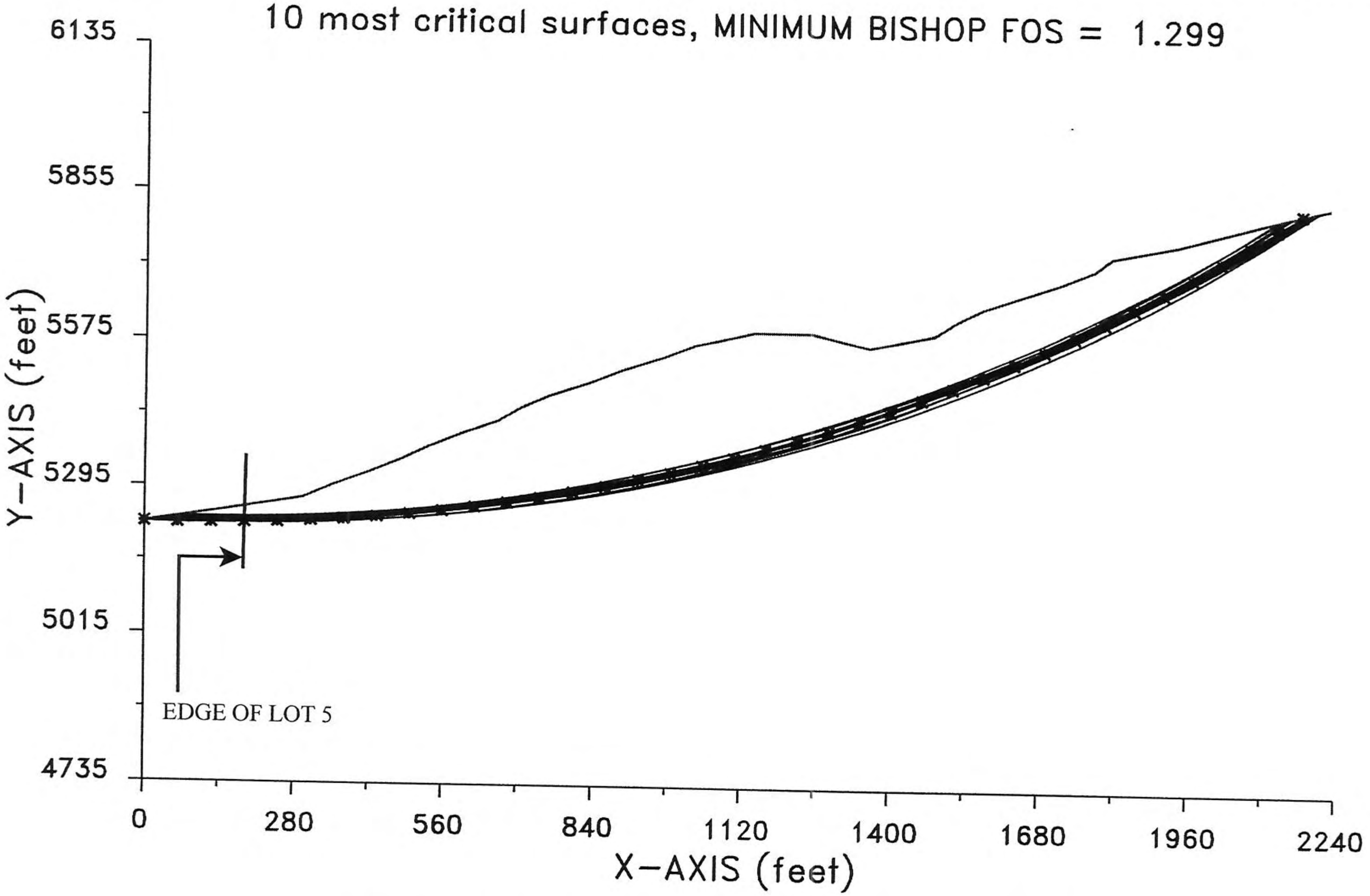


STABILITY ANALYSIS STATIC SLOPE-LOT 4

Figure 26

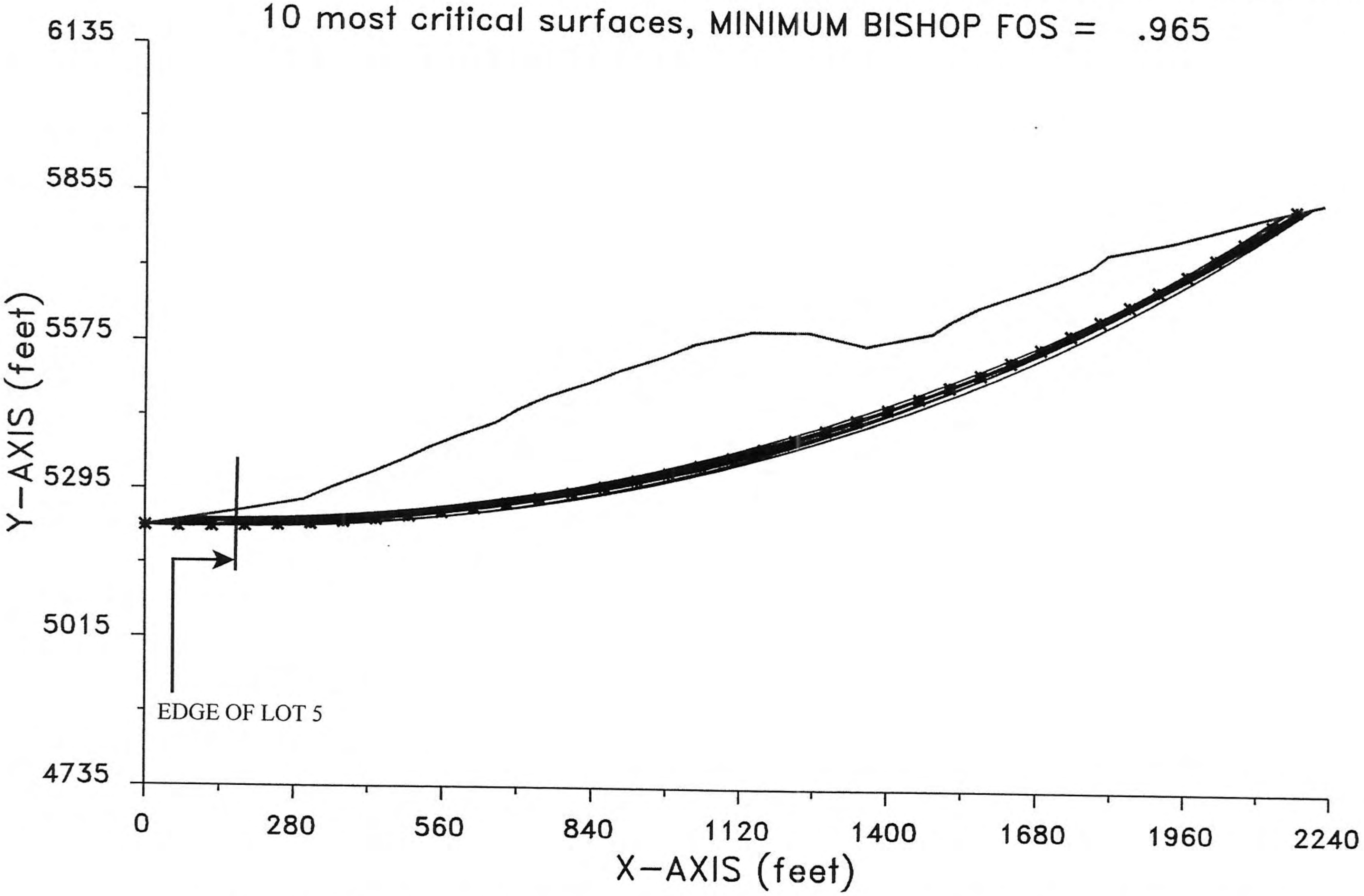


STABILITY ANALYSIS WITH SEISMIC EVENT-LOT 4



STABILITY ANALYSIS STATIC SLOPE-LOT 5

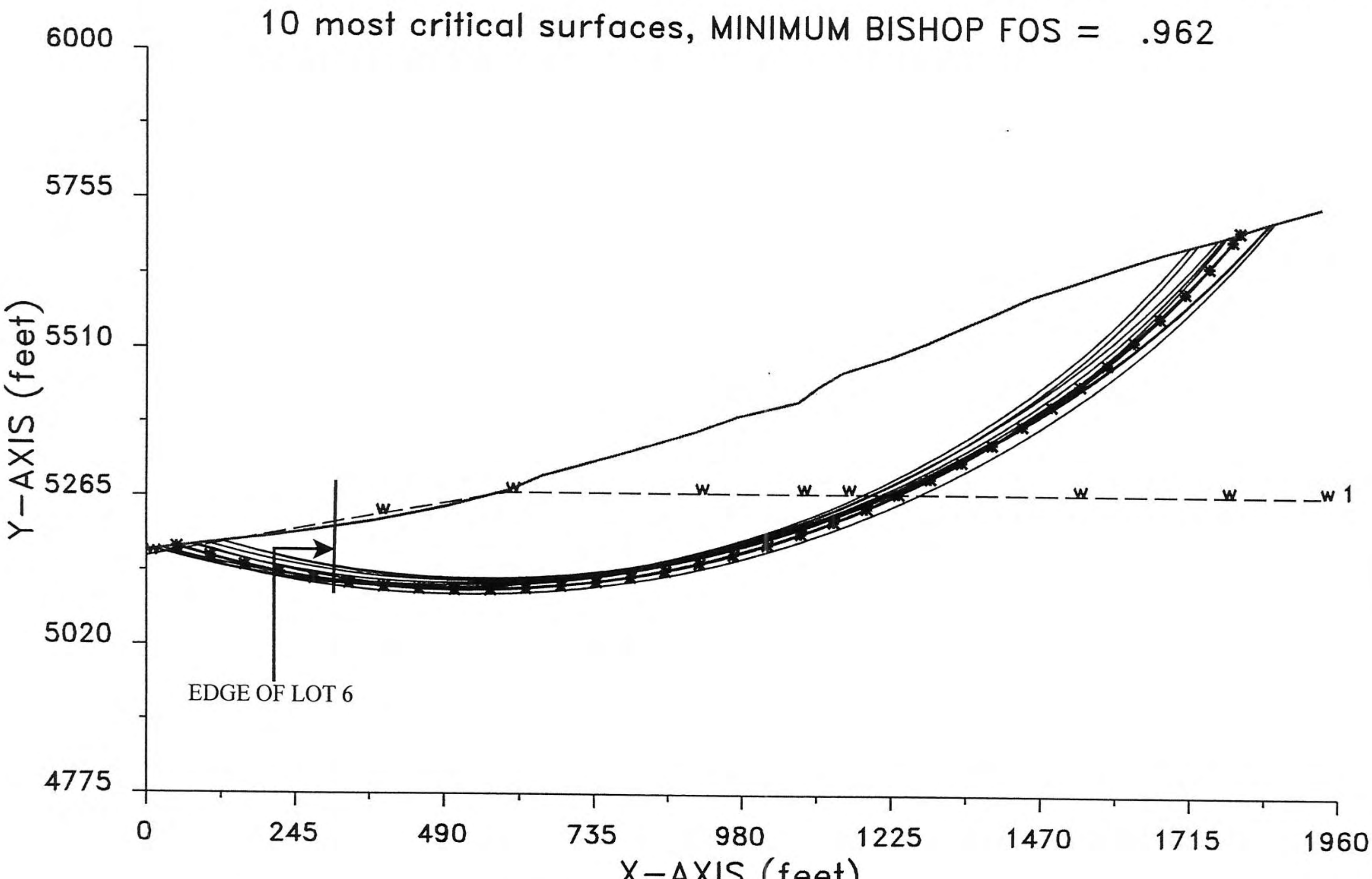
EARTHTEC TESTING AND ENGINEERING



STABILITY ANALYSIS WITH SEISMIC EVENT-LOT 5

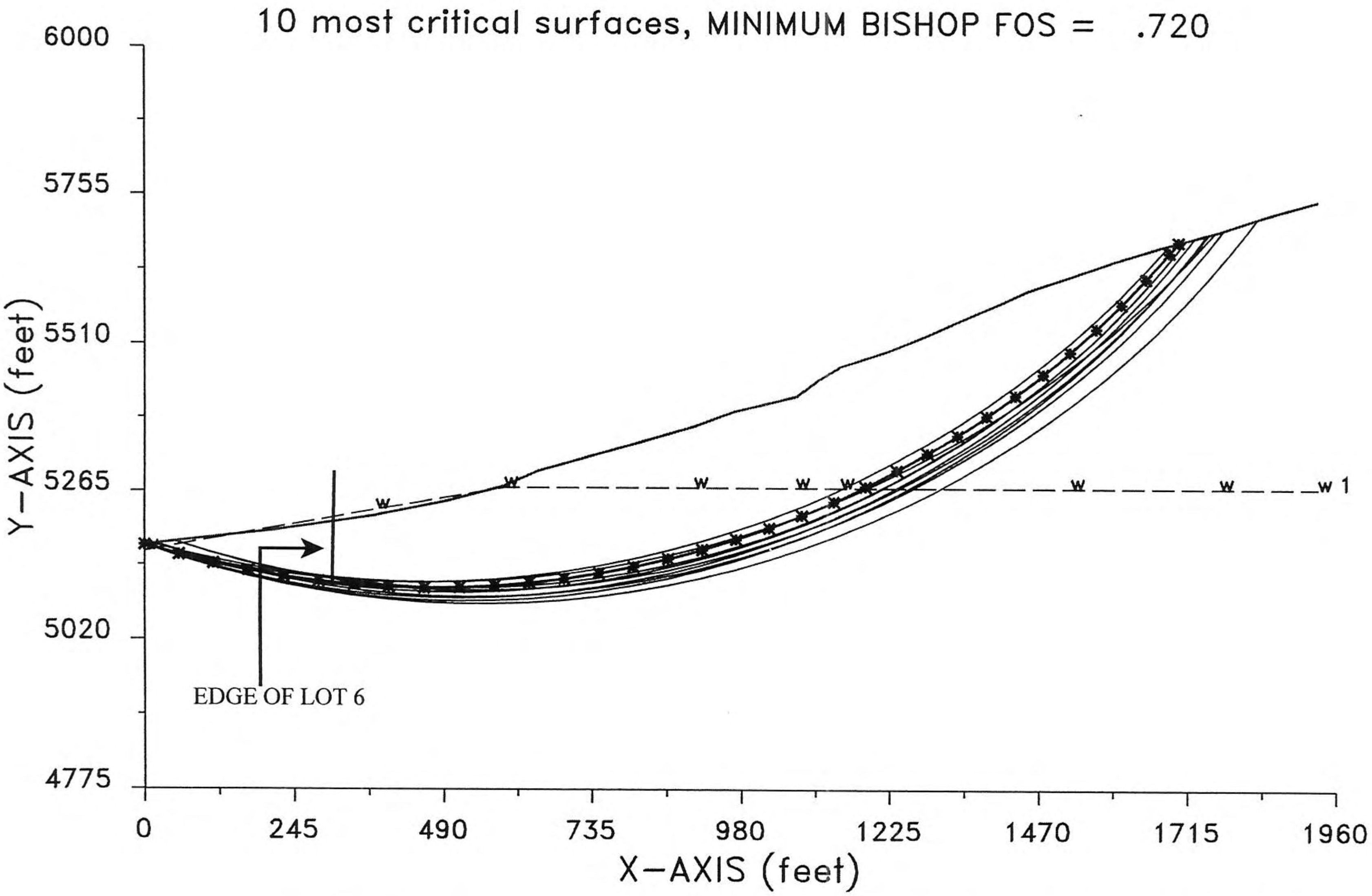
ETE Job No. 06-0020

Figure 29



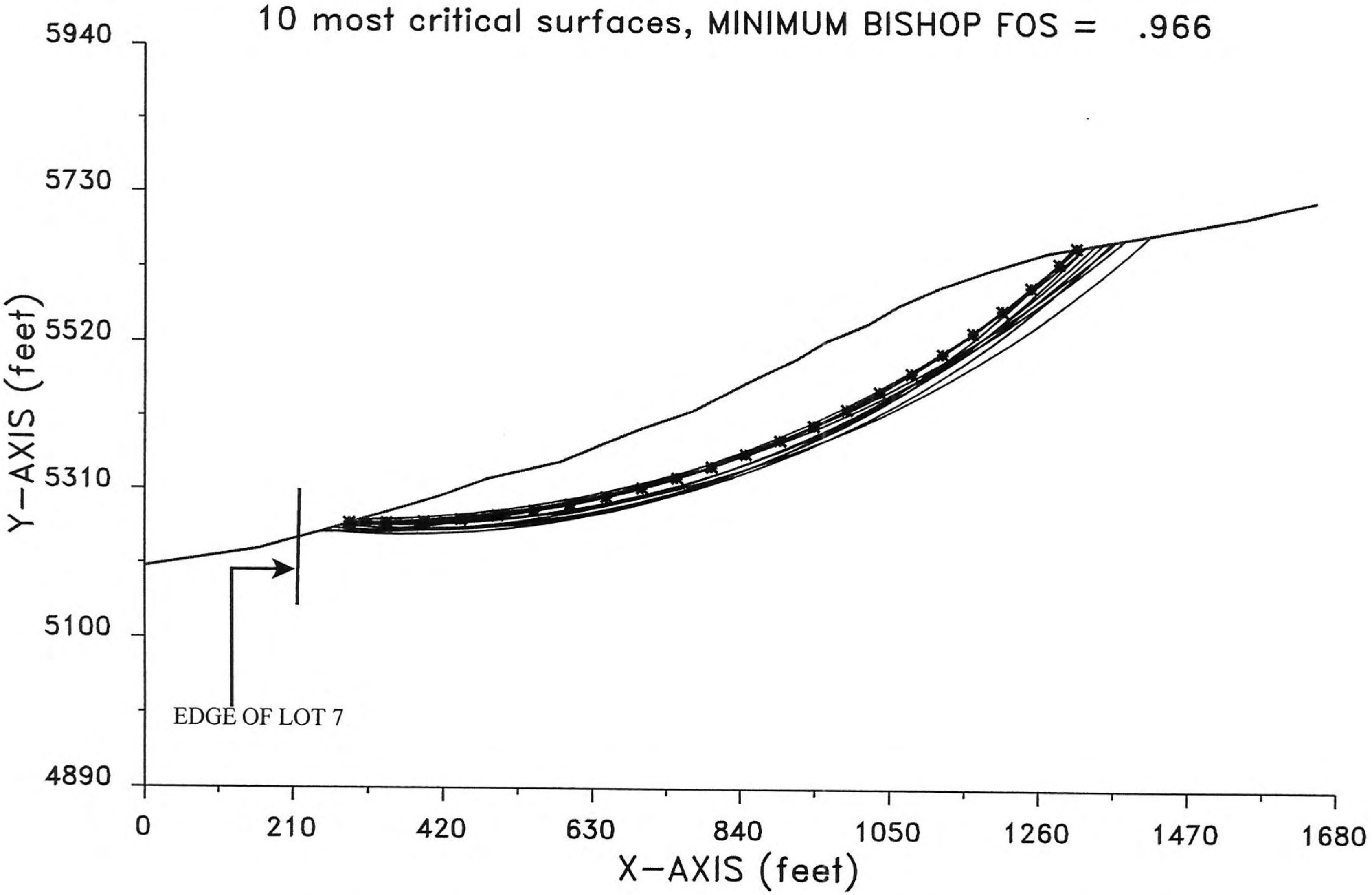
STABILITY ANALYSIS STATIC SLOPE-LOT 6

Figure 30



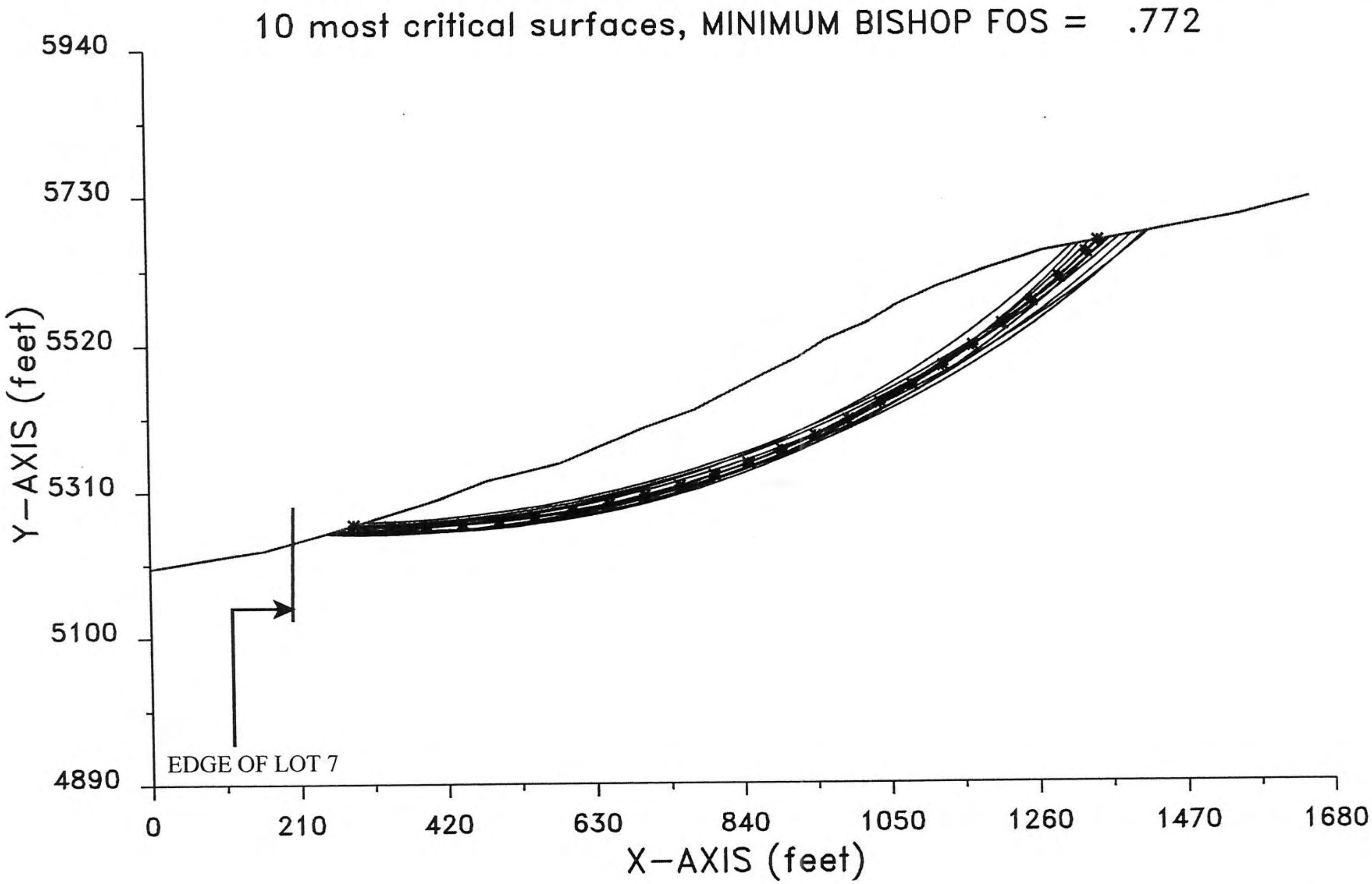
STABILITY ANALYSIS WITH SEISMIC EVENT-LOT 6

Figure 31



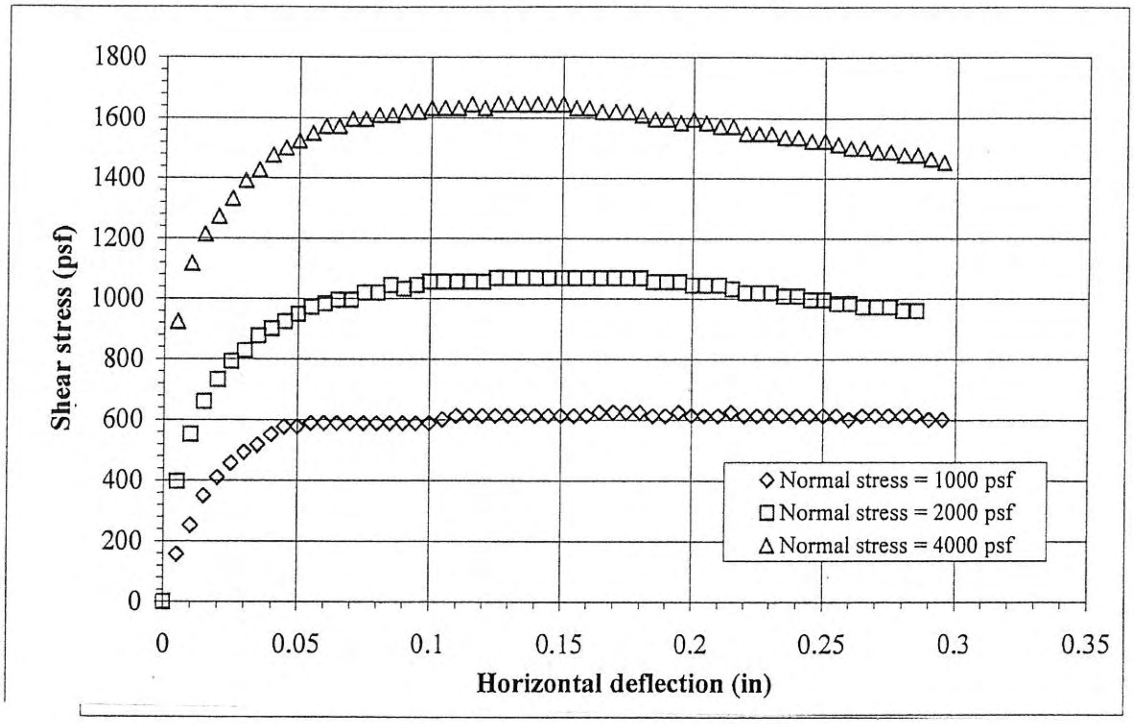
STABILITY ANALYSIS STATIC SLOPE-LOT 7

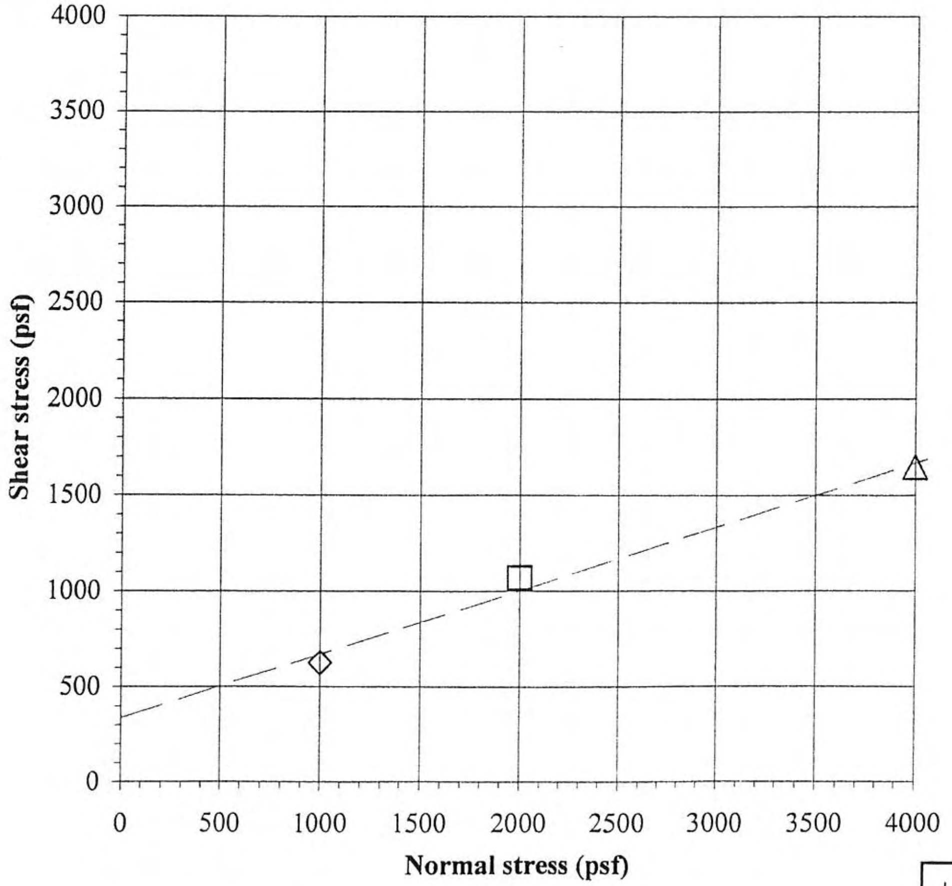
Figure 32



STABILITY ANALYSIS WITH SEISMIC EVENT-LOT 7

Figure 33





ϕ (deg)	18
c (psf)	336

REMOLDED DIRECT SHEAR
(CONSOLIDATED DRAINED)
TP-2 @ 8 FT

APPENDIX

WESTERN GEOLOGIC, LLC
74 NORTH N STREET
SALT LAKE CITY, UTAH 84103 USA

Phone: 801.359.7222 Fax: 801.359.2730 Email: craig_nelson@western-geologic.com

January 30, 2006

Mr. Robert E. Barton, P.E.
Earthtec Testing and Engineering, P.C.
1596 West 2650 South
Suite 108
Ogden, Utah 84401

SUBJECT: Geologic Hazards Evaluation
Pineview Estates at Radford Hills
Weber County, Utah

Dear Mr. Barton:

This report presents results of a reconnaissance-level engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for the 136-acre, Pineview Estates at Radford Hills development in Weber County, Utah (Figure 1 – Project Location). The site is on generally east-facing