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REPORT
GEOTECHNICAL STUDY
DETENTION PONDS AND ROADWAY SUBGRADES
PHASE 1 SUNRISE UTAH DEVELOPMENT
SOUTH JORDAN, UTAH

Submitted To:

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Submitted By:

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Job No. 3-817-004314

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Stantec Consulting, Inc.
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Attention: **Mr. Chris L. Robbins**

Gentlemen:

Re: Report
Geotechnical Study
Detention Ponds and Roadway Subgrades
Phase 1 Sunrise Utah Development
South Jordan, Utah

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for the Phase 1 development of the proposed Sunrise Utah Development in South Jordan, Utah. Phase 1 is located on the southeast portion of the proposed development. This phase will include construction of the 11400 South roadway from Bangerter Highway to about 4500 West and 4500 West Street between 11400 South and 11800 South Streets. The general location of the site with respect to major topographic features and existing facilities, as of 1999, is presented on Figure 1, Vicinity Map. A more detailed layout showing the proposed roadway layout and detention pond/park areas, is presented on Figure 2, Site Plan. The locations of the test pits and borings completed in conjunction with this study are also shown on Figure 2.

During the course of this study, our general findings and preliminary conclusions were transmitted to Mr. Chris Robbins of Stantec Consulting, Inc. AMEC Earth & Environmental, Inc. (AMEC) also conducted an earlier geotechnical study in the former evaporation pond area. The results of that geotechnical study were summarized in our report dated September 18, 2001[1].

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1 "Report: Feasibility Level Geotechnical Study, Proposed Sunrise Utah Development, Former Evaporation Pond Site, 4400 West to 4800 West, 10200 South to 11800 South, South Jordan, Utah" AMEC Job No. 1-817-003644.

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1.2 OBJECTIVES AND SCOPE

The objectives and scope of this study were planned in discussions between Mr. Chris Robbins of Stantec Consulting, Inc., and Mr. Joergen Pilz of AMEC.

In general, the objectives of this study were to:

1. Characterize and evaluate the subsurface soil and groundwater conditions along the roadway subgrade and proposed detention pond areas, and also at a box culvert canal crossing.
2. Provide appropriate infiltration rates and pavement subgrade, foundation and earthwork recommendations to be utilized in the design and construction of the proposed Phase I infrastructure.

In accomplishing these objectives, our scope included the following:

1. A field program consisting of the excavating/drilling, logging, and sampling of 9 exploration test pits and 5 borings to depths ranging from 11.5 to 30.5 feet below existing site grade. Field infiltration (percolation) tests were also completed in select borings and test pits.
2. A laboratory testing program, consisting of engineering and index property tests.
3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 AUTHORIZATION

Written authorization to proceed with our proposed scope of services was provided by Purchase Order 31812, dated January 24, 2001.

1.4 PROFESSIONAL STATEMENTS

Supporting data on which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration test pits and borings, projected groundwater conditions, and the layout and design data discussed in Section 2., Proposed Construction, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, AMEC must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices in use along the Wasatch front at this time.

2. PROPOSED CONSTRUCTION

The Phase 1 portion of the Sunrise Utah Development project will involve constructing the extension of 11400 South Street westward from Bangerter Highway, a roundabout, and a roadway extending southward along approximately 4500 West and tying into the existing 11800 South Street. This existing roadway will also be widened along a short reach. The 11400 South roadway will be a parkway with open space areas between and surrounding the traffic lanes. Immediately west of Bangerter Highway, 11400 South will cross the Provo Reservoir Canal across a reinforced concrete box culvert structure. Construction of the roadway westward will involve cuts of approximately 15 feet through a moderate hill slope (bench). The remainder of the roadways will be close to existing grade, except for a short reach of 4500 West Street, which will also require cuts through the moderately steep hill slope.

Traffic for the roadways is not known. The extension of 11400 South will be a major east-west arterial roadway. Traffic along 4500 West Street is projected to be less and more typical for a north-south principal roadway.

A number of open-space park areas will be developed adjacent to the roadways, as shown on Figure 2. These open space areas will also be utilized as detention/infiltration basins to store stormwater runoff generated within the Sunrise development boundaries.

The sideslopes of the detention basins will be constructed by a combination of cutting and embankment construction, resulting in a maximum overall slope height of about 10 feet at the various basins. As currently planned, the detention basins and embankments will be covered with grass or other vegetation. The crest of the embankment and cut slopes will be established to correspond with storage and infiltration requirements associated with the 100-year storm event. In general, the interior slopes of both the embankment fill and permanent excavation cuts are expected to be three horizontal to one vertical, or flatter. Downstream (outside) embankment slopes are expected to range from two horizontal to one vertical or flatter.

The Provo Reservoir canal box culvert will be an approximate 8-feet high by 8-feet wide structure extending for about 100 feet below the future 11400 South roadway. The box culvert will be reinforced concrete construction and be provided with a number of utility sleeves. Each end of the culvert will be provided with riprap protection to reduce scour and erosion.

3. SITE INVESTIGATIONS

3.1 FIELD PROGRAM

To characterize and evaluate the subsurface conditions along the roadways and the detention pond areas, 9 exploration test pits were excavated to depths ranging from 14.5 to 15.0 feet below the existing ground surface using a rubber tire-mounted backhoe. In addition, 5 borings were drilled to depths ranging from 11.5 to 30.5 feet using a CME-750 all-terrain drill rig. The approximate locations of the test pits and borings are shown on Figure 2.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the excavation and drilling operations, a continuous log was maintained of the subsurface conditions encountered at each location. In addition, relatively undisturbed tube samples and disturbed bulk samples of the soils encountered were obtained for subsequent laboratory testing and observation. The soils were classified in the field based upon visual and textural examination. These classifications were later supplemented by subsequent observation by the project engineer and testing in our laboratory. Detailed graphical representations of the subsurface conditions encountered at each exploration are presented on Figures 3A through 3E, Log of Borings and Figures 4A through 4I, Logs of Test Pits. The nomenclature utilized to describe the soil types is presented on Figure 5, Unified Soil Classification System.

The test pits were backfilled in moderately thick lifts and densified using the backhoe bucket and wheel rolling. Backfill consolidation and associated ground surface settlement should be expected at the test pit locations over time. Groundwater was not encountered in the test pits or borings. PVC pipe was installed at select locations indicated on the boring logs to perform field infiltration tests.

3.1.1 Field Infiltration Tests

Field percolation and infiltration tests were conducted in the test pits and borings, respectively. Borehole tests were completed within PVC pipe that had been installed in each boring. To conduct the tests, approximately one foot of gravel was placed at the bottom of the boring. A one and one-half-inch diameter, solid PVC pipe was then installed to the top of the gravel and an addition six inches of gravel was added. A two-feet thick zone of bentonite chips was then placed around the PVC pipe to seal the gravel at the bottom of the borehole. Water was then added to the bentonite chips to cause them to swell and seal the annulus between the borehole walls and PVC. The remainder of the annulus above the bentonite was backfilled with cuttings from the auger. The PVC pipe was then filled to the top with water and allowed to saturate over night. Several days later, the PVC pipe was filled back to the top and the rate at which water in the PVC pipe dropped was measured over time. Procedures described by the Bureau of Reclamation in the "Earth Manual" for field borehole permeability tests were used to estimate the permeability of the soils at the bottom of the borehole (Bureau of Reclamation, 1974). Results of the field borehole permeability tests are summarized in Table 1, Field Infiltration and Permeability Tests.

Percolation tests were also conducted within six-inch diameter holes excavated at various depths in the test pits. Percolation tests were performed in general accordance with the On-site Wastewater Systems Rule, Utah Department of Environmental Quality, dated February 15, 2000, (Utah Administrative Code R317-4). These infiltration tests were also evaluated in terms of permeability in accordance with the procedures described by the Bureau of Reclamation for boreholes. Results of the field permeability tests are also summarized in Table 1.