slopes on the west side of Ogden Valley, in the S½ Section 3 and N½ Section 10, Township 6 North, Range 1 East (Salt Lake Base Line and Meridian). Elevation of the site ranges from about 4,960 to 5,360 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;
- Logging of one trench and 11 test pits excavated at the site on January 23-24, 2006;
- 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), and Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah (Christenson and others, 2003).

SITE RECONNAISSANCE

On January 23-24, 2006 Mr. Bill D. Black of Western GeoLogic conducted a site reconnaissance of the property and surrounding area. Weather on both days of the site reconnaissance was partly cloudy, with temperatures in the 20's and 30's (°F). Slopes at the site were covered with about 2 feet of snow. Vegetation at the site consists mainly of sage brush, grasses, scattered oak brush, and a few mature pine trees. The site is on the west side of Ogden Valley about 400 feet west of the north bay of Pineview Reservoir, and is on east-facing slopes overlooking the Reservoir. Two unnamed drainages originate in the Wasatch Range to the west and flow generally eastward across the northern and southwest portions of the site (Figure 1). The northern drainage was flowing at the time of our reconnaissance, but snow cover obscured observation of the southern drainage. Slopes at the site generally have a steepness between about 6:1 (horizontal:vertical) and 8:1; steeper 3:1 slopes are found along the western site margin.