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Table 1, Field Infiltration and Permeability Tests

Location	Depth, ft	Soil/Bedrock Type	Average Est. Permeability cm/sec	Perc Rate Min/In	Description of Perc rate	Notes
TP-3	2.5	Sandy Gravel	1.4E-01	1.3	Good	Grades w/ clay layers
TP-5	4.2	Sandy Silt	6.1E-03	2.3	Good	Pinholes & cemented layers
TP-6	3.0	Fill - Clayey Silt	9.2E-05	4.0	Good	Fill
TP-7	10.1	Clayey Silt	3.2E-05	5.2	Good	Weakly Cemented
B-5	29.0	Clayey Silt	6.1E-07	29.4	Fair	Pinholes below fill

As expected, the percolation rates are relatively high for the coarse-grain gravels, but were also relatively high for fine-grain silt and clayey silt. The following must also be considered:

- Many samples from the borings indicated "pinholes," in the natural clayey silt soil structure. Typically, such soils are deposited in alluvial fans as debris flow deposits or as wind-blown deposits. Laboratory tests reveal a collapse potential of about 1 percent for these soils with "pinholes."

- The natural soils classify principally as a low plasticity clayey silt with a liquid limit of 34 and a plasticity index of 6 or 7. Layers of fine silty sand and non-plastic silt were also encountered. Soils meeting the Unified Soils Classification System (USCS) for clays were generally not encountered.

- Fine sand layers or sand "stringers" occur at some locations. These layers could lead to lateral migration of seepage.

- Permeable, granular soils overlying fine-grain sandy silts are present at some locations. At these locations, the percolation rate may decrease with depth.

- The infiltration rates are localized rates, and infiltration rates over larger areas are projected to be slower.

3.2 LABORATORY TESTING

3.2.1 General

To aid in classifying the soils and provide data necessary for our engineering analyses, moisture and density tests, plasticity index (Atterberg limit) tests, full and partial sieve analyses, and collapse tests were performed on selected undisturbed samples and bulk samples. In addition, a modified proctor compaction test and a California Bearing Ratio (CBR) test were completed on the soil type representing the predominant subgrade material. A description of each of the tests in addition to a summary of the test results are presented in the following sections.

3.2.2 Moisture and Density Tests

To aid in classifying the soils and to help correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented to the right of the corresponding sample notations on the test pit and boring logs and summarized in the table below. Also indicated on this summary table are the laboratory test results of the natural soils from the previous investigation at the evaporation ponds.

Identification			Classification and Index Properties			
Boring No.	Depth Ft.	Soil Description	USCS	W-C %	γ_{dry} pcf	γ_{tot} pcf
This Study						
B-1	5.5	Clayey Silt	ML-CL	27.3	79.7	101.5
B-2	10.5	Clayey/Sandy Silt	ML	28.9	70.9	91.4
B-2	15.0	Clayey/Sandy Silt	ML	22.4	75.1	91.9
B-3	5.5	Sandy Silt	ML	16.7	63.7	74.3
B-3	15.5	Sandy Silt	ML	21.4	73.6	89.4
B-3	20.5	Clayey/Sandy Silt	ML	37.0	66.9	91.7
B-4	5.5	Sandy Silt	ML	15.2	71.5	82.4
B-5	9.5	Clayey Silt	ML	17.1	99.5	116.5
B-5	24.0	Sandy Silt	ML	24.9	74.6	93.2
TP-1	13.0	Poorly Graded Sandy Gravel with Silt	GP-GM	4.9		
TP-3	3.0	Poorly Graded Sandy Gravel with Silt	GP-GM	2.1		
TP-4	4.0	Poorly Graded Sandy Gravel with Silt	GP-GM	1.1		
TP-5	10.0	Sandy Silt	ML	9.4		
TP-6	2.0	Sandy Silt	ML	7.5		
TP-7	11.0	Clayey Sandy Silt/Silty Sand	ML/SM	12.1		
TP-8	3.0	Silty Sand/Sandy Silt	SM/ML	15.0		
Study 1-817-003644 at Former Evaporation Ponds						
B-2	22.0	Poorly Graded Gravel w/ Sand	GP	6.7		
B-5	20.5	Silty to Poorly Graded Fine Gravel w/ Sand	GP	7.1		
B-10	18.0	Silty to Poorly Graded Gravel	GM-GP	5.6		
B-13	21.0	Silty Gravel	GM	4.8	106.8	111.9

USCS = Unified Soil Classification System
γ_{dry} = dry density
γ_{tot} = total density

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It is observed that the dry density of the silt soils was very low, corresponding to the "pinhole" structure observed at numerous exploration locations.

3.2.3 Atterberg Limits

To aid in soil classification, Atterberg limit tests were performed on representative samples of the near-surface fine-grained soils. The test results are tabulated below:

Boring or Test Pit No	Sample Depth (ft)	USCS Classification*	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
B-1	5.5	CL-ML	34	28	6
B-3	15.5	ML			Not plastic
TP-6	2.0	CL-ML	34	27	7

* Based upon portion of the sample passing the No. 40 sieve.

3.2.4 Gradation Tests

To aid in classifying the soils, full and partial gradation tests were performed on selected representative samples of the natural granular soils. Results of the gradation tests are tabulated below:

Test Pit or Boring No	Depth (feet)	Percent Passing by Weight											USCS Classification
		1 ½"	1"	¾"	½"	3/8"	No. 4	No. 10	No. 16	No. 40	No. 100	No. 200	
B-2	15.0											62	ML
TP-1	10-13	86	67	44	31	28	22	10	18	15	11	10	GP-GM
TP-3	3.0	76	67	66	59	54	42	20	9	5	3	2	GP
TP-4	4.0	63	54	37	29	20	7	2	2	2	2	1	GP
TP-5	10.0		100	100	96	95	95	95	95	94	93	88	ML
TP-7	11.0											36	SM
TP-8	3.0											24	SM

USCS-Unified Soils Classification System

The fine-grain samples from Test Pits TP-5, TP-7, and TP-8 each exhibited a number of "pinholes."

3.2.5 Collapse Tests

To assess the moisture sensitivity of the near-surface site soils, collapse tests were performed on relatively undisturbed representative samples of soils exhibiting a "pinhole" structure. The collapse tests were performed in accordance with the following procedure:

1. The sample was loaded to a specified axial pressure at in-situ moisture content.

2. The resulting axial deflection was measured and recorded.

3. The sample was saturated.

4. The resulting collapse was measured and recorded.

A tabulation of the results of the collapse tests is presented below:

Test Pit No	Sample Depth (ft)	USCS Classification	Dry Density (pcf)	Moisture Content (%)	Axial Load When Saturated (psf)	Collapse (-) or Swell (+) (%)
B-3	5.5	ML	94.9	14.8	800	(-) 1
B-5	24.0	ML	73.5	24.9	1,600	(-) 1

The percentage of collapse exhibited by the tested samples under relatively low to moderate axial loads indicate that the near-surface soils represented by the samples possess a slight potential for collapse when exposed to excess moisture.

3.2.6 Modified Proctor Compaction Test

To determine the moisture and density relationship of a composite sample of the near-surface soils, a laboratory compaction test was performed in accordance with the AASHTO[2] T-180 (ASTM[3] D-1557) compaction criteria. The results of the test are tabulated below:

Test Pit No	Depth (feet)	USCS Classification	Maximum Dry Density psf	Moisture Content Optimum (percent)
TP-6	2 feet Composite	CL/ML	111.3	16.1

The particular sample tested exhibited satisfactory compaction characteristics with a moderate dry density at a moisture content close the in-situ moisture content below about three feet.

3.2.7 California Bearing Ratio Test

CBR tests were performed in general accordance with ASTM D-1883 test procedures. The tests were performed using a 40-pound surcharge load, to model the weight of an approximate two-foot thick

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2 American Association of State Highway and Transportation Officials
3 American Society for Testing and Materials

pavement section. The tests were completed by recompacting a sample of the clayey silt soils to a dry density of 90 percent of the modified proctor compaction density. The clayey silt soils will be the dominant pavement subgrade soil type.

Test Pit No.	Sample Depth (feet)	CBR Value (%) Top of Sample	CBR Value (%) Bottom of Sample
TP-6	2.0 feet . Composite	13	Not tested

When compacted the above soils will exhibit relatively good subgrade support characteristics. However, the soils may be slightly moisture sensitive. For comparison, CBR tests completed by our laboratory for portions of the 12300 South roadway yielded CBR values ranging from as low as two to as high as nine for soils with similar plasticity indexes. However, these soils were tested using a surcharge load of only 10 pounds, which is considerably less than the load applied by a typical pavement section.

4. SITE CONDITIONS

4.1 SURFACE

The overall site is an open, undeveloped, parcel situated to the northwest of the existing Country Crossing subdivision. The site contains a distinct topographic break in slope extending in a northeast to southwest orientation. The relief along this break in slope is on the order of 25 feet or more. Beginning at Bangerter Highway, 11400 South Street crosses the Provo Reservoir canal immediately to the west of the Highway. The 11400 South Street will then extend along a gentle slope until reaching the break in slope. The roundabout will be located on relatively level terrain on top of the bench. The 4500 West Street will extend down the break in slope onto gently sloping terrain.

An existing detention basin has been constructed adjacent to 11800 South Street, in the southeast corner of the proposed Phase 1 development. This basin consists of over 20 feet of fill.

At the time of our field program, vegetation consisted of a moderate growth of wheat stubble. Numerous cobbles and gravel size soil particles were exposed on the surface. It should be noted that fine and coarse gravels are scattered over the surface of the site due to plowing and minor subsequent surface erosion.

4.2 SUBSURFACE SOIL CONDITIONS

Subsurface conditions encountered at the test pit and boring locations were relatively consistent across the site. In general, the predominant soil type encountered at each location, except Test

Pits TP-3, TP-4, and TP-9, was a low plasticity clayey to sandy silt. The clayey silts contained thin silty sand and gravel stringers and layers at various locations. These silt were generally light brown to gray in color and exhibited a porous "pinhole" structure at the locations indicated on the boring logs. The silts are also characterized by a very low dry density and total unit weight, which corresponds to the "pinholes" observed. Field drive sample blow-counts indicate that the clayey silts are generally medium stiff to stiff.

In the vicinity of the proposed box culvert, the clayey silts are underlain by a poorly graded gravel and silty sand at depths ranging from about 9 to 15 feet. The clayey silts are medium stiff at the box culvert location, presumably due to infiltration of moisture from the canal. Similar poorly graded sandy gravel deposits were also encountered at the location of Test Pit TP-3 and TP-4. The gravel deposits contained cemented (caliche) layers and zones of coarse cobble layers, along with layers of sands. The gravel deposits were generally medium dense and light brown in color.

Man-placed fills were encountered adjacent to the canal in Boring B-1 and in Boring B-5 at the detention pond constructed adjacent to 11800 South Street on the southeast portion of the property. The man-placed fills consisted primarily of medium stiff clayey silts derived from the natural soils.

In general, beginning at Bangerter Highway along 11400 South Street and extending westward to the roundabout, the following soil types were encountered:

Table 2 – Roadway and Detention Pond Area Subgrade soils

Location	Depth (from / to) feet	USCS Soil Type
TP-1	0-11	ML (Clayey Silt)
	11-15	SM-GM/GP (Sand and Gravel)
B-1	0-13	ML (includes fill)
	13-15	GP (Sandy Gravel)
TP-2	0-9	ML (Clayey silt)
	9-15	SM/ML (Silty Sand/Sandy Silt)
B-2	0-16.5	ML (Clayey and Sandy Silt)
B-3	0-21.5	ML (Clayey and Sandy Silt)
TP-3, TP-4	0-15	GP (Sandy Gravel)
TP-5	0-15	ML (Sandy Silt)
TP-6	0-7	CL-ML (Clayey Silt Fill)
	7-12	ML (Sandy Silt)
	12-15	CL-ML (Clayey Silt-Silty Clay)
TP-7	0-10.5	ML (Sandy Silt)
	10.5-15	ML-SM (Silt And Silty Sand Layers)
Along 11800 South Street		
B-4	0-3	SM (Silty Sand)
	3-11.5	ML (Sandy Silt)
B-5	0-21	Fill (ML)
	21-27	ML (Sandy Silt)
	27-30.5	CL-ML (Silty Clay-Clayey Silt)

The lines designating the contacts between soil types on the test pit and boring logs generally represent the approximate subsurface boundaries between those soil types. In-situ, the transition between different soil types are gradual.

4.3 GROUNDWATER CONDITIONS

Although very moist conditions were encountered at several feet below ground surface. groundwater was not encountered in any of the test pits or borings. Water levels in the proximity of the canal crossing are expected to be a function of the canal levels, where soil moisture conditions ranges to very moist.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 DISCUSSIONS OF FINDINGS

From a geotechnical standpoint, the site subsurface conditions encountered in the borings and test pits are suitable for constructing roadways and the detention pond/sedimentation basin facilities as planned. The principal geotechnical concern is the small to moderate collapse potential of the soils indicated by the "pinholes" observed in the field, the low unit weight of the soils, and the results of the collapse tests, which indicated a slight collapse potential. In general, though, the undisturbed natural soils underlying the site, and/or structural fills extending to the undisturbed natural soils, should provide suitable foundation support to the planned pond embankments, roadways and culvert. The near-surface soils are predominantly clayey to sandy silts, which should provide suitable material for embankment construction. The clayey to sandy silts will possess relatively low permeability when compacted, but are porous and potentially moisture sensitive in their natural state.

- Collapse of the near-surface soils could impact embankments placed on these soils. However, the detention basin embankments are expected to be relatively low height. To limit the possibility of soil collapse in the future due to excess moisture, we recommend the following approach.

- Excavate the detention basins with a base below any future basements. Fill the basins with water or surface runoff prior to further construction to allow any near surface collapse to occur.

- After the excavations have been filled with water, utilize a minimum of 12 inches of the on site clayey silts as a liner along the sides of the detention ponds. The "liner" may be constructed using the on site lower permeability soils compacted to 95 percent of the modified proctor density and to within 2 percent of the optimum moisture content. Over time, such a liner may gradually deteriorate due to desiccation; however, a compacted clay layer will retard lateral migration of the water stored in the basin(s).

- Cover the sides of the detention basins with either vegetation or loose soil to limit the possibility of desiccation.

As development proceeds, it should be expected that periodic maintenance of the ponds may be required, such as proofrolling or reworking the pond slopes and base. The degree of any desiccation cracking after the initial filling of the ponds will be a function of the climatic conditions.

A secondary geotechnical issue is the presence of permeable natural sands and gravel layers at the surface and underlying the near-surface natural clayey silts. Water detained in the ponds could infiltrate into these permeable soils and potentially create random and "perched" groundwater conditions that could impact present and future down-gradient facilities. Based on conditions observed in the current test pits, we project that most of the excavated pond areas will be underlain by several feet or more of natural clayey silts. We recommend that the base of the ponds be potholed under the direction of qualified geotechnical personnel once planned subgrade has been reached to confirm the thickness of the natural clays underlying the pond area.

As discussed above, we recommend that the sides of the pond(s) be lined with compacted clay to limit infiltration of ponded water into more permeable natural granular soils and to retard the advance of excess moisture into undisturbed, potentially collapsible, natural clayey silts. In addition, we recommend placing a one-foot-thick layer of compacted clay (clay liner) beneath structural elements established over undisturbed natural clays to limit possible leakage from infiltrating potentially collapsible soils. The clay liner can be constructed by scarifying and compacting the exposed natural clayey silts subgrade soils to an appropriate depth, placing a sufficient thickness of compacted clay obtained from on or off-site borrow sources, or a combination of these approaches. To limit desiccation of the clay forming the liner, which would result in higher permeability characteristics, the surface of the detention pond should be covered with grass and sod or six to eight inches of loosely placed soil.