Digital orthophoto aerial photography (National Aerial Photography Program; frames NAPP 10103 104, NAPP 10103 77, and NAPP 10103 78; October, 1997) and unpublished Utah Geological Survey photogeologic mapping was reviewed to obtain information about the geomorphology of the site and surrounding area (Figure 2, left inset map). The site is on the west side of Ogden Valley in west-facing slopes overlooking Pineview Reservoir (Figure 2, left inset map). One small landslide is mapped in the northwest part of the site (labeled ms, Figure 2). Topography of the mapped landslide appears subdued on the air photos and no head scarp was evident. Two Holocene alluvial fans are in the northern and southwestern parts of the site, associated with the unnamed drainages discussed above (afy and af2, Figure 2). Remnants of an older alluvial fan are also in the eastern half of the site (afo, Figure 2). Intervening surficial deposits are shallow alluvium and colluvium overlying Tertiary bedrock. The older alluvial fan was likely downcut by the drainages and stranded; deposition would have continued at the drainage mouths in the younger fans. An east-dipping trace of the West Ogden Valley fault also crosses the western margin of the development (Figure 2), but displays no surficial evidence at the site. According to Greg McDonald, Utah Geological Survey (verbal communication, January 2006), scarps are found only on the northern part of the fault at the north end of Ogden Valley. No other geologic hazards are evident on the photos or were observed at the site.