Based on conditions encountered in the test pits and borings, most, if not all, of the natural soils excavated from within the pond areas will consist of clayey to sandy silts suitable for use as embankment and liner material. If additional clayey embankment and liner materials are necessary, the area surrounding the pond should provide sufficient sources of suitable clayey silts.

5.2 GEOSEISMIC/ENGINEERING GEOLOGY CONSIDERATIONS

From an engineering geology standpoint, we have identified no constraints to the design or construction of the proposed facility. The overall site is gently sloped with no evidence of past instability. Review of available literature indicates that there are no active faults passing through or immediately adjacent to the site. The nearest active fault trace is the Wasatch fault which is located approximately 8.5 miles to the east of the site and the Oquirrh fault, which is located about 11.0 miles to the west of the site.

5.3 EMBANKMENTS/STRUCTURAL ELEMENTS

5.3.1 Foundation Design

The foundation soils supporting the pond embankments, as well as any structural facilities associated with the ponds, should generally consist of natural clayey silts. The undisturbed, natural clayey silts below a depth of about 15 to 16 inches are generally medium stiff with stiff to very stiff zones and will exhibit moderate strength and compressibility characteristics provided they remain undisturbed and partially saturated. Existing non-engineered fills must be removed from all areas to be occupied by embankments or structure.

For foundation design, we recommend using a maximum allowable bearing pressure of 1,500 pounds per square foot. We recommend minimum footing widths of 1.5 and 2.0 feet for continuous and isolated spread footings, respectively, and a minimum embedment for frost protection of 2.5 feet. For transient loading conditions (wind, seismic, etc.), the maximum allowable bearing pressure may be increased by 50 percent.

Lateral loads imposed upon spread, continuous, or mat/slab foundations may be resisted by the development of passive earth pressures against the sides of the foundations and by friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.40 should be utilized for footings established on properly prepared natural clays. Passive resistance provided by properly placed and compacted cohesive structural fills above the water table may be considered equivalent to a fluid with a density of 200 pounds per cubic foot.

A combination of passive earth resistance and base friction may be utilized provided that the friction component of the total is divided by a factor of safety of 1.5.

5.3.2 Liquefaction

The Sunrise Utah site is located in an area considered to have a low liquefaction potential. The embankments will be constructed of compacted clays, the main body of which should remain partially saturated even when the pond is full. Accordingly, the embankments are not expected to liquefy even during a major seismic event. The foundation soils consist of natural, partially saturated, medium stiff clays overlying thick zones of partially saturated, medium dense gravels. Because of the lack of saturation and the confining pressures generated by the embankments, liquefaction of the foundation soils is also not anticipated.

5.3.3 Settlements

Total settlements along the crests of the embankments will depend on the height of the embankments, the compressibility of the foundation soils and any collapse that may occur after construction. Total elastic settlements along the crests of the embankments due to self-weight consolidation of the embankment fills should be less than 1 inch. We anticipate that approximately 60 to 70 percent of the total elastic embankment settlements will occur during construction.

If the natural silts underlying the embankments or associated structural elements become saturated following construction, additional settlements due to potential soil collapse must be expected. Projecting that the wetted front will advance to a depth of less than three feet due to the absence of a sustained source of water, collapse-related settlements on the order of about one inch could occur. If the wetted front advances deeper, the resulting collapse-related settlements would be proportionally higher. In addition, desiccation cracks may develop in the liner. Such cracking will require maintenance, such as scarifying and compaction in the area where the cracking is observed.

5.4 POND AREA

The sideslopes along the pond area will be created wholly or partially by cutting into the natural soils. Typical slopes within the pond area will be three horizontal to one vertical. If silts, sands or gravels are exposed in permanent cut slopes within the pond area, the 12-inch thick clay liner should extend over these soils. Construction may be facilitated by over-cutting the slopes by approximately one foot and placing the clay "liner" at a time near completion of construction.

In order to protect the liner from desiccation and cracking, we strongly recommend that the liner be covered. A suitable cover would be sod and grass or six to eight inches of loosely dumped and spread soil. At points of concentrated water flow, erosion protection must be provided. The erosion protection may consist of a layer of cobbles placed on a filter fabric or an erosional control mat.

Periodic observation and maintenance of the pond area should be performed. Exposed areas of the liner should be immediately covered and holes caused by burrowing rodents should be immediately filled.

5.5 POND EARTHWORK

Initial preparation of the site must consist of the removal of all surface vegetation, topsoil (where encountered), non-engineered fill, and other deleterious materials from all areas that will ultimately be structurally loaded. Vegetation and deleterious materials should be removed from the site. Topsoil, if encountered, will be unsuitable for utilization as embankment fill. It should be noted that topsoil was not encountered at the test pit locations.

Where embankments and structural elements will be established at or near existing grades, portions of the upper 15 to 16 inches of plow-disturbed soils remaining after topsoil removal should be scarified and compacted to the requirements for structural fill.

It should be noted that, from a handling and compaction standpoint, the on-site clayey silts soils will be relatively sensitive to changes in moisture content and will require very close moisture control during placement and compaction. <u>This will be very difficult, if not impossible, during wet and cold periods of the year.</u>

5.6 CULVERT FOUNDATION SUPPORT

5.6.1 Allowable Bearing Pressure

In evaluating the allowable bearing pressure for the culvert, the soft silt soils encountered within the depths explored were considered to be the controlling subsurface soils. We recommend that the culvert be designed using a maximum allowable bearing pressure of 2,500 pounds per square foot on a minimum of 12 inches of compacted granular fill.

5.6.2 Settlement

We project that under normal operations the culvert will vary from about one-half full to nearly full for an extended period of several months each year. Assuming an even distribution of load across the base of the culvert, we calculate a maximum base contact pressure of 1,200 pounds per square foot under the maximum total load of the culvert. The maximum total load of the culvert would include the weight of the culvert, the weight of the water when full, the overlying pavement section and a traffic surcharge of 250 pounds per square foot. When no water is in the culvert, the maximum base contact pressure is estimated to be about 900 pounds per square foot.

The cohesive soils underlying the culvert are may soften due to the water present in the canal. The maximum anticipated based contact pressures will be less than the past consolidation pressures. For the above maximum base contact pressures, we have calculated maximum total settlements of about one inch. Differential settlements along the culvert are expected to be negligible. Over half of the expected settlements are expected to be complete within six to eight weeks after construction of the culvert and placement of the overlying pavement section. Delaying placement of the final pavement section until settlements are complete will reduce the differential settlement between the culvert and surrounding grade.

5.6.3 Lateral Resistance

For the base of the culvert established on at least one foot of compacted granular structural fill extending to undisturbed natural cohesive soils, we recommend using a coefficient of 0.40 for determining base sliding lateral resistance. If used in combination with resistance from passive earth pressures, the base-sliding coefficient must be reduced by a factor of safety of 1.5.

5.6.4 Installation

The culvert should be established on granular structural fill extending to undisturbed natural soils. Under no circumstances can the culvert be established directly on soft, wet, or disturbed soils, frozen soils, or within ponded water.

The excavation will encounter fine-grained soils that may be very moist to wet. These natural, fine-grained subgrade soils may degrade significantly during site preparation activities, especially where the base of the excavation is near or below the groundwater level and during wet periods of the year. It is our opinion that including a layer of granular bedding fill beneath the culvert will facilitate construction by limiting construction-related disturbance of the anticipated saturated soils.

If very soft, saturated subgrade conditions are encountered, placement of the granular bedding fill to the required density may be difficult, if not impossible. In that case, we recommend over-excavating the subgrade soils to a depth of 12 inches and replacing those soils with granular stabilizing fill, such as crushed rock or clean gravel and cobbles. Once the subgrade has been stabilized, the granular bedding fill can be placed and compacted. Alternatively, a geotextile reinforcing/separation fabric can be placed over the exposed subgrade before placement and compaction of the granular bedding fill.

If the granular bedding fill becomes disturbed, the fill must be re-compacted to the requirements for structural fill prior to pouring concrete.

The width of granular bedding fill below the culvert should extend laterally at least six inches beyond the edges of the culvert for each foot of fill thickness beneath the culvert.

5.7 LATERAL EARTH PRESSURES

The culvert will retain backfill placed between the structure and the temporary excavation cuts. To facilitate placement and compaction, we recommend that the backfill consist of a clean, moderately angular, granular material consisting of sands and gravels. In evaluating lateral earth pressure parameters, we assigned the backfill a moist unit weight of 130 pounds per cubic foot and an internal friction angle of 35 degrees.

The following table lists equivalent fluid densities for use in determining design lateral earth pressures under static and seismic load conditions. The seismic criteria have been developed for horizontal acceleration values of 0.40 and 0.48 g, which correspond to average ground motion return periods of 475 and 2,350 years.

Load Condition	Equivalent Fluid Density (pcf)		
	Static	475-Year Event	2,350-Year Event
Active	35	28	31
At-Rest (restrained)	55	50	60
Passive	320[1]	320[2]	320[2]

[1] Factor of safety of 1.5
[2] Factor of safety of 1.0

The at-rest equivalent fluid densities for seismic events are additional to the static at-rest values. If materials other than those described above are used as backfill immediately adjacent to the abutment walls, the above equivalent fluid densities will change and could increase.

In determining the lateral earth pressures acting on the culvert structure, we recommend the following approaches:

1. At-rest static and seismic earth pressures are determined using the above equivalent fluid densities. The total static at-rest force is determined and applied using a distribution appropriate for braced conditions. The total seismic at-rest force is determined using an inverted triangular pressure distribution that decreases with depth. The maximum pressure is based on the height of the wall times the seismic equivalent fluid density. The total seismic at-rest force is applied at a point above the base of the wall equivalent to six-tenths the height of the wall.

2. The passive static and seismic earth pressures can be determined using the above equivalent fluid densities and are both applied using a triangular pressure distribution. Note that the seismic component of the total passive earth pressure acts in the opposite direction to the static component. Accordingly, seismic passive values greater than the static values are irrelevant.

5.8 CULVERT EARTHWORK

5.8.1 Excavations

Excavations for the culvert are projected to encounter primarily natural, fine-grained, cohesive soils overlain by canal embankment fills. Temporary construction excavations in the undisturbed, natural, cohesive soils not exceeding four feet in depth and not overlain by existing fills may be constructed with sideslopes of one horizontal to one vertical (1:1 H:V). Deeper excavations in undisturbed, natural, cohesive soils above or below the groundwater table may be constructed with sideslopes no steeper than 1.5 horizontal to one vertical (1.5H:1V). Loose or disturbed surficial soils may require flatter sideslopes.

If cohesionless fine-grained or granular soils are encountered, particularly below the groundwater table, flatter side slopes, shoring and bracing, and/or dewatering systems will be required. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated.

5.8.2 Structural Fill Materials and Compaction

In general, structural fill materials for the roadway pavement and their placement must conform to UDOT or South Jordan specifications. However, structural fill used to stabilize soft or saturated subgrade soils should meet the following requirements.

To stabilize soft subgrade conditions or where structural fill is required, a stabilizing fill consisting of a mixture of coarse gravels and cobbles or a gap-graded, angular, one and one-half to two-inch-minus gravel should be utilized. A stabilizing fill, if utilized, should be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the fill may be compacted by at least two passes of moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles should be adequately compacted so that the "fines" are "worked into" the voids in the underlying coarser gravels and cobbles.

5.9 PAVEMENTS

Traffic data for the Sunrise Utah development is currently not available and will be required for design of the pavement section. The following design parameters are recommended.

5.9.1 Soil Conditions

The majority of the soils underlying the future principal roadway pavements will be fine-grained sandy to clayey silts and low plasticity silty clay. Based on the results of the laboratory CBR testing, the silty clay subgrade soils have CBR values of 13 percent when scarified and recompacted to 90 percent of the modified proctor test (ASTM D-1557). However, infiltration of water into the subgrade over time can deteriorate the subgrade support capacity. We therefore recommend a small reduction in the tested laboratory value to a CBR support value of 10 as the design support value.

The upper portion of the Phase 1 development area consists of granular sands and gravels, as encountered in Test Pits TP-3 and TP-4. Based on the gradation analysis, these soils will have a CBR support value of at least 20. Infiltration of moisture into these soils is also significantly less critical.

The clayey silt and silty clay subgrade soils are also moisture sensitive and possess a small collapse potential upon wetting. To reduce the settlement potential in the clayey silt and silty clay areas, we recommend that 12 inches of the subgrade be scarified and recompacted to 90 percent of the modified proctor density (ASTM D-1557). The scarification and recompaction will reduce the infiltration of surface moisture further down into the underlying subgrade soils. This will reduce, but not eliminate the future settlement potential. However, our field experience indicates generally satisfactory performance over time when this is accomplished. In the area of the granular sands and gravels, the subgrade should be proofrolled by passing moderately loaded construction equipment over the subgrade areas at least twice to identify loose or disturbed areas. Such loose or disturbed areas should be removed down to a maximum depth of 18 inches and recompacted to at least 90 percent of the modified proctor density.

Another important consideration for the pavements below 11400 South and roadways that may be transferred to UDOT, will be the requirement to collect and discharging any surface drainage that makes its way into the pavement section. Placement of a minimum four-inch thick drainable base layer within the pavement section is generally required by UDOT along the principal arterial roadways. The drainable base generally discharges to edge drains (which are routed to the storm drain system) or is "daylighted" along the edge of the pavement section. Care in the design must be exercised in the layout of the drainage system so that surface moisture does not infiltrate into the

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subgrade through the drainable base. Such drainage measures are only warranted on the principal roadways and in the areas of the fine-grain size soils. The secondary roadways should incorporate scarification and recompaction of the fine-grained subgrade soils, but a drainable base layer is generally too costly below these pavements.

5.9.2 Pavement Section Design Parameters

The following table lists the parameters that should be used in design of the principal arterial pavement sections. The parameters generally follow the standard parameters listed in the UDOT Design Manual.

Design Parameter	Pavement Type	Design Value
Design Life	Flexible	20 years
	Rigid	Up to 40 years
Reliability	All	90 percent
Standard Deviation:	Rigid	0.35
	Flexible	0.45
Initial Serviceability	Rigid	4.5
	Flexible	4.2
Terminal Serviceability	All	2.5
Modulus of Subgrade Reaction	Rigid	Figure 3C-1 (Design Manual)
Resilient Modulus	Flexible	Based on CBR x 1,500
28-Day Mean PCC Modulus of Rupture	Rigid	650 psi
28-Day Mean Elastic Modulus of Slab	Rigid	4,000,000 psi
Effective k-Value	Rigid	Calculated
Load transfer Coefficient	Rigid	3.0 (Tied)
Drainage Coefficient	All	1.0
Flexible Pavement Structural Coefficients		
Plant Mix Seal Coat	Flexible	0.30
Hot Mix Asphalt	Flexible	0.40
Open-Graded Untreated Base Course	Flexible	0.10
Modified Untreated Base Course	Flexible	0.08
Flexible Pavement Layer Thickness		
Plant Mix Seal Coat	Flexible	1.0 inch
Hot Mix Asphalt	Flexible	UDOT Design Chart
Open-Graded Untreated Base Course	Flexible	UDOT Design Chart
Modified Untreated Base Course	Flexible	Varies with Structural Number
Subgrade CBR (silt soils)	Either	10
Resilient Modulus (silt soils)	Rigid	10000 psi
Subgrade CBR (sands and gravels)	Either	20
Resilient Modulus (sands and gravels)	Rigid	30000 psi

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5.9.3 Pavement Section

We understand that Stantec is developing an estimate of the future traffic along 11400 South Street and the remaining roadways. When this data becomes available, appropriate pavement sections can be developed for the principal and secondary roadways.