SUBSURFACE INVESTIGATION

To evaluate subsurface conditions at the site, a field exploration was developed to excavate one trench across the West Ogden Valley fault trace and 11 test pits in other areas of the property (Figures 2 and 3). The trench extended southwestward from the upper road at the site for a total distance of 191 feet. Figures 4a-c are a detailed log of the north trench wall at a scale of 1 inch equals 5 feet (1:60). Figures 5a-c shows logs of the test pits.

The trench at the site exposed a sequence of alluvium and colluvium displaying no evidence of faulting such as displaced bedding, vertical terminations, aligned clasts, or backtilting. The oldest sediments in the trench were alluvium and colluvium consisting of poorly bedded sandy gravel likely from old slope wash, ephemeral stream sediments, and thin debris flow deposits from the slopes to the west (unit 1, Figures 4a-c). A thin paleosol A horizon was evident on top of unit 1 east of 85 feet horizontal (Figures 4b-c). Unit 1 is overlain by a matrix-rich debris flow deposit comprised of gravelly sand with cobbles and silt (unit 2, Figures 4a-b), which buried the paleosol A horizon in the eastern half of the trench. Unit 2 is in turn overlain by additional alluvium and colluvium that displays a coarse basal lense (unit 3, Figures 4a-c), likely representing a thin clast-supported debris flow combined with subsequent slope wash colluvium. The modern A-horizon soil is forming in all these units at the surface. No evidence of water was observed in the trench, and the exposed sediments appeared dry and generally firm.

Test pit 1 was excavated at the toe of the small landslide in the northwestern part of the site (Figures 2 and 3), and exposed landslide colluvium consisting of blocks of clay-rich weathered Norwood Tuff (Figure 4a). At this location, down-to-the-east normal faulting would place the Norwood Tuff near the ground surface on the upthrown side of the West Ogden Valley fault, and deep beneath the surface on the downthrown side to the east. The landslide thus may represent an old failure of a stranded Norwood Tuff bedrock exposure on the upthrown (western) side of the fault. No exposures of the Norwood Tuff are mapped along the western site margin on the upthrown side of the fault, but are found on the downthrown side further to the east. No other landslide deposits were observed in the remaining test pits at the site. Test pits 2, 3, 4, 6, 8, and 11 (Figures 4a-c) exposed alluvium of the fan depositional sequence discussed in the Site Reconnaissance section above. Competent tuffaceous siltstone and sandstone was encountered in test pits 5 and 7; test pits 9 and 10 exposed weathered clay-rich tuffaceous bedrock overlain by alluvium and colluvium (Figures 4b-c). The test pit exposures thus appear to be consistent with the geologic mapping on Figure 2. No water was observed in the test pits, although surficial sediments in some of the test pits appeared moist, particularly where underlain by weathered clay-rich bedrock.

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows two unnamed drainages cross the northern and southwestern parts of the site. The northern creek was flowing at the time of the investigation, but the southern creek was obscured by snow cover. The topographic map also shows a small spring-fed irrigation pond about 450 feet south of the site (Figure 1), but no springs are shown within the site boundaries. The nearest large body of water is Pineview Reservoir about 400 feet to the east.

Avery (1994) indicates ground water 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. Ground water flow is generally from the valley margins into the valley fill, and then toward the head of Ogden Canyon (Avery, 1994).

The site is in a recharge zone on the western margin of Ogden Valley near the bedrock/valley fill interface. Depth of the valley fill increases eastward. Depth to ground water at the site is unknown, but is probably generally greater than 30 feet. No evidence of ground water was observed in the trench or test pits at the site to the depth explored. Elevation of the shallow aquifer likely varies somewhat based on seasonal and climatic fluctuations, and areas along the east-flowing unnamed drainages likely have shallow seasonal ground-water levels. Perched conditions above less-permeable, clay-rich weathered bedrock, are likely at the site which could also produce shallow water levels.

GEOLOGY

The site is located on the western margin of Ogden Valley. This valley is a sediment-filled intermontane valley within the Wasatch Range, a major north-south trending mountain range marking the eastern boundary of the Basin and Range physiographic province (Stokes, 1977). Surficial geology of the site is shown on unpublished Utah Geological Survey mapping for Ogden Valley (Figure 2) and on Coogan and King (2001). The unpublished mapping is part of an ongoing project to map surficial geology of Ogden Valley, whereas Coogan and King (2001) is based primarily on older mapping for this area (Greg McDonald, Utah Geological Survey, verbal communication, February 2005). Figure 2 shows the site is in alluvial-fan deposits of successive ages (units afy, af2, and afo), a small landslide deposit (unit ms), alluvium and colluvium (unit ac), and weathered Tertiary bedrock (unit Tn). The trench and test pit exposures (Figures 4-5) generally confirm the surficial geologic mapping. Descriptions of Precambrian bedrock units west of the site (label preceded by a capital Z, Figure 2) were not provided in the unpublished mapping, but are in Coogan and King (2001). Descriptions of surficial units and bedrock in the site vicinity, from youngest to oldest in age, are:

> ***afy, af1, af2*** - *Younger alluvial-fan deposits (Holocene).* Mostly sand, silt, gravel, clay and cobble that is poorly bedded/sorted; includes debris flows particularly in drainages and at drainage mouths (fan heads). Qaf1 and Qaf2 are Holocene (post-Bonneville) and designated afy where they cannot be differentiated.
>
> ***ms*** - *Landslide and slump deposits (Holocene and Pleistocene).* Poorly sorted clay to boulder-sized material; locally includes flow deposits; generally characterized by hummocky topography, head and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with age; thickness highly variable. Near former Lake Bonneville units with relative-age number suffixes were: 1) emplaced in the last 80 to 100 years; 2) are post Lake Bonneville in age; 3) were emplaced during or shortly after Lake Bonneville regression; and 4) were emplaced before Lake Bonneville transgression; extensive deposits in Lake Bonneville sediments in North Ogden and Kaysville quadrangles include earthquake liquefaction features. Suffixes y (as well as 1&2) and o (as well as 3&4) indicate probable Holocene and Pleistocene ages, respectively. Locally, unit involved is shown in parentheses.

ac *- Alluvium and colluvium (Holocene and Pleistocene).* Mostly silt, sand, gravel, clay, cobble, and boulders. Includes stream and fan alluvium, colluvium, and locally, mass-movement deposits.

la/lf *- Lake Bonneville deposits (Holocene and Pleistocene); post- and pre-Lake Bonneville alluvial-fan deposits, undivided; and fine-grained lacustrine deposits.* Mostly poorly sorted and poorly bedded sand, silt, and gravel; and clay, silt, and fine sand deposited offshore in Lake Bonneville. In the Kaysville quadrangle, deposits below the Gilbert shoreline are the same age as the shoreline, while deposits below the historic-highstand shoreline (4,213 feet [1,284.5 m]) of Great Salt Lake are recent.

afo *- Older alluvial-fan deposits (Pleistocene).* Mostly sand, silt, gravel, clay and cobble that is poorly bedded/sorted. Qafb is associated with Pleistocene Lake Bonneville. Qaf4 and Qafo are older than Lake Bonneville. Qafo deposits are early and middle Pleistocene (possibly older?) deposits and may include those previously mapped as Huntsville Fanglomerate. Qafo may be somewhat lithified, and characterized by a reddish matrix and a well-developed B-horizon.

Tn *- Norwood Tuff (lower Oligocene and upper Eocene).* Typically light-gray to light-brown tuff, tuffaceous siltstone and sandstone, altered tuff/claystone, and conglomerate; generally considered younger than the Fowkes, but not well dated; up to about 5,000 feet (1,525 m) thick, thickest between Morgan and Huntsville.

Zmcg *- Maple Canyon Formation (upper Proterozoic).* Green arkosic metasandstone with argillite partings and local quartzite, 500 to 1,000 feet (150-305 m) thick; 1,000 to 1,500 feet (305-460 m) total thickness.

ZYpg *- Formation of Perry Canyon (upper and possibly middle Proterozoic).* "Sandstone" member (ZYpg) - Metasiltstone and metasandstone with some argillite, 3,000 feet (915 m) thick.

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 Salt Lake Valley and the intermontane Cache, Ogden, and Morgan Valleys (Oviatt and others, 1992). Sediments from Lake Bonneville are found at lower elevations east of the site.

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, named the Bonneville beach, after 16,000 years ago. The lake remained at this level until 14,500 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 11,000 years ago the lake had eventually dropped below the present elevation of Great Salt Lake. Oviatt and others (1992) deem this low stage the end of the Bonneville lake cycle.

Seismotectonic Setting

The site is located on the western margin of Ogden Valley, a roughly 40-square mile back valley described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys of the northern Wasatch Range are in a transition zone between the Basin and Range and Middle Rocky Mountains provinces (Stokes, 1977). The Basin and Range is characterized by a series of generally north-trending elongate mountain ranges, separated by predominately alluvial and lacustrine sediment-filled valleys and typically bounded on one or both sides by major normal faults (Stewart, 1978). The boundary between the Basin and Range and Middle Rocky Mountains provinces is the prominent, west-facing escarpment along the Wasatch fault zone at the base of the Wasatch Range. Late Cenozoic normal faulting, a characteristic of the Basin and Range, began between about 17 and 10 million years ago in the Nevada (Stewart, 1980) and Utah (Anderson, 1989) portions of the province. The faulting is a result of a roughly east-west directed, regional extensional stress regime that has continued to the present (Zoback and Zoback, 1989; Zoback, 1989). The back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988). Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the east and west sides of the valley. The West Ogden Valley fault is mapped trending northwestward across the western margin of the site (Figures 2 and 3), but displays no surficial evidence for faulting in the area. The most recent movement on this fault is pre-Holocene (Sullivan and others, 1986; Black and others, 2003).

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.

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, Salt Lake, and Provo segments of the Wasatch fault zone; the East Great Salt Lake fault zone; the Morgan Fault; the West Valley fault zone; the Oquirrh fault zone; and the Bear River fault zone (Black and others, 2003).

The extent of property damage and loss of life due to ground shaking depends on factors such as: (1) proximity of the earthquake and strength of seismic waves at the surface (horizontal motions are the most damaging); (2) amplitude, duration, and frequency of ground motions; (3) nature of foundation materials; and (4) building design (Costa and Baker, 1981). Peak accelerations (% of gravity) at the site for 10% and 2% probabilities of exceedance in 50 years are estimated at 20 %g, and 43 %g respectively (Frankel and others, 2002). Horizontal accelerations on the 10 percent in 50-year map were typically used in building design prior to 2003.

Given this 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.

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.

A concealed trace of the West Ogden Valley fault crosses the western margin of the site. This fault only displays surficial faulting evidence (scarps) at the north end of Ogden Valley (Greg McDonald, verbal communication, January 2006). Although movement on the fault is believed to be pre-Holocene, one trench was excavated across the approximate (dashed) location of the fault trace in the southwestern part of the site (Figure 3) to assess the risk from surface faulting. The trench exposed an unfaulted sequence of Holocene to possibly late Pleistocene alluvium and colluvium. Based on all of the above, the hazard from surface faulting appears 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, ground water conditions, and presence of susceptible soils.

No soils susceptible to liquefaction are mapped at the site. Surficial sediments at the site appear to consist mainly of clayey colluvium, sandy and gravelly alluvium, and clay-rich to competent bedrock. Based on the above, the hazard from liquefaction is low.

Tectonic Deformation

Tectonic deformation refers to subsidence from warping, lowering, and tilting of a valley floor that accompanies surface-faulting earthquakes on normal faults. Large-scale tectonic subsidence may accompany earthquakes along large normal faults (Lund, 1990). Tectonic subsidence is believed to mainly impact those areas immediately adjacent to the downthrown side of a normal fault. The site is not on the downthrown side of any active (Holocene) faults, and thus the risk from tectonic subsidence is rated as low.

Seismic Seiche and Storm Surge

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

Stream Flooding

Stream flooding may be caused by direct precipitation, melting snow, or a combination of both. In much of Utah, floods are most common in April through June during spring snowmelt. High flows may be sustained from a few days to several weeks, and the potential for flooding depends on a variety of factors such as surface hydrology, site grading and drainage, and runoff. Two unnamed drainages cross the northern and southwestern parts of the site on Figure 1; a third drainage is shown ending about 150 feet southwest of the site on Figure 3. Lots in and bordering these areas could experience seasonal stream flooding. Site hydrology and runoff should be addressed by the civil engineering design for the development. Recommendations with regard to stream flooding should be in conformance to applicable local government and Weber County development guidelines.

Shallow Groundwater

No springs are shown on the topographic map for the Huntsville quadrangle at the site. Depth to ground water can 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. Depth to ground water at the site is likely generally greater than 30 feet; however, shallower seasonal levels are likely in the floodplains of the unnamed drainages. No ground water was observed in the trench or test pits at the site to the depth explored. Based on this, shallow ground water should not pose a significant constraint for the development. Evaluation of and recommendations regarding shallow ground water should be addressed in a geotechnical engineering evaluation during the subdivision approval process.

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 air photo and geologic map (Figure 2) show a small landslide in and upslope of lot 6 at the site (Figure 3). Test pit 1 (Figure 4a) exposed colluvium at the toe of the slide derived from failure of an exposure of clay-rich Norwood Tuff, which is no longer evident or mapped upslope to the west. Topography of the landslide also appears subdued on the air photos of the site. The landslide thus may be a failed block of Norwood Tuff that was stranded by faulting in the geologic past, and is likely an old failure that occurred during wetter periods such as during the Pleistocene.

Slopes west of lot 6 have thus been involved in prior landsliding, although slopes in other areas of the site appear currently stable. The hazard from landsliding is rated as high for lot 6 (Figure 3), but is likely low in the remainder of the development. However, we recommend stability of slopes in lot 6 and bordering the western edge of the site be evaluated in a geotechnical engineering evaluation prior to the subdivision approval process as a conservative approach. Recommendations for reducing the risk from landsliding should be provided if factors of safety are determined to be unsuitable. Specific recommendation to reduce the risk from landsliding to lot 6 should be included. Care should also be taken that site grading does not destabilize the slopes without prior geotechnical analysis and grading plans, and that no ponded water is allowed to remain on the slopes which may reduce stability. Water is a significant contributor to slope instability, particularly in clay-rich sediments and weathered bedrock.

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. Several alluvial fans of successive ages are mapped at the site emanating mainly from the two unnamed drainages to the west (Figure 2). The trench at the site also exposed debris flow deposits from the southern drainage, which range from about 1 to 5 feet thick and buried a thin paleosol A horizon (suggesting a Holocene age). Snow cover prevented observation of surficial debris-flow features such as channels or levees during our reconnaissance. Ongoing deposition appears to be mainly at the mouth of and along the drainages.

Based on the above evidence, debris flows may pose a hazard to the northwestern and southwestern parts of the site. Berms to deflect and route potential debris flows in the drainages may be effective to reduce the risk from sediment and flooding from such events. Design and placement of the berms should be addressed by the civil engineering design for the development. Given the alpine location of the site, VanDine (1996) provides a good reference for berm design and placement techniques for reducing debris flow and flooding hazards. The berms should be designed to accommodate sediment thicknesses of up to 5 feet, based on the trench exposure.

Rock Fall

No boulders from rock falls were observed on the surface of the site, and no significant outcrops of bedrock are located in the slopes directly above the site that could present a source area for rock fall clasts. Based on this, the risk 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 steep mountain fronts of these slope aspects, the risk from snow avalanche appears 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" to "High" radon-hazard potential area (Black, 1993). A high hazard rating indicates that geologic factors are favorable for indoor radon concentrations above 4 picocuries per liter of air, which is the action level recommended by the Environmental Protection Agency. A moderate hazard rating indicates that geologic factors are favorable for indoor radon concentrations between 2 to 4 picocuries per liter of air. However, 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. Fat to lean clays were exposed in the test pits at the site that may be susceptible to swelling or collapse. 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

Principal geologic hazards at the site are earthquake ground shaking, stream flooding, debris flows, landsliding, and radon. The following recommendations are provided to address these potential hazards:

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

- The civil engineering design preparing the drainage report for the development should address site hydrology and runoff, and provide recommendations as needed to reduce potential seasonal stream flooding hazards.

- A design-level geotechnical engineering study should be conducted prior to construction to:
    1. Address soil conditions at the site for use in foundation design, site grading, and drainage;
    2. Provide recommendations regarding building design to reduce risk from seismic acceleration; and
    3. Evaluate stability of slopes at the site, both in lot 6 and (as a conservative measure) unfailed slopes along the western site margin, including providing recommendations for reducing the risk from landsliding if factors of safety are unsuitable. The geologic information included in this report may be used in developing the slope model.

- Flooding and debris deposition from debris flows is a hazard to portions of the site. We recommend that these issues be addressed in the site drainage plan being prepared by the project civil engineer. One possible hazard reduction technique would be construction of berms to deflect flood waters and debris from events in the unnamed drainages in the northwestern and southwestern parts of the site. We recommend a minimum design debris flow thickness of 5 feet be considered in hazard reduction measures.

- Testing following construction is recommended to determine indoor radon levels and if mitigation measures are warranted.

The site is considered suitable for the proposed development if the recommendations in this report are followed.

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.

Excavation Backfill Considerations

The trench may be in areas where structures could subsequently be placed. However, the backfill may not have been replaced in the trench in compacted layers. The fill could settle with time and upon saturation. Should structures be located in a trenched area, no footings or structure should be founded over the trench excavation unless the backfill has been removed and replaced with structural fill, if the fill is to support a structure. Care should also be taken in site grading and drainage to ensure the trench does not become eroded and channeled.

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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ATTACHMENTS

Figure 1. Location Map
Figure 2. Air Photo and Geologic Map
Figure 3. Site Plan
Figure 4. Trench Log
Figure 5. Test Pit Logs

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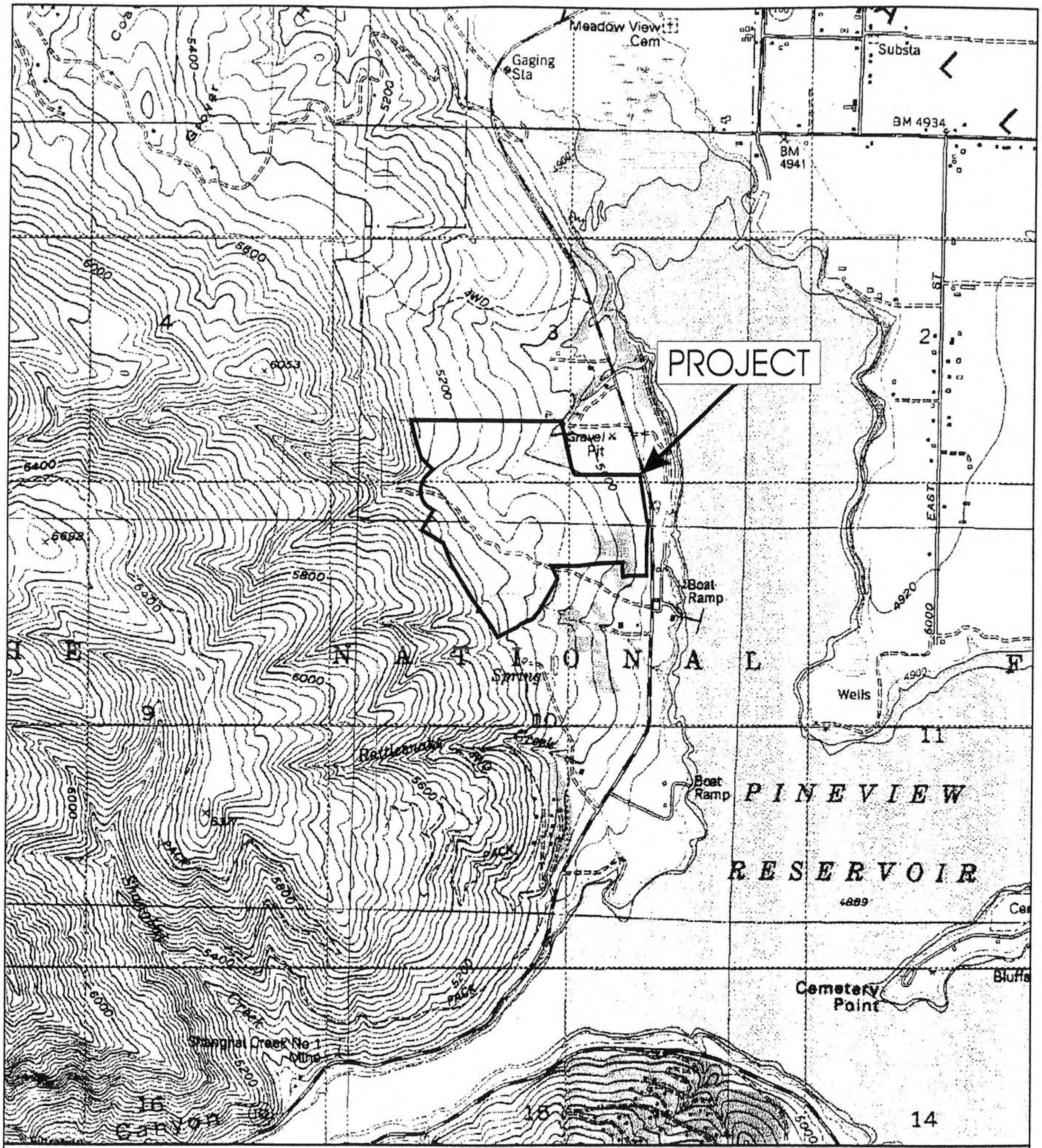

Source: U.S. Geological Survey 7.5 Minute Series Topographic Map, HUNTSVILLE, UT, 1991.