We appreciate the opportunity of providing this service for you. If you have any questions concerning this report or require additional information, please do not hesitate to contact the undersigned.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Joergen Pilz State of Utah No. 168810
Senior Geotechnical Engineer

Reviewed by:

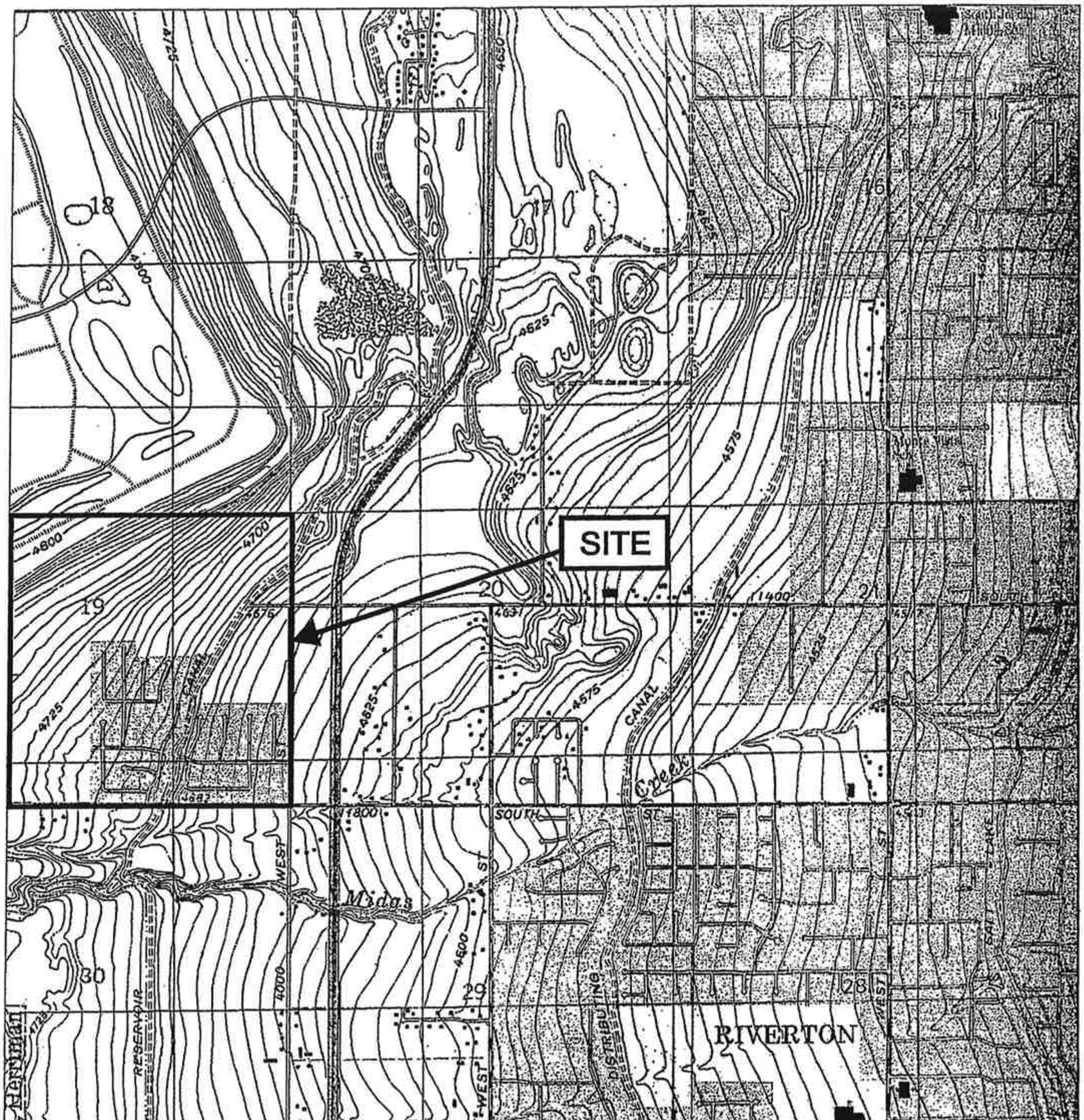
J. Wade Gilbert, State of Utah No. 367656
Professional Engineer

JWG/JWG:sn

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	through 3E, Logs of Borings
	Figures	4A	through 4I, Log of Test Pits
	Figure	5,	Unified Soil Classification System

Addressee (3)

STANTEC COUNSULTING, INC.
JOB NO. 3-817-004314



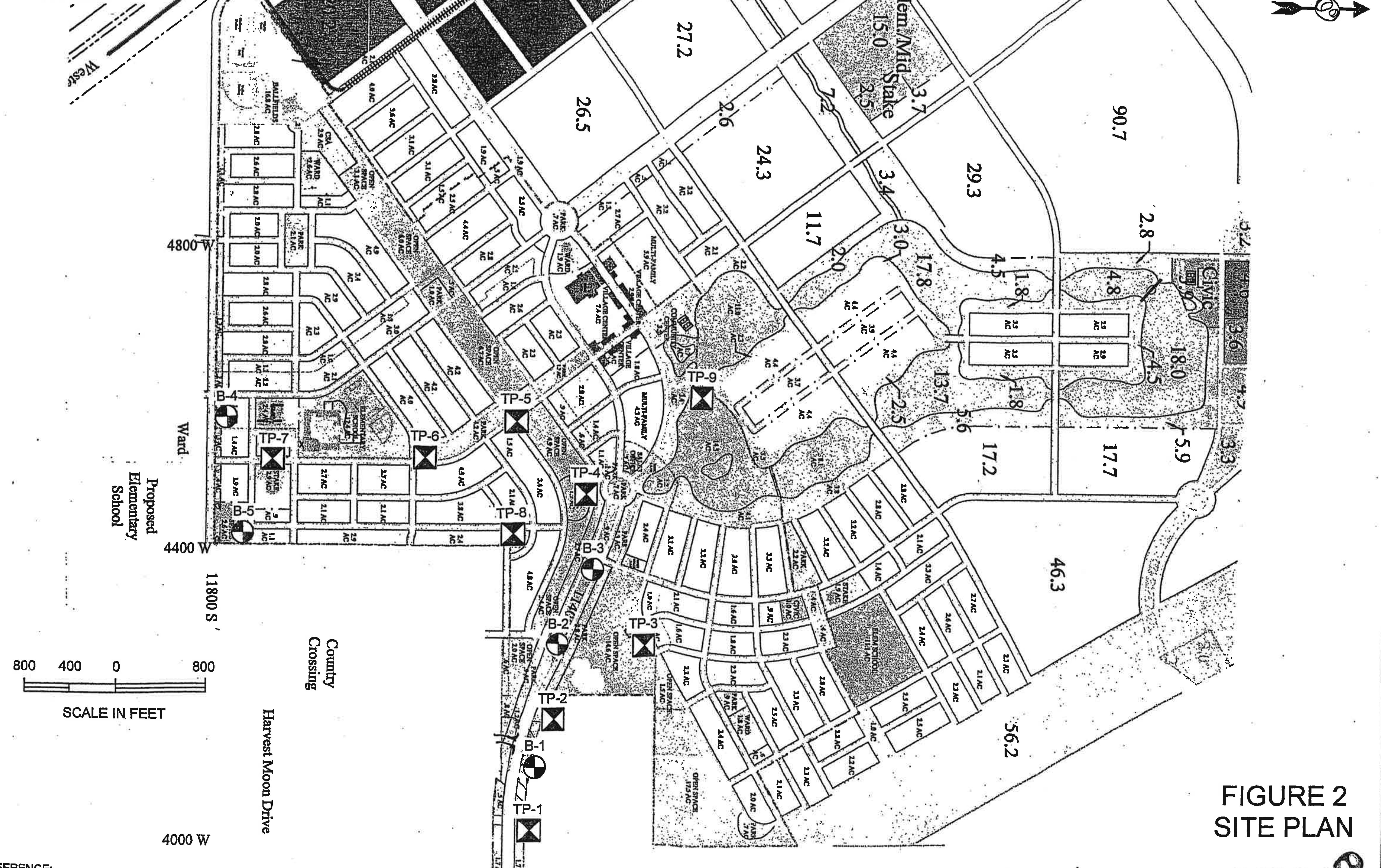
SCALE IN FEET

1000 0 1000 2000

FIGURE 1
VICINITY MAP

REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAP
TITLED "MIDVALE, UTAH"
DATED 1999