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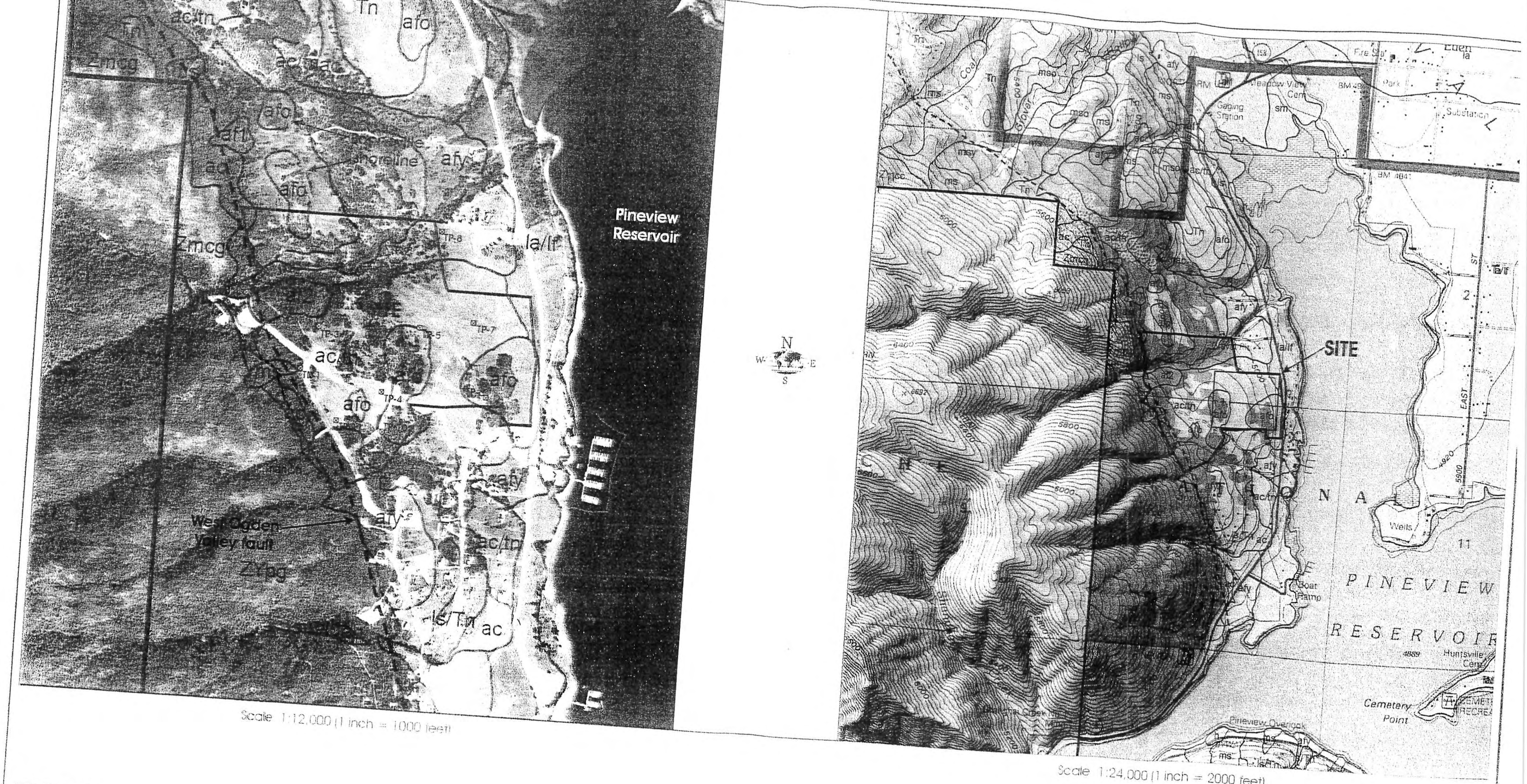
Scale 1:24,000
(1 inch = 2000 feet)

LOCATION MAP

GEOLOGIC HAZARDS EVALUATION

Pineview Estates at Radford Hills
Weber County, Utah

FIGURE 1



Scale 1:12,000 (1 inch = 1000 feet)

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

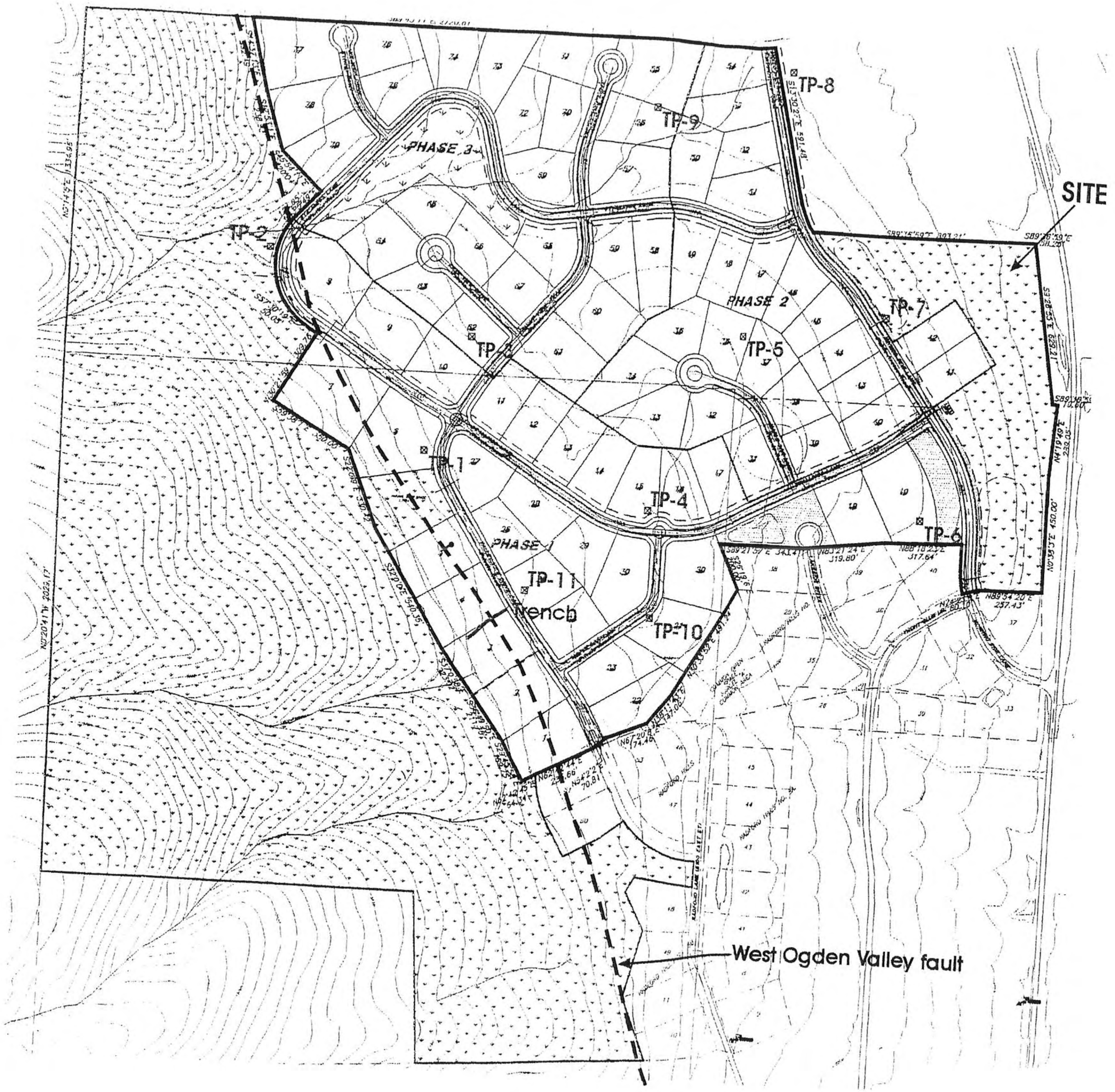
WESTERN

Source: unpublished Utah Geological Survey mapping, Ogden Valley, Utah.
See text for explanation of geologic units.

AIR PHOTO AND GEOLOGIC MAP

GEOLOGIC HAZARDS EVALUATION
Pineview Estates at Radford Hills
Weber County, Utah

FIGURE 2



Source: fault mapping from unpublished Utah Geological Survey mapping; test pit and trench locations measured in the field using a handheld GPS unit, WAAS enabled, accurate to within 10 feet.

N
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Scale 1:6,000
(1 inch = 500 feet)

LICENSED PROFESSIONAL GEOLOGIST
BILL DUANE BLACK
NO. 5224898-2250
STATE OF UTAH

WESTERN
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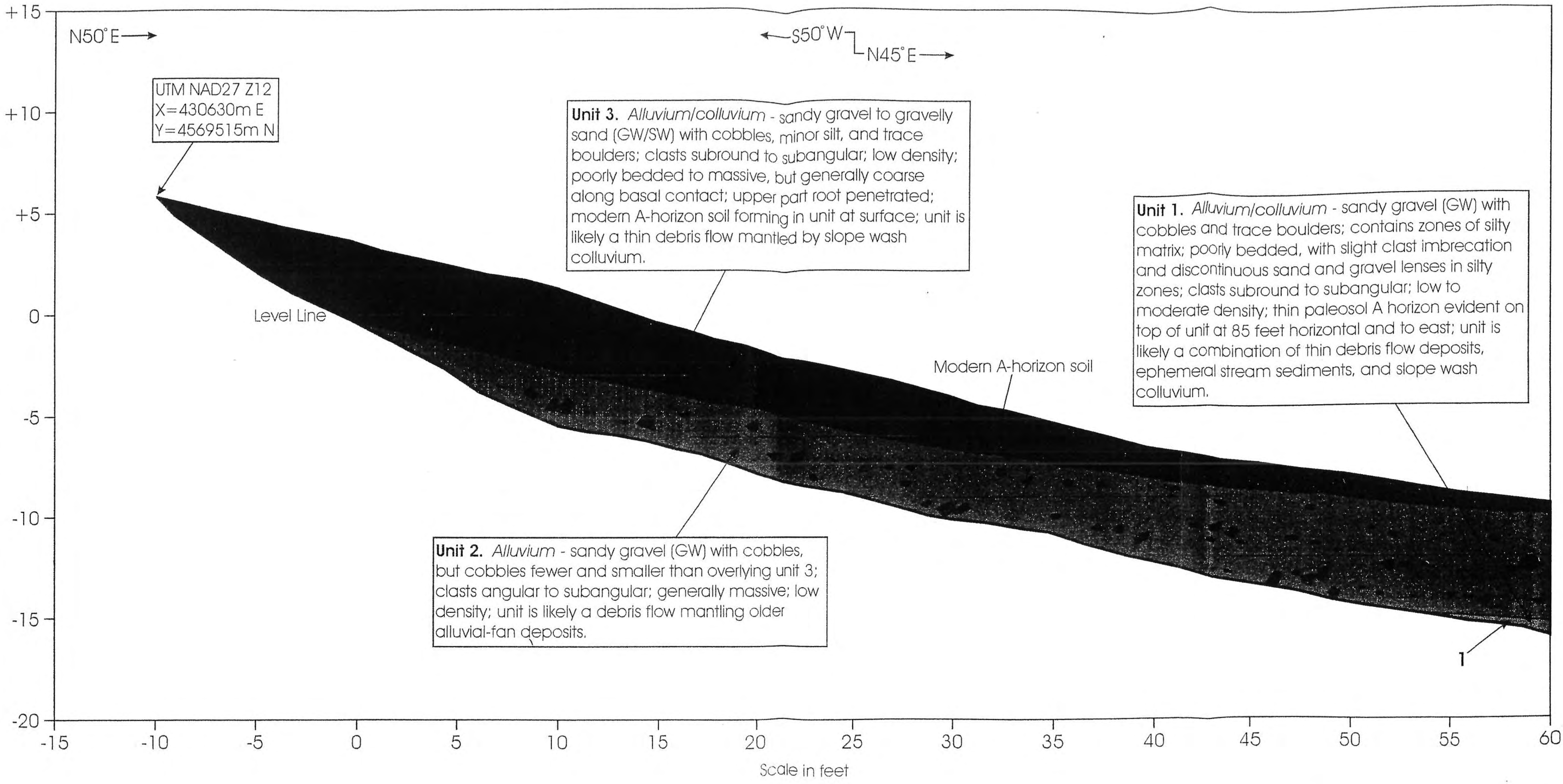
SITE PLAN