STANTEC CONSULTING, INC.
JOB NO. 3-817-004314



REFERENCE:
ADAPTED FROM DRAWING
PROVIDED BY CLIENT

FIGURE 2
SITE PLAN

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-1

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/GM/FILL	moist loose	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; gray to brown; FILL
								ML FILL	moist medium stiff	**CLAYEY SILT** with some fine to coarse sand; brown, FILL
			X	D	11					
5										
			X	D	10	80	27.3	ML-CL	moist to very moist medium stiff LL = 34 PI = 6	**CLAYEY SILT** trace sand; gray with oxidation staining
			X	D	6					
10										grades to clayey silt/silty clay
								GP	slightly moist very dense	**FINE TO COARSE SANDY FINE AND COARSE GRAVEL** with trace silt; brown
			X	D	114					
15										Stopped drilling at 14.0'. Stopped sampling at 15.5'. * Groundwater not encountered.
20										
25										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE 3A

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

JOB NO. 3-817-004314 DATE 02-12-03

LOG OF TEST BORING NO. B-2

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/ GM	loose to 12" moist	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; brown
								ML	moist loose/medium stiff	**CLAYEY AND FINE SANDY SILT** with trace of occasional pinholes; light brown
5				D	17					
10				D	22	71	28.9			grades with numerous fine to coarse sand seams to 1/16" thick
15				D	17	75	22.4		-200 = 62	grades with fine sand seams and some some orange oxidation staining without sand seams
										Stopped drilling at 15.0'.
										Stopped sampling at 16.5'.
										* Groundwater not encountered.
20										
										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25										

GROUNDWATER

DEPTH	HOUR	DATE
	*	

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE 3B

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-3

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/GM	loose to 12" moist loose to medium dense	**SILTY FINE TO COARSE SAND AND FINE AND COARSE GRAVEL**; brown
								ML	slightly moist loose/stiff	**CLAYEY AND FINE SANDY SILT** with pinholes; light brown with orange oxidation staining
5			X	D	17	64	16.7		many pinholes	
10			X	D	18				moist	
15			X	D	26	74	21.4		medium dense/very stiff non-plastic	grades mottled gray and yellow- to orange-brown
									loose sand layers	
20			X	D	20	67	37.0		stiff silt layers	many pinholes
25										Stopped drilling at 20.0'. Stopped sampling at 21.5'. * Groundwater not encountered.

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE 3C

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-3

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
30										
35										
40										
45										
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.

FIGURE 3C
(con't)

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-4

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM	loose to 12" moist	**SILTY FINE TO COARSE SAND** with some fine gravel; dark brown to brown
										grades with layers of silty gravel and cobbles to 4" wide 6" to 12" thick
								ML	slightly moist stiff	**FINE SANDY SILT** with occasional silty clay layers to 1/4" thick and trace pinholes; light brown to grayish-brown with orange oxidation staining
5				D	19	71	15.2			
10				D	25				very stiff	grades without pinholes
										Stopped drilling at 10.0'.
										Stopped sampling at 11.5'.
										* Groundwater not encountered.
15										
20										
										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25										

GROUNDWATER

DEPTH	HOUR	DATE
	*	

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.

FIGURE 3D

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-5

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/ ML FILL	loose to 6" moist loose to medium dense	**SILTY FINE TO COARSE SAND/SANDY SILT** with some medium to coarse sand and fine gravel; brown, FILL
				D	37					
								SM/ ML FILL	slightly moist loose	**FINE SANDY SILT/SILTY SAND;** light brown with slight mottling, FILL
				D	20					
5										
				D	28	99	17.1	ML FILL	slightly moist very stiff	**CLAYEY SILT** with trace fine sand; brown with occasional light brown mottled pockets, FILL
10										
				D	47					
15										
				D	49				moist	grades dark brown
20										
								ML	slightly moist loose	**FINE SANDY SILT** with pinholes; light gray with orange oxidation staining
				D	15	75	24.9			
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.

FIGURE 3E

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST BORING NO. B-5

JOB NO. 3-817-004314 DATE 02-12-03

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25										
								CL-ML	moist stiff	SILTY CLAY-CLAYEY SILT; blocky; gray
				D	14					
30										
										Stopped drilling at 29.0'. Stopped sampling at 30.5'. * Groundwater not encountered.
35										
40										
45										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
50										

GROUNDWATER

	DEPTH	HOUR	DATE
∇		*	
▼			

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE 3E
(con't)

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PROJECT: Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-1

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					SM/ GM FILL	moist "loose" to "medium dense"	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; brown, FILL
		X	D		ML-CL	moist to slightly moist "medium stiff" to "stiff"	**CLAYEY SILT TO SILTY CLAY**; blocky; grayish-brown
5							
						moist	
							grades predominantly clayey silt
10		X	D				
					SM/ GM	slightly moist "dense"	**SILTY FINE TO COARSE SAND AND FINE AND COARSE GRAVEL** with clay; brown
		X	D	4.9	GP	slightly moist "medium dense" to "loose"	**SANDY GRAVEL**; fine to coarse sand; fine and coarse gravel; brown
15							Stopped excavation at 15.0'. No significant sidewall caving. * Groundwater not encountered.
20							
25							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

SAMPLE TYPE
B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4A

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-2

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE

LOCATION

ELEVATION

DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					ML	moist "dense"/"stiff" slightly moist "medium dense"	**CLAYEY AND FINE SANDY SILT** with trace to some medium to coarse sand and fine gravel and occasional to numerous pinholes; plow-disturbed to 6" to 12"; dark brown to brown
		X	D				
			TW				
5							grades to fine sandy silt; low density; light brown
		X	D			"loose"	
10					SM/ ML	slightly moist "medium dense"	**SILTY FINE TO COARSE SAND/SANDY SILT;** weakly cemented or blocky and numerous silt seams to 1/8" thick; grayish-brown with oxidation layers to 1/4" thick
		X	D				
15							Stopped excavation at 15.0'. No significant sidewall caving. * Groundwater not encountered.
20							
25							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

SAMPLE TYPE

B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4B

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PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-3

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

	DEPTH	HOUR	DATE
∇		*	
▼			

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D		SM/ GM/ ML	moist "dense"	**CLAYEY SILT/SILTY FINE TO COARSE SANDY FINE AND COARSE GRAVEL** with cobbles to 6"; dark brown
		X	D	2.1	GP	slightly moist to dry "loose" to "medium dense"	**SANDY GRAVEL AND COBBLES TO 6"**; fine to coarse sand; fine and coarse gravel; light brown
5							well sorted layers of cobbles, sands, and gravels
10							grades with numerous silt and silty sand layers to 6" thick
15							Stopped excavation at 15.0'.
							Some sidewall caving below 2.0'.
							* Groundwater not encountered.
20							
							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25							

SAMPLE TYPE

B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4C

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-4

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D		SM/ GM	moist "dense"	**SILTY FINE TO COARSE SAND FINE AND COARSE GRAVEL** with clay; plow-disturbed to 12"; dark brown
		X			GP	slightly moist "medium dense"	**SANDY GRAVEL** with some silt; fine to coarse sand; fine and coarse gravel; brown
						"loose"	grades without silt; light brown
		X	D	1.1			grades with some cementation in 6" layers 2' to 3' apart
5							
						"very loose"	oxidized gravel zone
10						"medium dense"	grades with moderate cementation with numerous cobbles to 4" and occasional cobbles to 6"
15							Stopped excavation at 15.0'.
							Some sidewall caving below 8.0'.
							* Groundwater not encountered.
20							
							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25							