GEOLOGIC HAZARDS EVALUATION
Pinview Estates at Radford Hills Development
Weber County, Utah

FIGURE 3



Unit 3. *Alluvium/colluvium* - sandy gravel to gravelly sand (GW/SW) with cobbles, minor silt, and trace boulders; clasts subround to subangular; low density; poorly bedded to massive, but generally coarse along basal contact; upper part root penetrated; modern A-horizon soil forming in unit at surface; unit is likely a thin debris flow mantled by slope wash colluvium.

Unit 1. *Alluvium/colluvium* - sandy gravel (GW) with cobbles and trace boulders; contains zones of silty matrix; poorly bedded, with slight clast imbrecation and discontinuous sand and gravel lenses in silty zones; clasts subround to subangular; low to moderate density; thin paleosol A horizon evident on top of unit at 85 feet horizontal and to east; unit is likely a combination of thin debris flow deposits, ephemeral stream sediments, and slope wash colluvium.

Unit 2. *Alluvium* - sandy gravel (GW) with cobbles, but cobbles fewer and smaller than overlying unit 3; clasts angular to subangular; generally massive; low density; unit is likely a debris flow mantling older alluvial-fan deposits.

TRENCH LOG (-10 to 60')

GEOLOGIC HAZARDS EVALUATION

Pineview Estates at Radford Hills
Weber County, Utah

FIGURE 4A

SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Trench Wall Logged

Trench logged by Bill Black, P.G. on
January 23, 2006
Reviewed by Craig V Nelson, P.G., R.G., C.E.G.

BILL DUANE BLACK
NO. 5224898-2250

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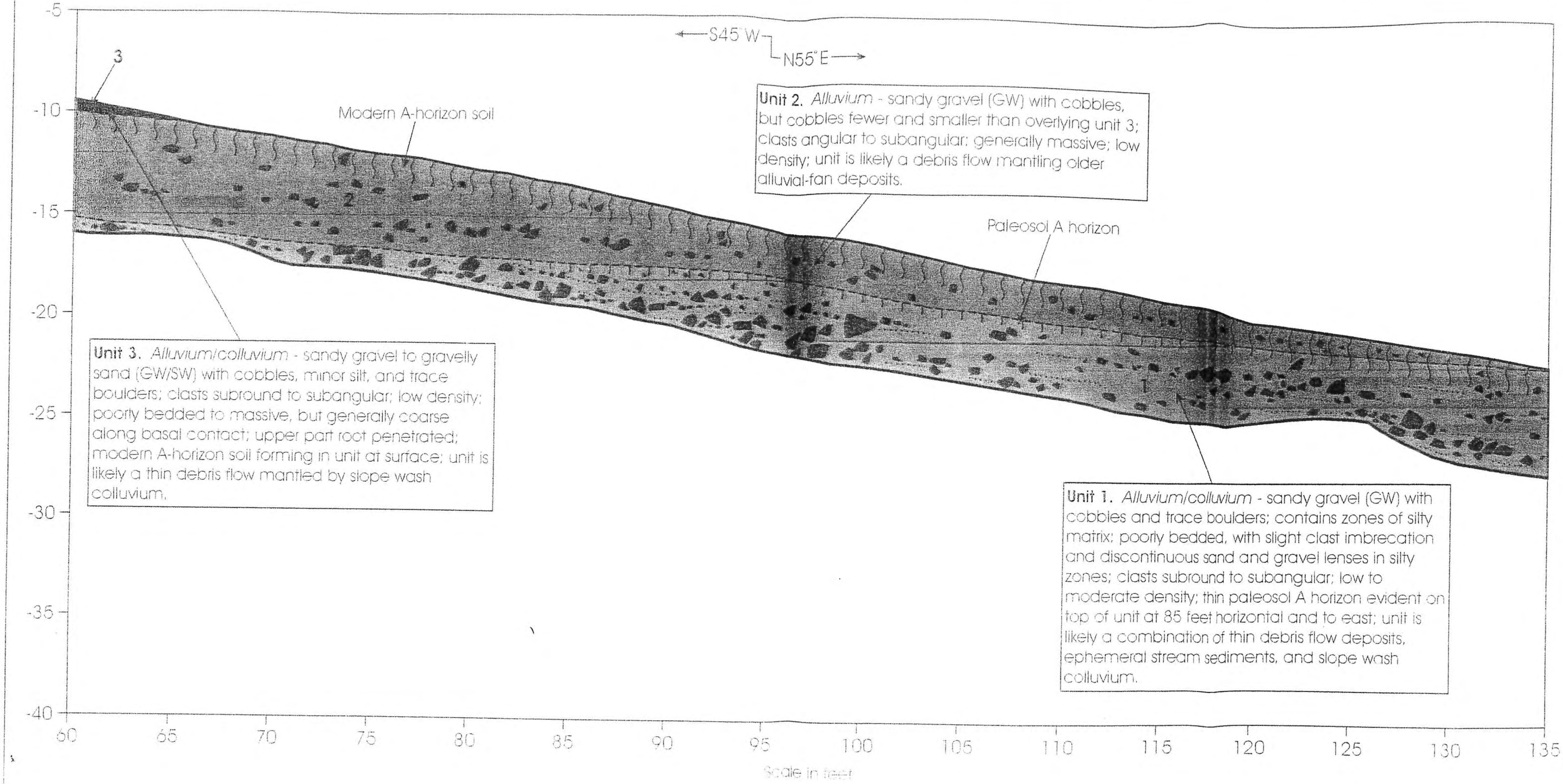


Unit 3. *Alluvium/colluvium* - sandy gravel to gravelly sand (GW/SW) with cobbles, minor silt, and trace boulders; clasts subround to subangular; low density; poorly bedded to massive, but generally coarse along basal contact; upper part root penetrated; modern A-horizon soil forming in unit at surface; unit is likely a thin debris flow mantled by slope wash colluvium.

Unit 2. *Alluvium* - sandy gravel (GW) with cobbles, but cobbles fewer and smaller than overlying unit 3; clasts angular to subangular; generally massive; low density; unit is likely a debris flow mantling older alluvial-fan deposits.

Unit 1. *Alluvium/colluvium* - sandy gravel (GW) with cobbles and trace boulders; contains zones of silty matrix; poorly bedded, with slight clast imbrecation and discontinuous sand and gravel lenses in silty zones; clasts subround to subangular; low to moderate density; thin paleosol A horizon evident on top of unit at 85 feet horizontal and to east; unit is likely a combination of thin debris flow deposits, ephemeral stream sediments, and slope wash colluvium.

WESTERN GeoLogic

BILL DUANE BLACK
NO. 5224898-2250

SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Trench Wall Logged

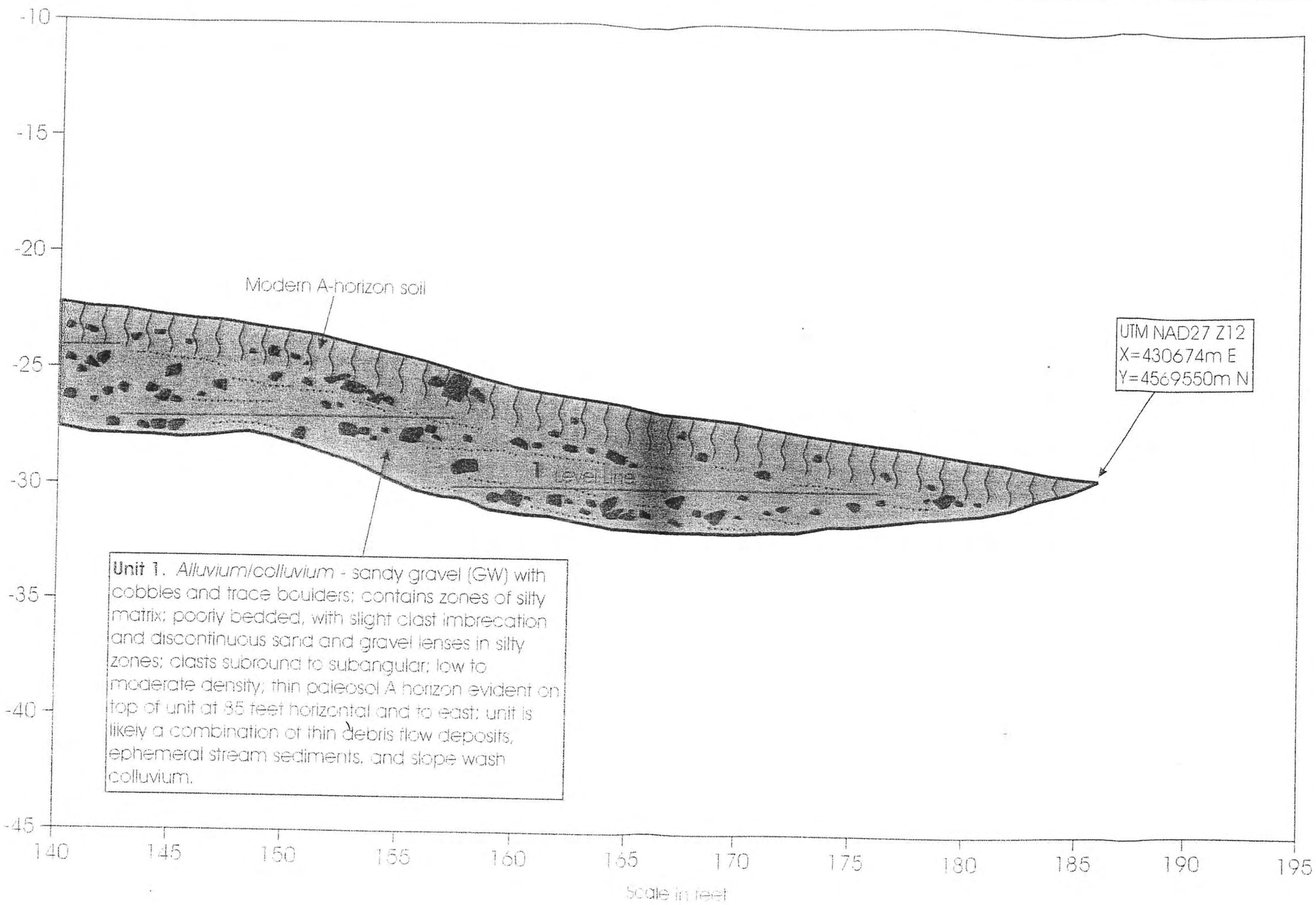
Trench logged by Bill Black, P.G. on
January 23, 2006
Reviewed by Craig V. Nelson, P.G., R.G., C.E.G.