SAMPLE TYPE
B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4D

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-5

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D		SM	loose to 3" moist "medium dense" "dense"	**SILTY FINE SAND**; major roots (topsoil) to 3"; dark brown
					ML	slightly moist to dry "medium dense"	**FINE SANDY SILT**; weakly cemented with numerous pinholes; light brown
			TW				occasional to numerous pinholes to 10'
5							
10		X	D	9.4		moist	weakly cemented, many pinholes; tan
						"dense"	
15							Stopped excavation at 15.0'. No significant sidewall caving. * Groundwater not encountered.
20							
25							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

SAMPLE TYPE

B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4E

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-6

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					SM/GM FILL	loose to 12" moist	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; plow-disturbed or fill to 12"; dark brown, FILL
		X	D	7.5	CL-ML FILL	"loose" slightly moist "stiff" LL = 34 PI = 7	**SILTY CLAY/CLAYEY SILT** with trace fine to coarse sand and fine gravel; light brown mottled with dark brown clods mixed in, FILL
5		X	D				grades dark brown
		X	D		ML	slightly moist "medium dense"	**FINE SANDY SILT**; light brown
10							
		X	D		CL-ML	moist "stiff"	**ALTERNATING LAYERS OF SILTY CLAY AND CLAYEY SILT**; light brown and gray
15							Stopped excavation at 15.0'. No significant sidewall caving. * Groundwater not encountered.
20							
25							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

SAMPLE TYPE
B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4F

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-7

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					SM/ML FILL	loose to 6" moist "medium dense"	SILTY FINE SAND/SANDY SILT; dark brown to brown, FILL
		X	D		ML	slightly moist "dense"	FINE SANDY SILT; moderately cemented; light brown
5							
						moist "medium dense"	grades to weakly cemented
10							
		X	D	12.1	ML/ SM	moist "medium stiff"/ "loose" -200 = 26	CLAYEY SILT TO SANDY SILT AND SILTY SAND LAYERS; brown
						"stiff"	grades blocky; grayish-brown
		X	D				
15							Stopped excavation at 15.0'. No significant sidewall caving. * Groundwater not encountered.
20							
							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25							

SAMPLE TYPE

B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4G

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-8

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	
	.	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in % / Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					SM/	moist	**SILTY FINE SAND/SANDY SILT** with some medium to coarse sand and fine gravel to 12" deep; dark brown
		X	D		ML	"loose"	
						slightly moist to dry "medium dense"	grades light brown with occasional to numerous pinholes
			TW	15.0 / 49		-200 = 24	
5						slightly moist	grades with occasional pinholes to approximately 10'
		X	D				
10						moist "dense"	
		X	D				
15							Stopped excavation at 15.0'.
							No significant sidewall caving.
							* Groundwater not encountered.
20							
							The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
25							

SAMPLE TYPE
B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4H

amec

PROJECT Sunrise Utah - Phase 1
11400 to 11800 S. 4000 to 4800 W., South Jordan, UT

LOG OF TEST PIT NO. TP-9

JOB NO. 3-817-004314 DATE 02-11-03

GROUNDWATER

DEPTH	HOUR	DATE
	*	

BACKHOE TYPE
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture in %	Dry Density Pcf	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0						SM/ML FILL	loose to 12" moist to slightly moist "loose"	**FINE SANDY SILT/SILTY SAND**; dark brown to brown, FILL (SLUDGE & SOIL)
						ML FILL	slightly moist "stiff"	**CLAYEY SILT**; light brown, FILL
						GC FILL	moist "dense"	**CLAYEY FINE AND COARSE GRAVEL**; rounded subrounded grains; dark brown with some yellow-orange claystone (tailings), FILL
						SP/GP/FILL		
5						SM/GM FILL	slightly moist "loose" to "medium stiff"	**FINE TO COARSE SAND AND FINE AND COARSE GRAVEL**; dark brown, FILL
							slightly moist "loose" to "medium dense"	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; dark brown, FILL
						CL/ML FILL	moist "medium stiff"	**SILTY CLAY/CLAYEY SILT**; light brown, FILL
10						SM/GM FILL	slightly moist "medium dense"	**SILTY FINE TO COARSE SAND AND FINE GRAVEL**; light brown, FILL
						ML FILL	slightly moist "stiff"	**CLAYEY AND FINE SANDY SILT**; light brown, FILL
		X	D			CL FILL	moist "very stiff"	**CLAY SLUDGE**; light brown, orange, yellow, white, FILL
15								Stopped excavation at 14.5'. No significant sidewall caving. * Groundwater not encountered.
20								
25								The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

SAMPLE TYPE

B - Bucket Sample
D - Disturbed Bulk Sample
SW - Sidewall Sample
TW - Thinwall Sample

FIGURE 4I

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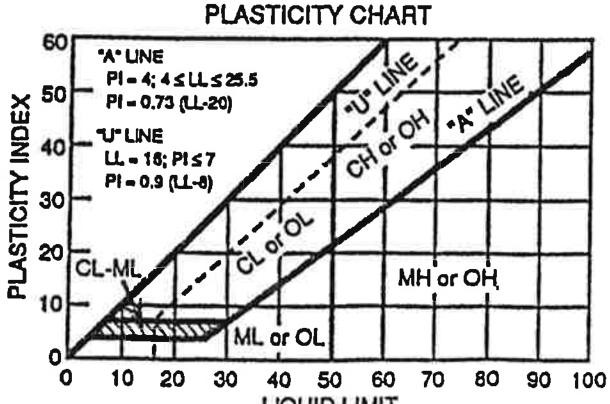
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified for engineering purposes by the Unified Soil Classification System. Grain-size analyses and Atterberg Limits tests often are performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. Graphic symbols are used on boring logs presented in this report. For a more detailed description of the system, see "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)" ASTM Designation: 2488-84 and "Standard Test Method for Classification of Soils for Engineering Purposes" ASTM Designation: 2487-85.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands
					SP	Poorly graded sands, gravelly sands
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits plot below "A" line & hatched zone on plasticity chart)	SILTS OF LOW PLASTICITY (Liquid Limit less than 50)			ML	Inorganic silts, clayey silts of low to medium plasticity
		SILTS OF HIGH PLASTICITY (Liquid Limit 50 or more)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts
	CLAYS (Limits plot above "A" line & hatched zone on plasticity chart)	CLAYS OF LOW PLASTICITY (Liquid Limit less than 50)			CL	Inorganic clays of low to medium plasticity, gravelly, sandy, and silty clays
		CLAYS OF HIGH PLASTICITY (Liquid Limit 50 or more)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity
	ORGANIC SILTS AND CLAYS	ORGANIC SILTS AND CLAYS OF LOW PLASTICITY (Liquid Limit less than 50)			OL	Organic silts and clays of low to medium plasticity, sandy organic silts and clays
		ORGANIC SILTS AND CLAYS OF HIGH PLASTICITY (Liquid Limit 50 or more)			OH	Organic silts and clays of high plasticity, sandy organic silts and clays
ORGANIC SOILS		PRIMARILY ORGANIC MATTER (dark in color and organic odor)			PT	Peat

NOTE: Coarse-grained soils with between 5% and 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone on the plasticity chart have dual classifications.

PLASTICITY CHART



DEFINITION OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 12 in.
Cobbles	12 in. to 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200 sieve
Coarse sand	No. 4 to No. 10 sieve
Medium sand	No. 10 to No. 40 sieve
Fine sand	No. 40 to No. 200 sieve
Fines (silt and clay)	Less than No. 200 sieve

FIGURE 5

NOTES