TRENCH LOG (60 to 135')

GEOLOGIC HAZARDS EVALUATION

Pineview Estates at Radford Hills
Weber County, Utah

FIGURE 4B



Unit 1. *Alluvium/colluvium* - sandy gravel (GW) with cobbles and trace boulders; contains zones of silty matrix; poorly bedded, with slight clast imbrecation and discontinuous sand and gravel lenses in silty zones; clasts subround to subangular; low to moderate density; thin paleosol A horizon evident on top of unit at 85 feet horizontal and to east; unit is likely a combination of thin debris flow deposits, ephemeral stream sediments, and slope wash colluvium.

WESTERN

LICENSED PROFESSIONAL GEOLOGIST
BILL DUANE
BLACK
NO. 5224898-2250
STATE OF UTAH

SCALE: 1 inch = 5 feet
(no vertical exaggeration)
North Trench Wall Logged

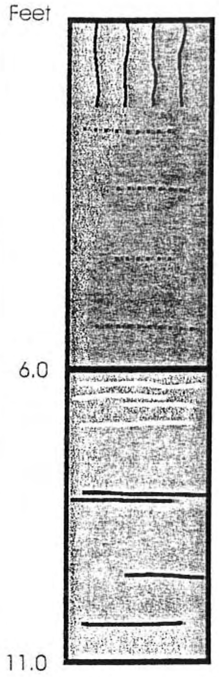
Trench logged by Bill Black, PG, on
January 23, 2006
Reviewed by Craig V. Nelson, PG, [illegible]

TRENCH LOG (135 to 186')

GEOLOGIC HAZARDS EVALUATION
Pineview Estates at Radford Hills
Weber County, Utah

FIGURE 4C

Test Pit 1



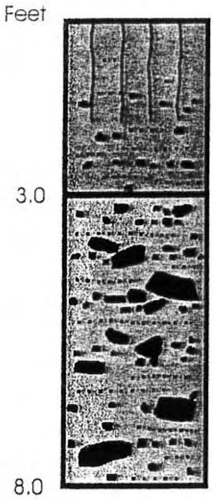
Modern A-horizon soil

Colluvium - mottled orange to grayish olive clayey sand (SM); upper part root penetrated; generally massive; low density; moist at base of A horizon; likely old landslide deposits from an upslope Norwood Tuff source area.

Landslide block? - Norwood Tuff block comprised of lean to fat clay (CL/CH); upper 2 feet stage III-IV carbonate K-horizon soil; moderate density; poorly bedded to massive.

No water

Test Pit 2



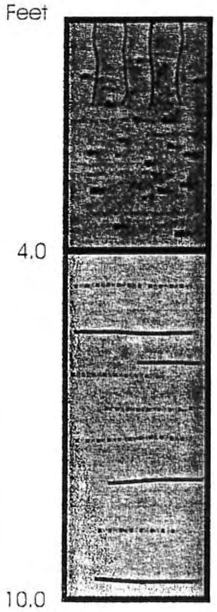
Modern A-horizon soil

Organic-rich alluvium/colluvium - gravelly sand (SW); root penetrated; low density; poorly bedded to massive.

Alluvium/colluvium - sandy gravel to gravelly sand (GW/SW) with rounded to angular cobbles and boulders; moderate density; poorly bedded to massive; clasts have stage II carbonate.

No water

Test Pit 3



Modern A-horizon soil

Alluvium/colluvium - sand with clay and gravel (SM); generally massive; low density.

Alluvium - possibly old alluvial-fan sediments comprised of clayey sand to sandy clay (SM/CL); iron oxide stained in discontinuous zones; poorly bedded to massive; moderate density; upper portion moist.

No water

Test Pit 4

Modern A-horizon soil, partially graded

Alluvium - sand with gravel and cobbles (SW); clasts round to subangular with stage II carbonate; low density; poorly bedded.

Alluvium/colluvium - possibly old alluvial-fan sediments comprised of lean to fat clay (CL/CH) with cobbles; iron-oxide stained; moderae to high density; poorly bedded to massive; slightly moist.

No water

WESTERN
GEOLOGIC

Test pits logged by
Bill D. Black, P.G.
on January 23-24, 2006

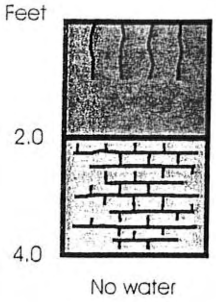
TEST PIT LOGS

GEOLOGIC HAZARDS EVALUATION

Pinview Estates at Radford Hills Development
Weber County, Utah

FIGURE 5A

Test Pit 5

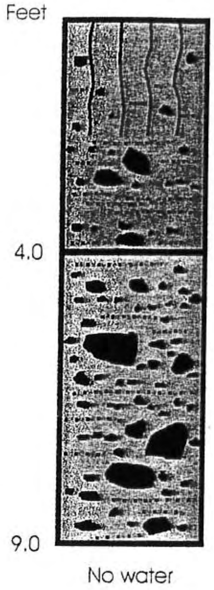


Modern A-horizon soil

Alluvium/colluvium - lean clay with silt (CL); generally massive; low density; Bw soil horizon in lower half of unit.

Norwood Tuff - Tertiary bedrock comprised of competent tuffaceous siltstone; well bedded; high density; backhoe refusal at 4 feet.

Test Pit 6

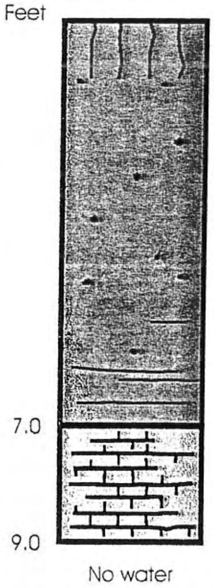


Modern A-horizon soil

Alluvium - gravelly sand to sandy gravel (SW/GW) with cobbles and trace boulders; clasts subangular to subround; poorly bedded; low to moderate density.

Alluvium - sandy gravel (GW) with cobbles and boulders; clasts angular to subround, stage II carbonate in upper half of unit; moderate density; poorly bedded to massive.

Test Pit 7



Modern A-horizon soil

Alluvium - lean clay (CL) with trace silt, gravel, and sand; generally massive, but indistinct bedding in lower part; low density.

Norwood Tuff - Tertiary bedrock comprised of competent tuffaceous siltstone and sandstone; high density; poorly bedded.

Test Pit 8

Modern A-horizon soil

Alluvium - gravelly sand (SW) with cobbles; clasts round to subangular with stage II carbonate; poorly bedded, with discontinuous gravel lenses; low to moderate density.

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Test pits logged by
Bill D. Black, P.G.
on January 23-24, 2006

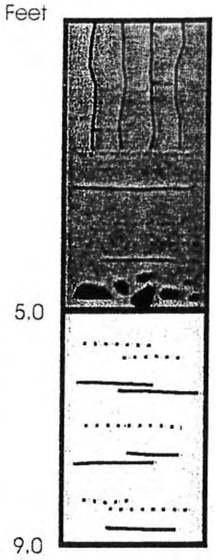
TEST PIT LOGS

GEOLOGIC HAZARDS EVALUATION

Pinview Estates at Radford Hills Development
Weber County, Utah

FIGURE 5B

Test Pit 9



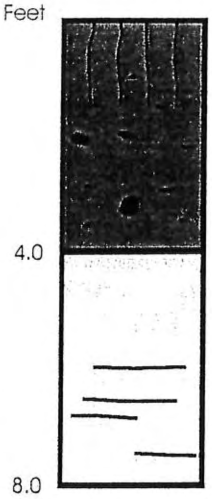
Modern A-horizon soil

Alluvium - sandy clay (CL) with basal cobbly zone; clasts subround to angular; poorly bedded; low density.

Weathered bedrock - highly weathered tuffaceous sandstone of the Norwood Tuff; comprised of sandy clay (CL); poorly bedded; moderate density.

No water

Test Pit 10



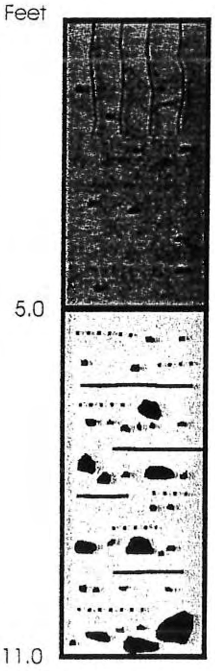
Modern A-horizon soil

Alluvium/colluvium - clay (CL) with trace gravel, sand, and cobbles; massively bedded; low density.

Weathered bedrock - highly weathered tuffaceous siltstone of the Norwood Tuff; comprised of lean to fat clay (CL/CH); stage III-IV carbonate in upper part; moderate density; poorly bedded.

No water

Test Pit 11



Modern A-horizon soil

Alluvium/colluvium - clay (CL) with gravel and sand; massively bedded; low density.

Alluvium - clay (CL) with gravel, cobbles, and trace boulders; massive to poorly bedded with some sand lenses; clasts subround to subangular, with stage II carbonate in upper part; moderate density; likely old alluvium derived partially from Norwood Tuff exposures.

No water

WESTERN GEOLOGIC

Test pits logged by
Bill D. Black, P.G.
on January 23-24, 2006

TEST PIT LOGS

GEOLOGIC HAZARDS EVALUATION

Pinview Estates at Radford Hills Development
Weber County, Utah

FIGURE 5C